

## ADDENDUM No.3

# Roosevelt High School CTE Center 4029 S 28<sup>th</sup> Avenue S Minneapolis, MN 55406

Drawings dated: April 14, 2026

LSE Project Number: 22.1007.03

LSE ARCHITECTS, INC.  
1401 GLENWOOD AVENUE  
MINNEAPOLIS, MN 55405

May 5, 2026

This Addendum forms a part of the Contract Documents and modifies the original Bidding Documents dated **April 14, 2026**.

Acknowledge receipt of this Addendum in the space provided on the **Bid**. Failure to do so may subject Bidder to disqualification.

This Addendum consists of **two (2) pages, plus attachments**. Reference made to the Project Manual and Drawings shall be used as a guide only. Bidders shall determine the work affected by Addendum items.

**CHANGES TO THE ARCHITECTURAL DRAWINGS**

A405 – WATER SERVICE LAB PLAN

2/A405 – ADD keynotes to Water service plan features

A410 – TOILETS FLOOR PLANS & ELEVATIONS

1/A410 – ADD elevation mark in toilets 190K,190D, 190E and 190F

A411 – TOILET ELEVATION

1/A411 – ADD elevation 21 and 22

**CHANGES TO THE MECHANICAL, ELECTRICAL, OR PLUMBING DRAWINGS DRAWINGS**

See Hallberg Engineering Narrative

**Attachments**

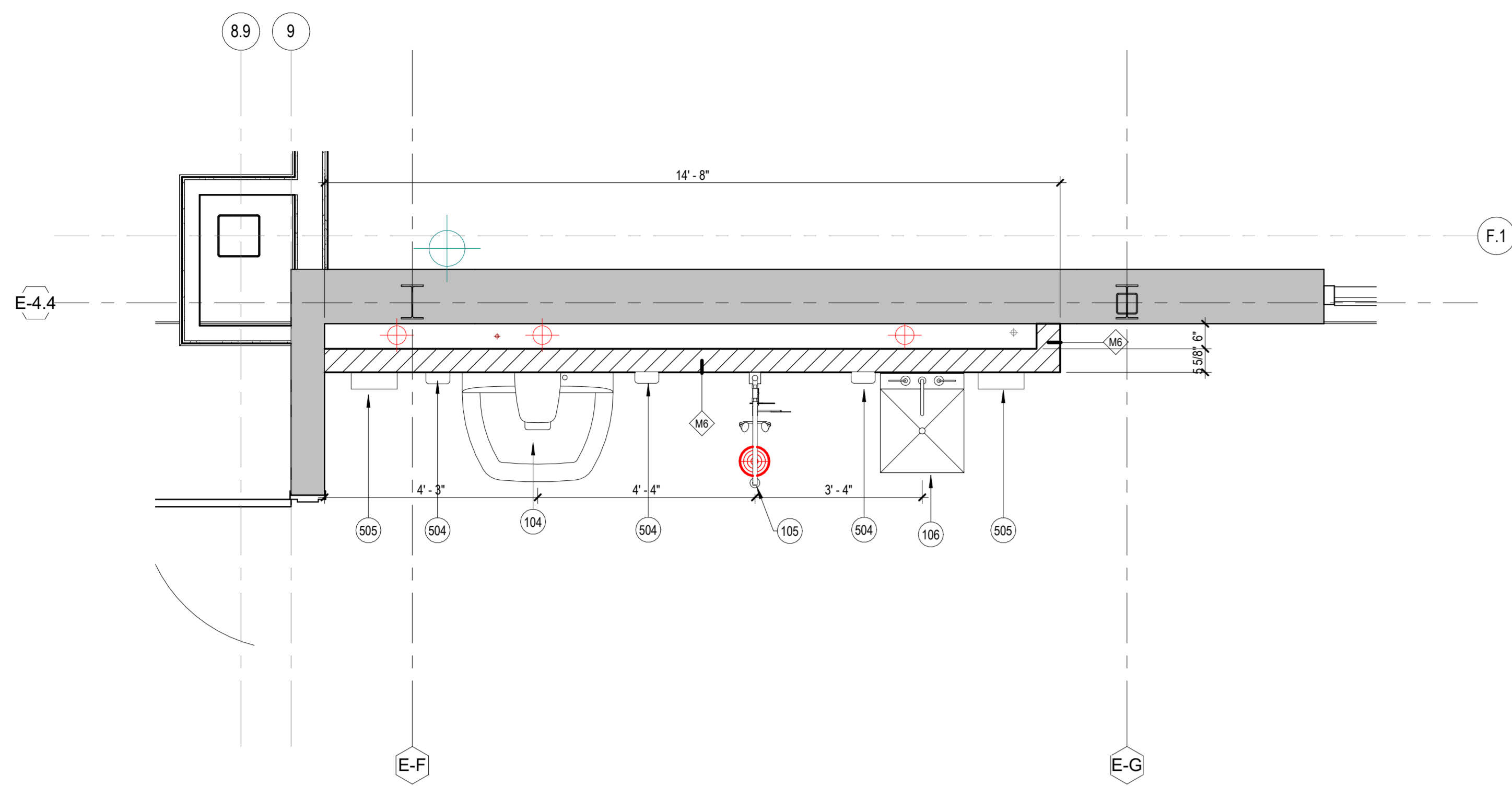
DRAWING A405 – WATER SERVICE LAB PLAN

DRAWING A410 – TOILETS FLOOR PLANS &ELEVATIONS

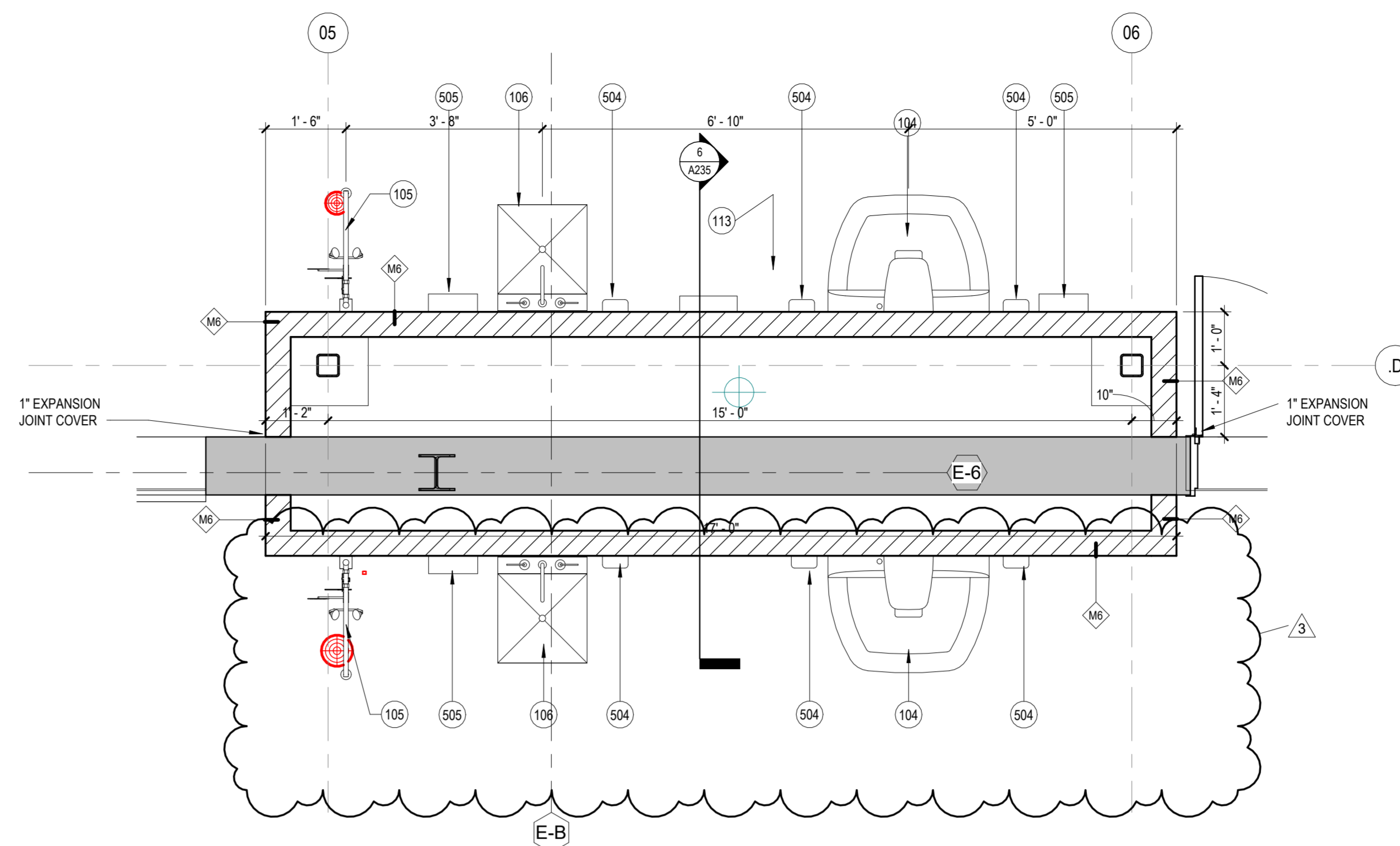
DRAWING A411 – TOILETS ELEVATION

Hallberg NARRATIVE – See narrative for reissued sheets

**END OF ADDENDUM**



1 MACHINE LAB WATER SERVICE PLAN  
A405 1/2" = 1'-0"



2 AUTO REPAIR LAB WATER SERVICE PLAN  
A405 1/2" = 1'-0"

WATER SERVICES	
Key Value	Keynote Text
104	HANDWASH SINK, SEE PLUMBING
105	EYEWASH STATION, SEE PLUMBING
106	UTILITY SINK, SEE PLUMBING
113	FIRE EXTINGUISHER
504	SOAP DISPENSER - BY OWNER, INSTALLED BY CONTRACTOR SEE TA.4
505	PAPER TOWEL DISPENSER - BY OWNER, INSTALLED BY CONTRACTOR SEE TA.3

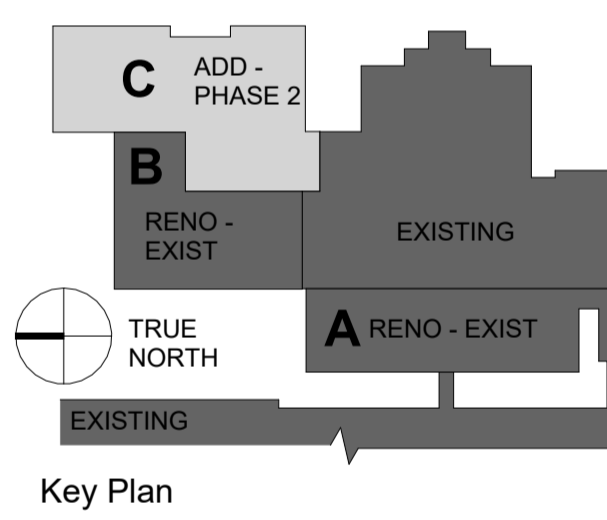


**LSE**  
ARCHITECTS

LAWAL SCOTT ERICKSON ARCHITECTS, INC.  
1401 Glenwood Avenue South  
Minneapolis, MN 55405  
612.343.1010 office  
612.338.2280 fax  
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**Roosevelt High School CTE Center**  
4029 S 28th Ave S  
Minneapolis, MN 55406  
MPS # 24ROOSCTE



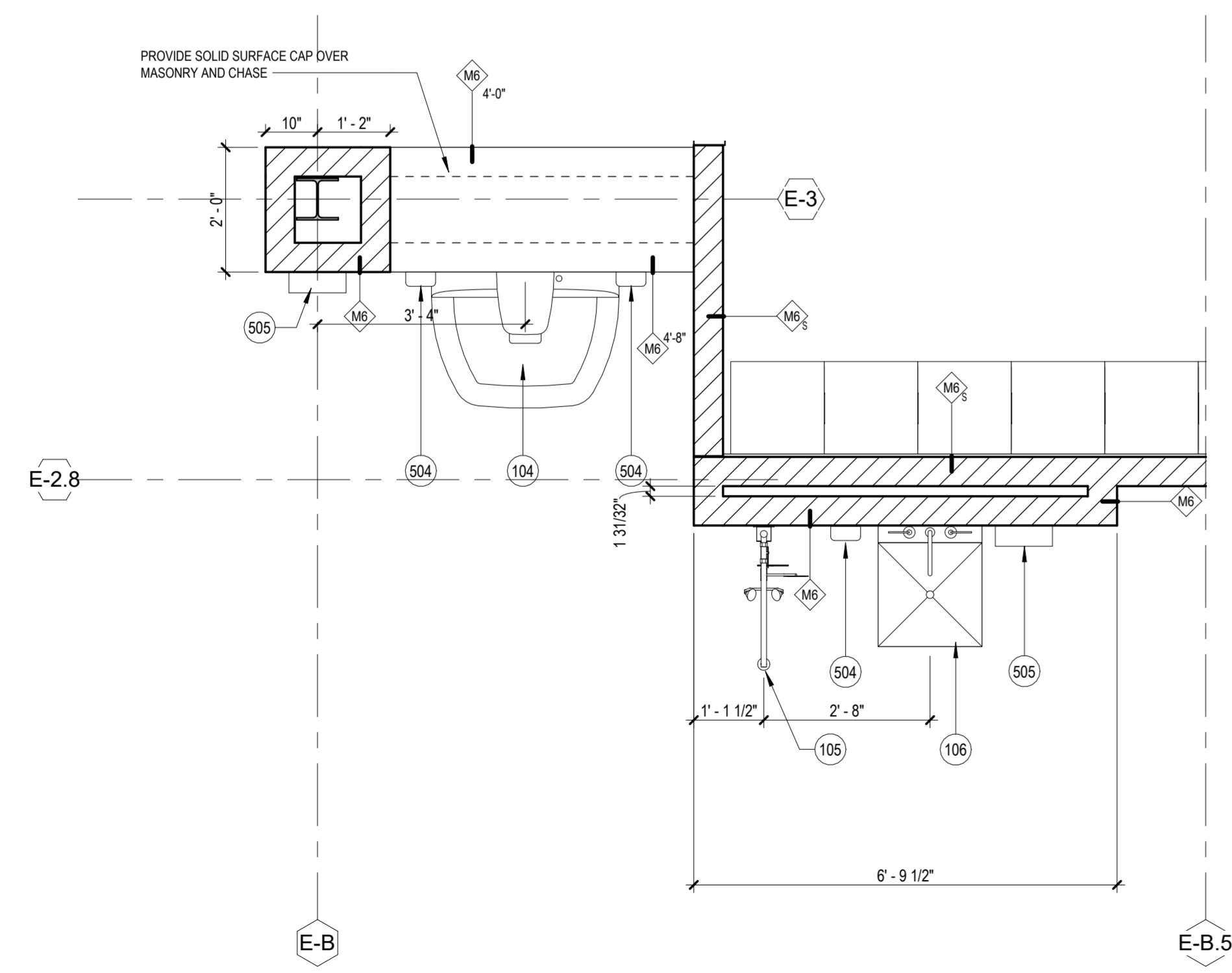
Key Plan

No.	Date	Revision Description
	04.14.2026	BID SET
3	05.05.2026	ADD.#3

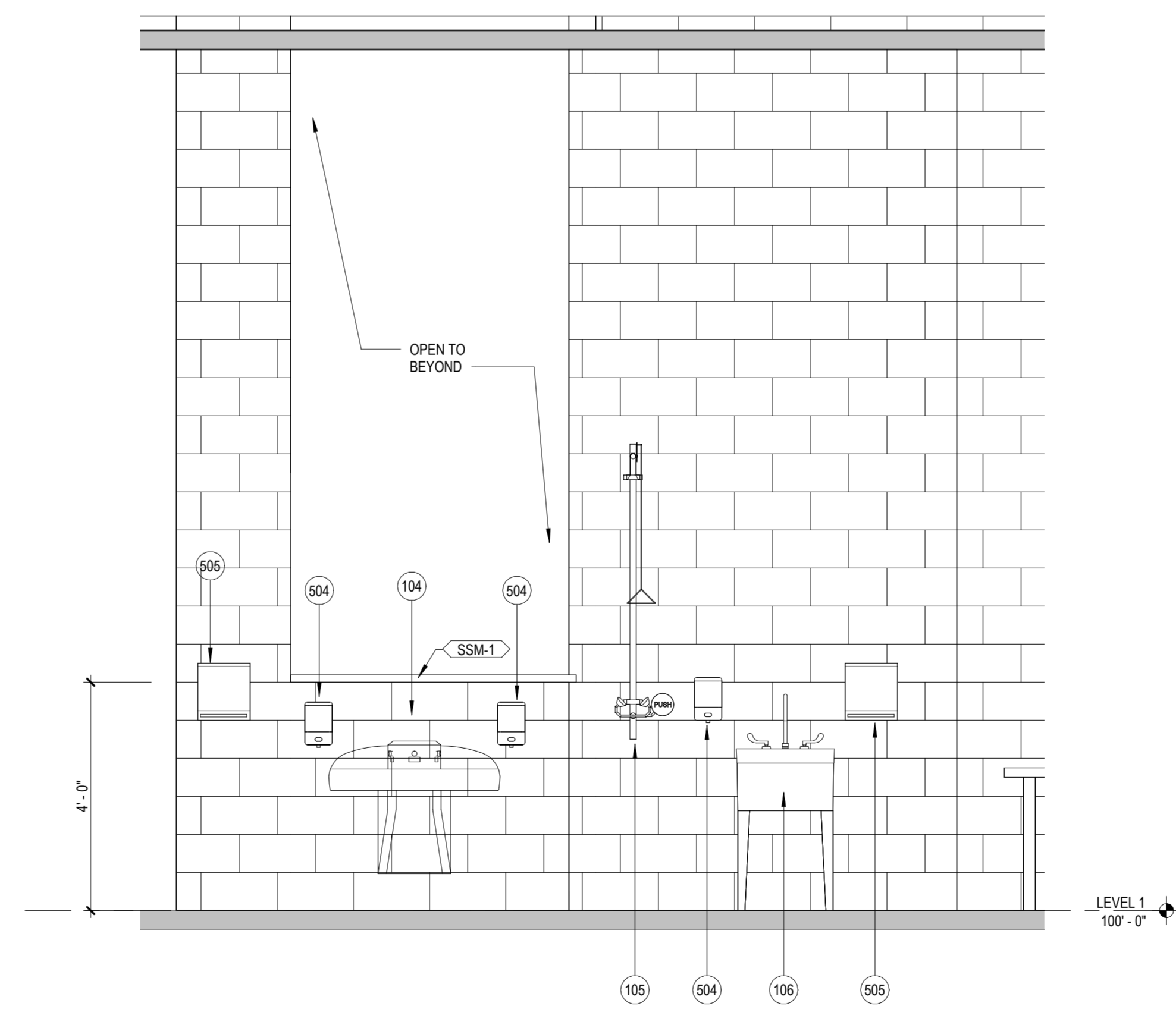
**BID SET**  
**WATER SERVICE LAB PLANS**

Project 23.1007.03  
Date 4.14.2026  
Drawn by DH  
Checked by CL **A405**

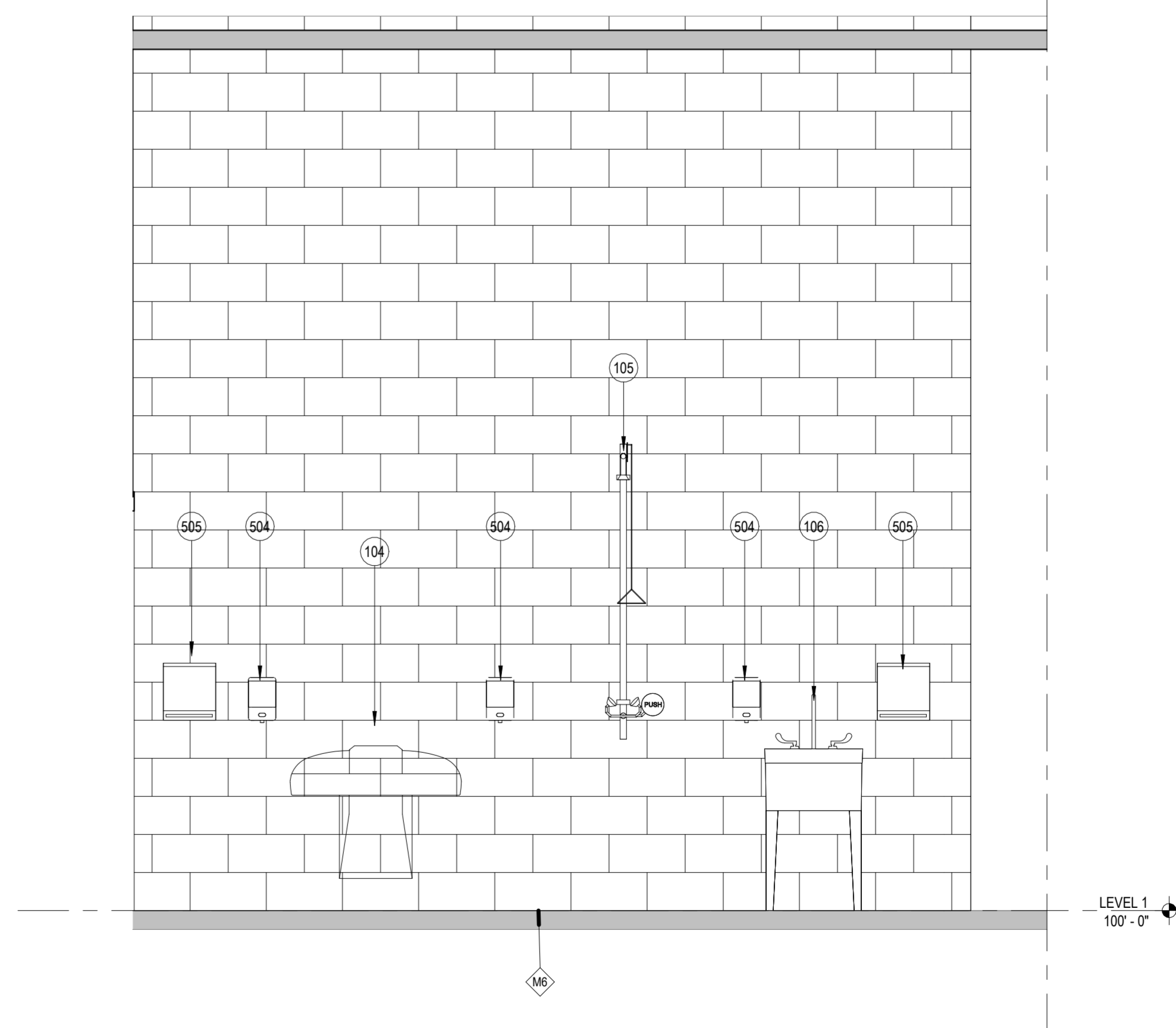
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3 WELDING WATER SERVICE PLAN  
A405 1/2" = 1'-0"



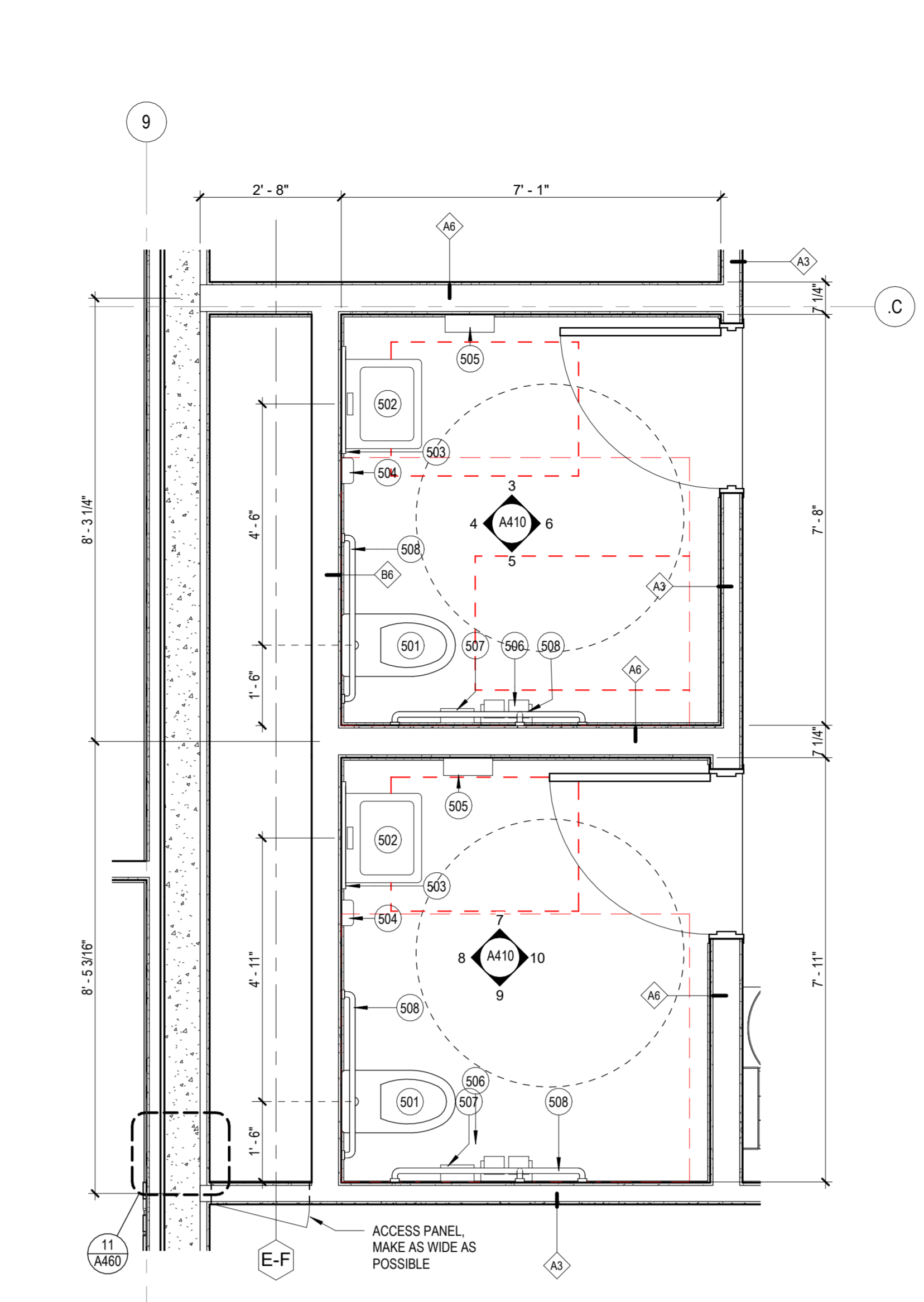
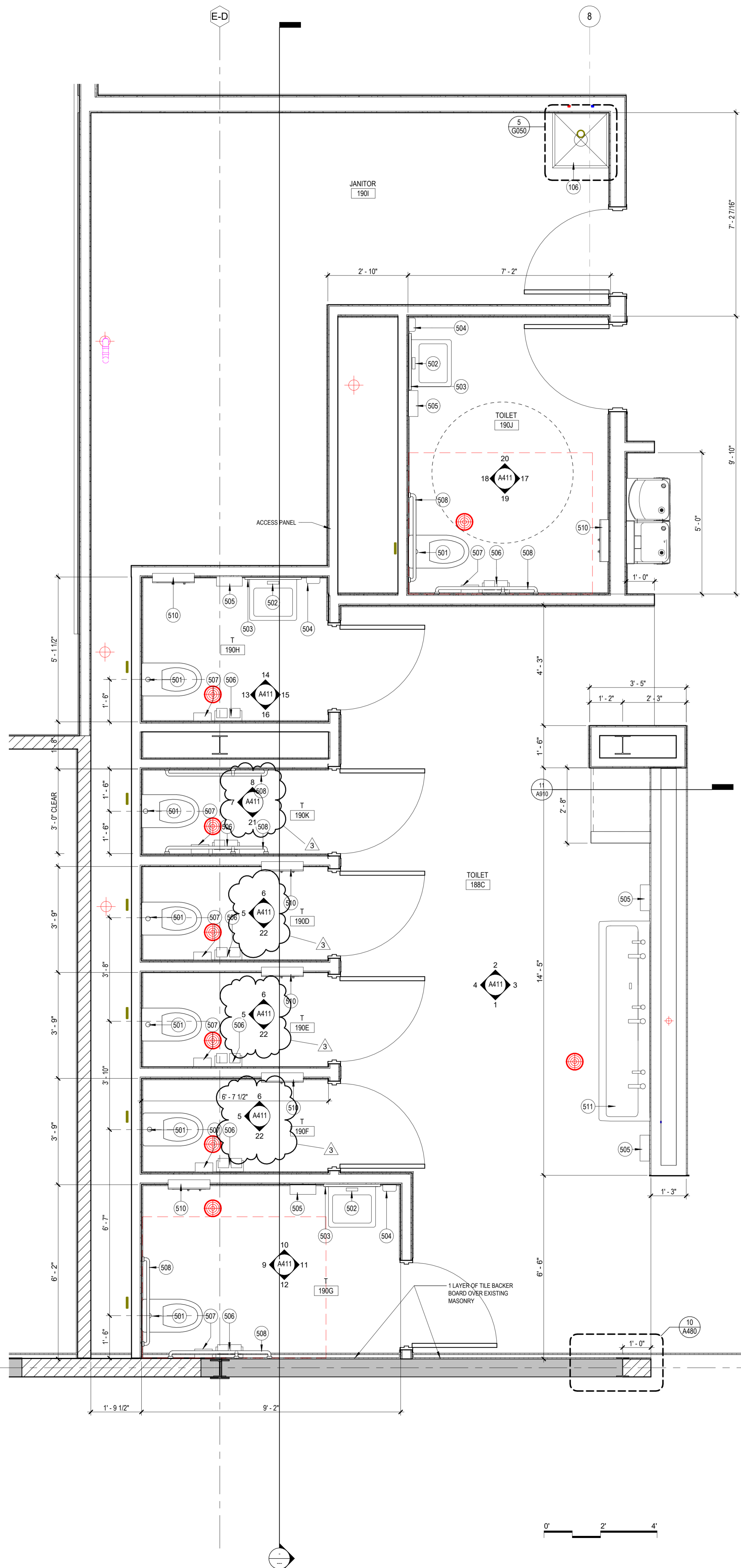
4 WELDING SERVICE ELEVATION  
A405 1/2" = 1'-0"



5 WATER SERVICE ELEVATION  
A405 1/2" = 1'-0"

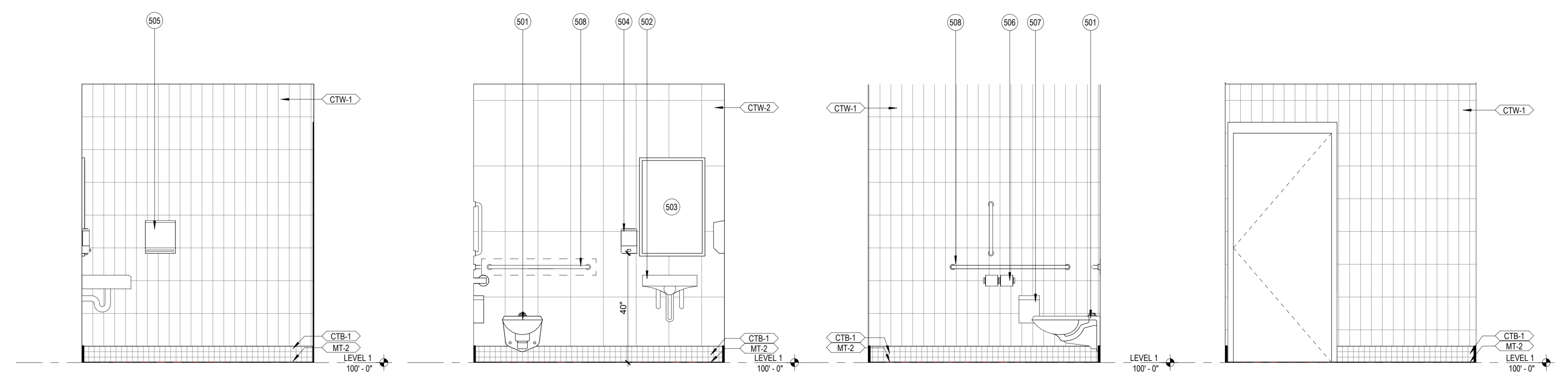
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2 ADMIN TOILET PLAN  
1/2" = 1'-0"

KEYNOTE LEGEND	
Key Value	Keynote Text
106	UTILITY SINK - SEE PLUMBING
501	WALL MOUNTED TOILET
502	WALL MOUNTED LAVATORY
503	WALL MOUNTED MIRROR
504	SOAP DISPENSER - BY OWNER, INSTALLED BY CONTRACTOR SEE TA-4
505	PAPER TOWEL DISPENSER - BY OWNER, INSTALLED BY CONTRACTOR SEE TA-3
506	TOILET PAPER DISPENSER - BY OWNER, INSTALLED BY CONTRACTOR
507	SANITARY WIPERIN DISPOSAL
508	GRAB BARS
510	SANITARY PRODUCTS DISPENSER
511	MULTI-STATION WASH FOUNTAIN

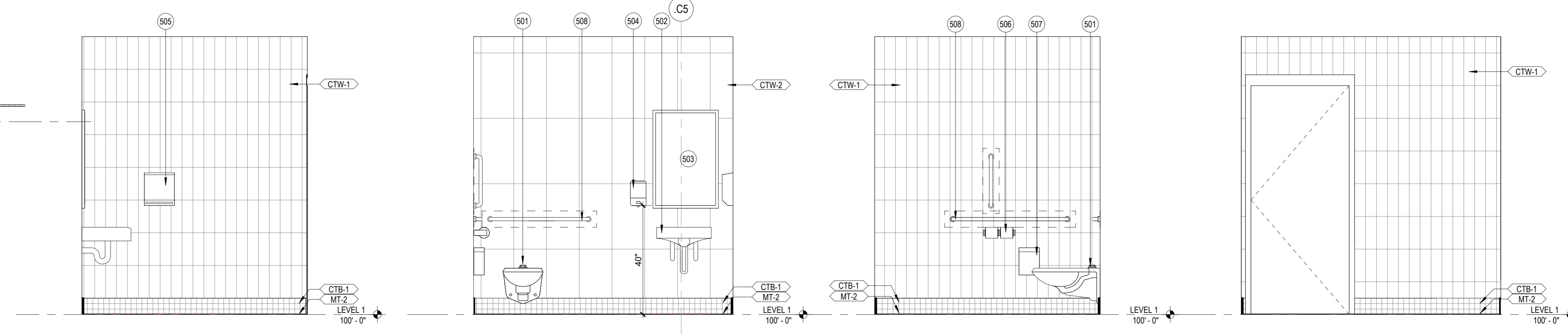


3 ADMIN TOILET 191F - EAST WALL  
1/2" = 1'-0"

4 ADMIN TOILET 191F - NORTH WALL  
1/2" = 1'-0"

5 ADMIN TOILET 191F - WEST WALL  
1/2" = 1'-0"

6 ADMIN TOILET 191F - SOUTH WALL  
1/2" = 1'-0"

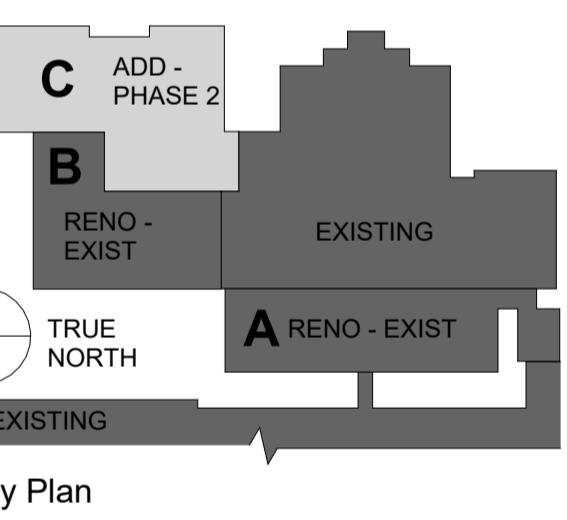


7 ADMIN TOILET 191G - EAST WALL  
1/2" = 1'-0"

8 ADMIN TOILET 191G - NORTH WALL  
1/2" = 1'-0"

9 ADMIN TOILET 191G - WEST WALL  
1/2" = 1'-0"

10 ADMIN TOILET 191G - SOUTH WALL  
1/2" = 1'-0"

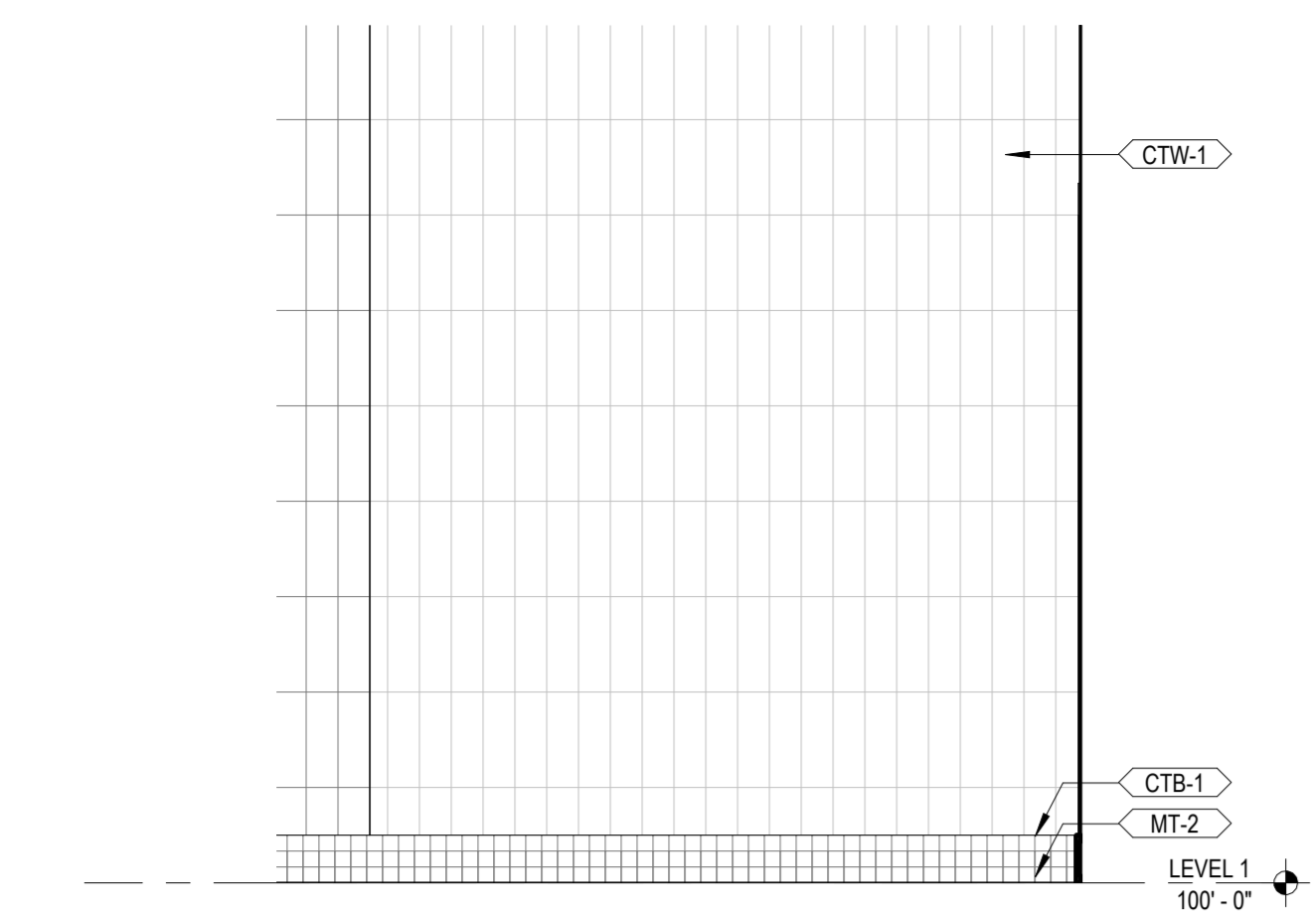


No.	Date	Revision Description
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3	05.05.2026	ADD.#3

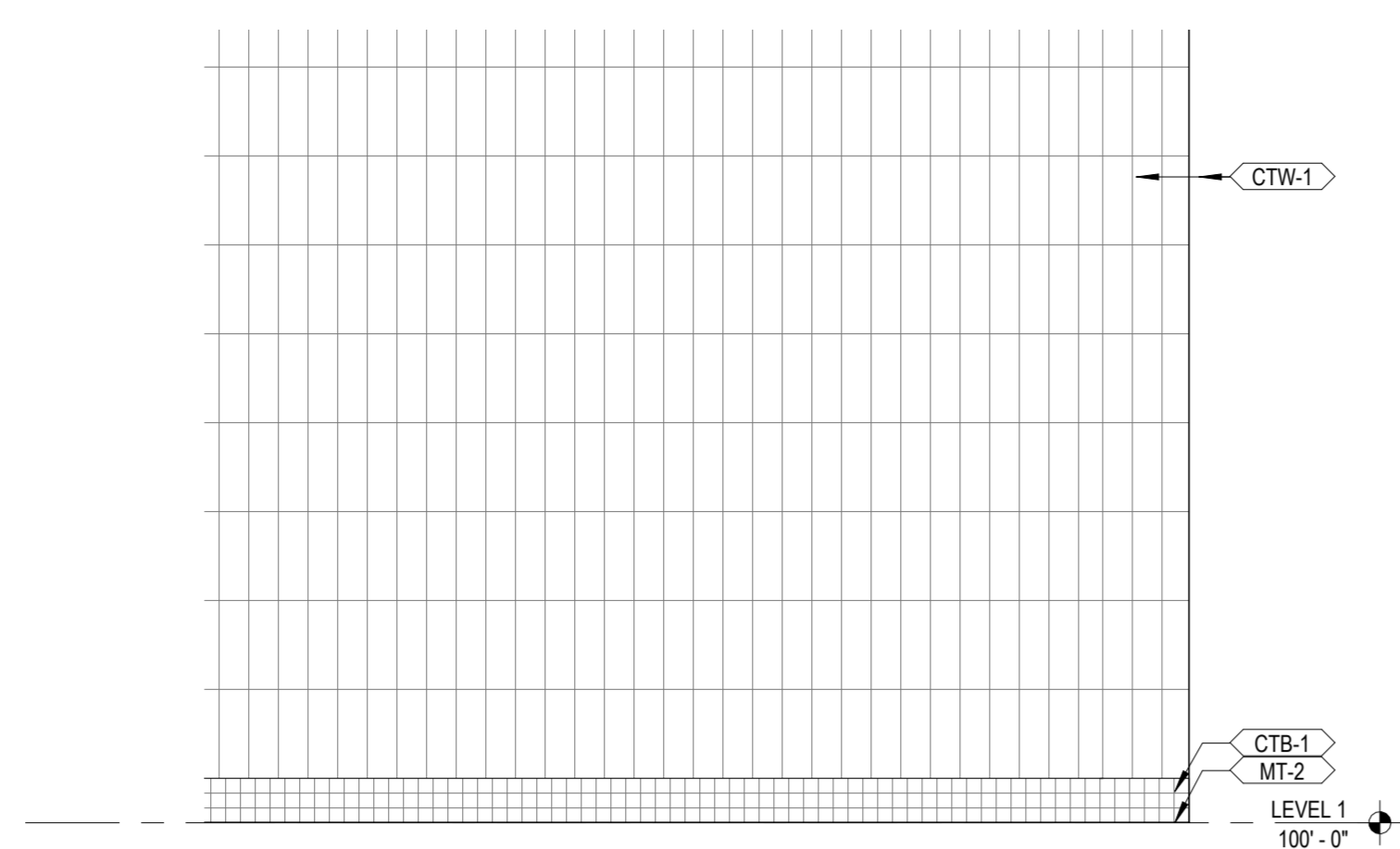
**BID SET**  
**TOILETS FLOOR PLANS & ELEVATIONS**

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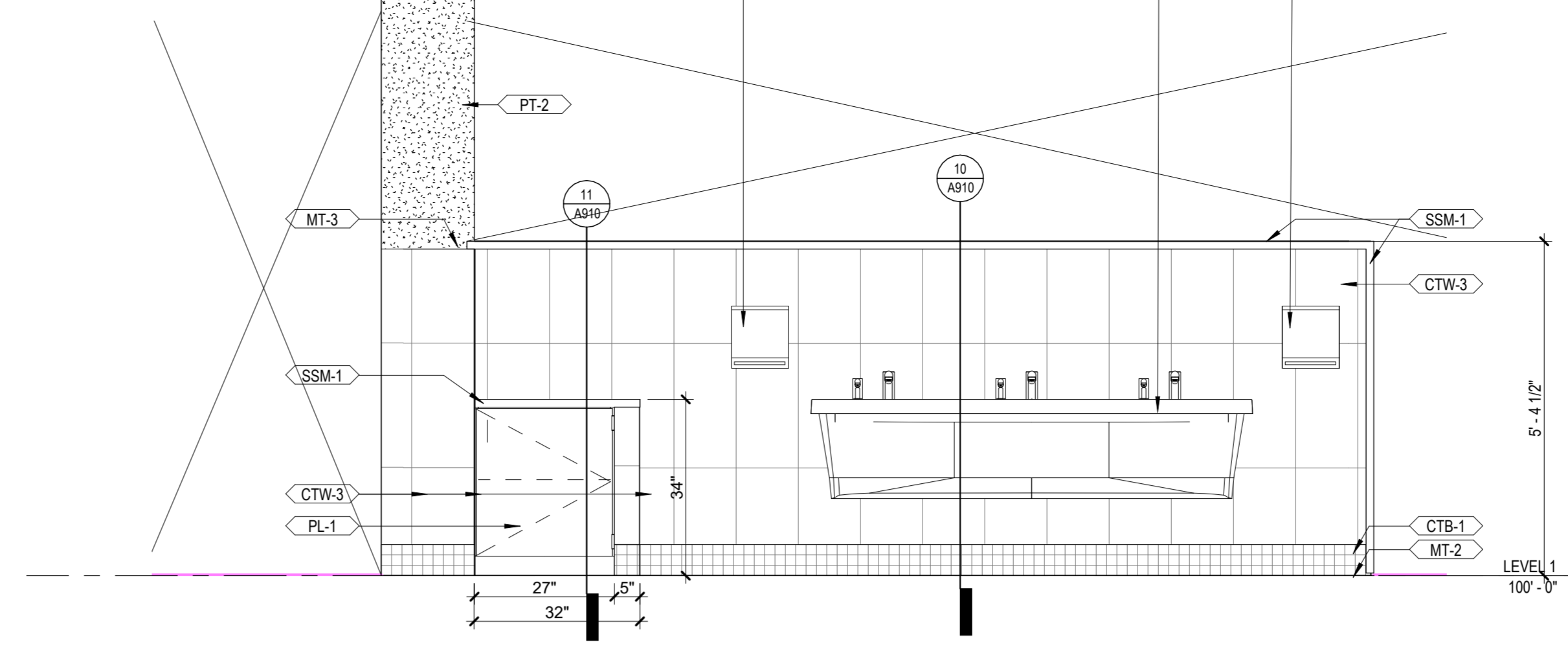
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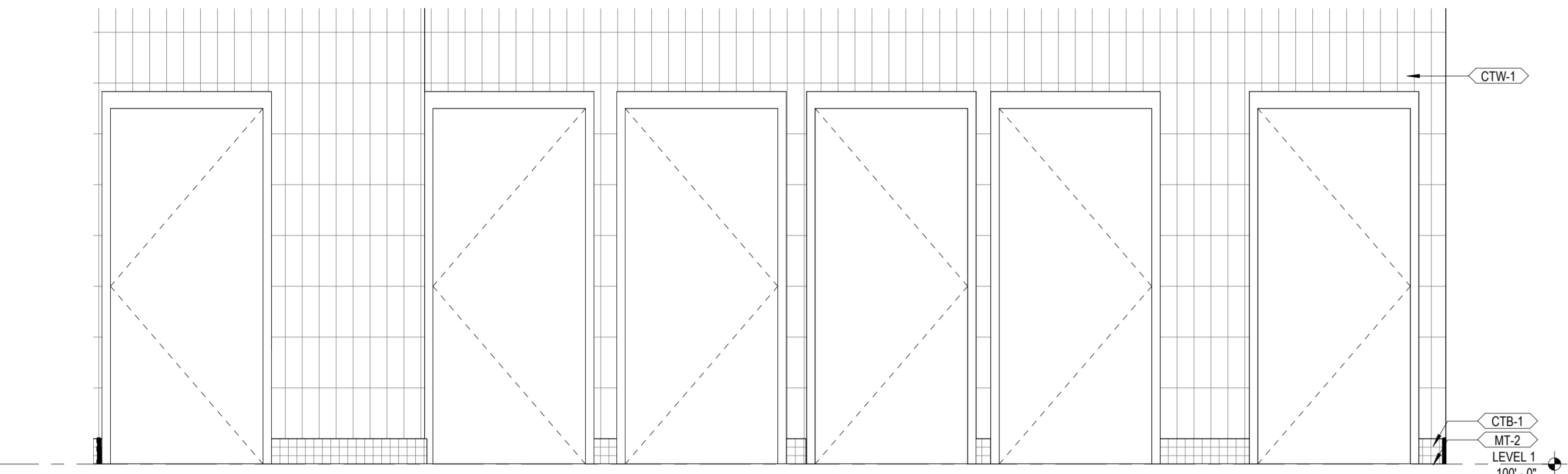
1 COMMONS TOILET - WEST WALL  
A411 1/2" = 1'-0"



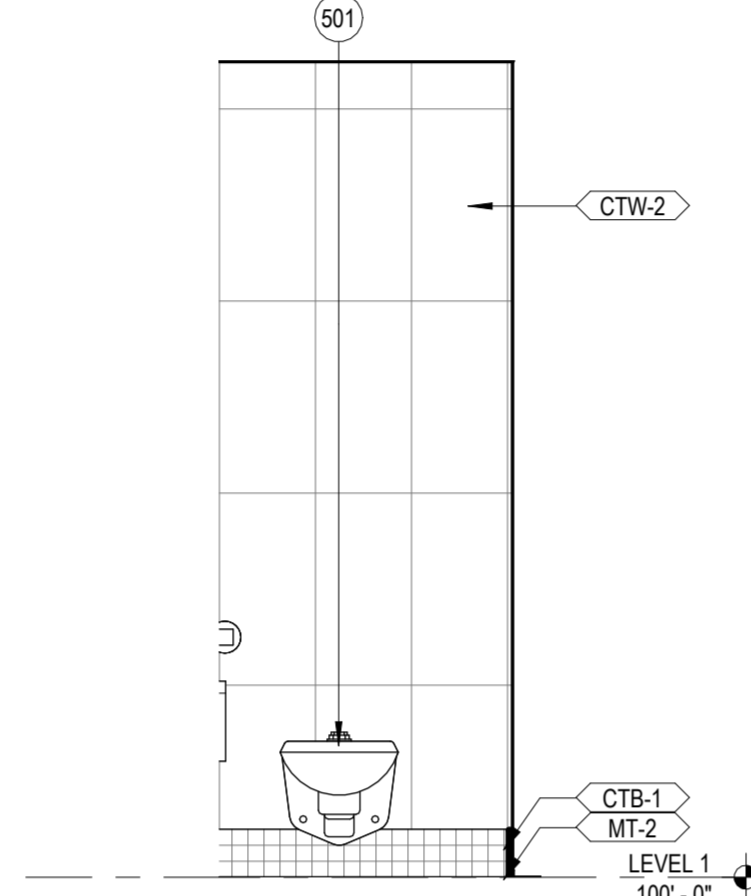
2 COMMONS TOILET - EAST WALL  
A411 1/2" = 1'-0"



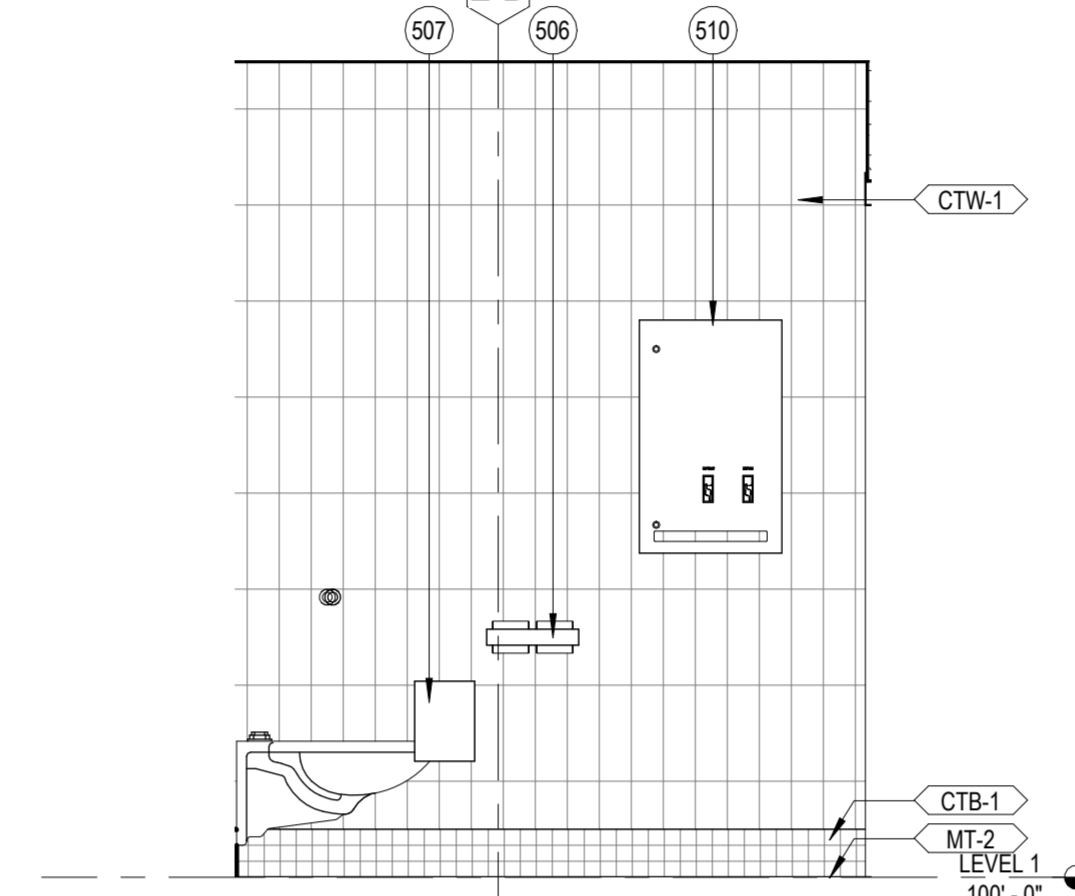
3 COMMONS TOILET HANDWASH - SOUTH WALL  
A411 1/2" = 1'-0"



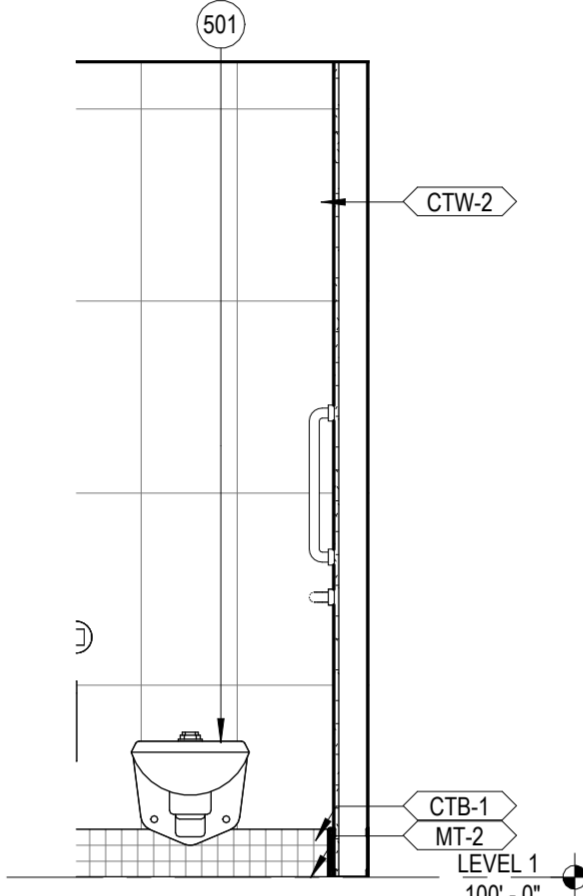
4 COMMONS TOILET - NORTH WALL  
A411 1/2" = 1'-0"



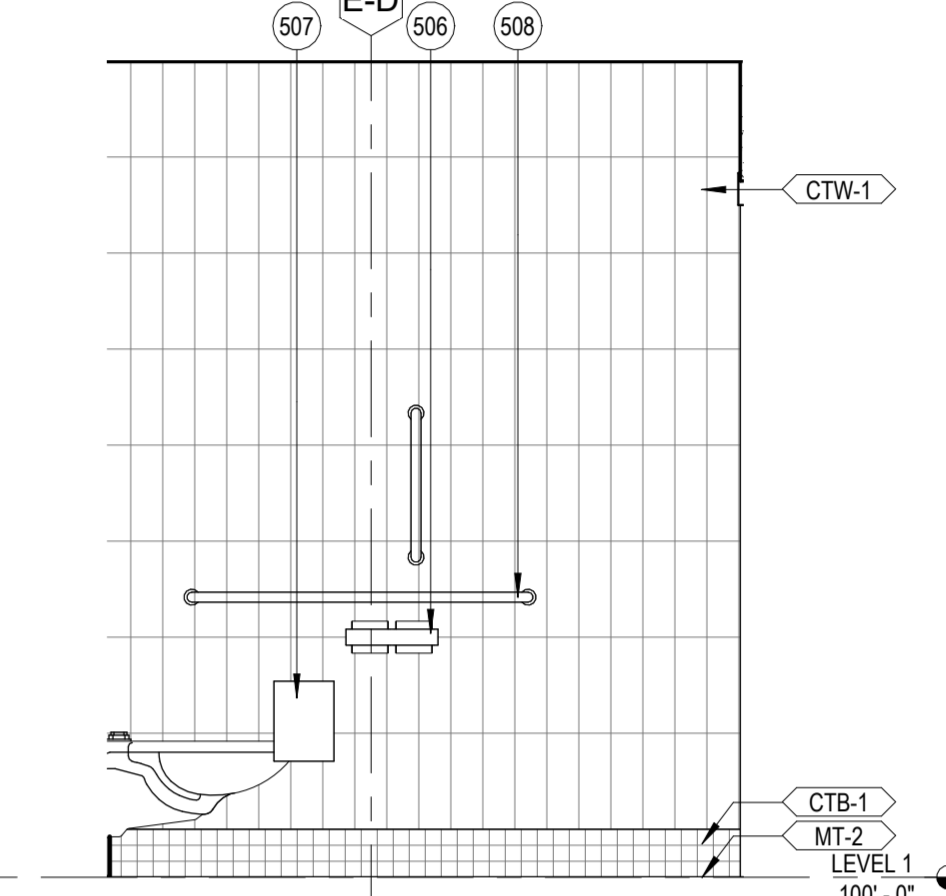
5 SINGLE USER TOILET - WET WALL  
A411 1/2" = 1'-0"



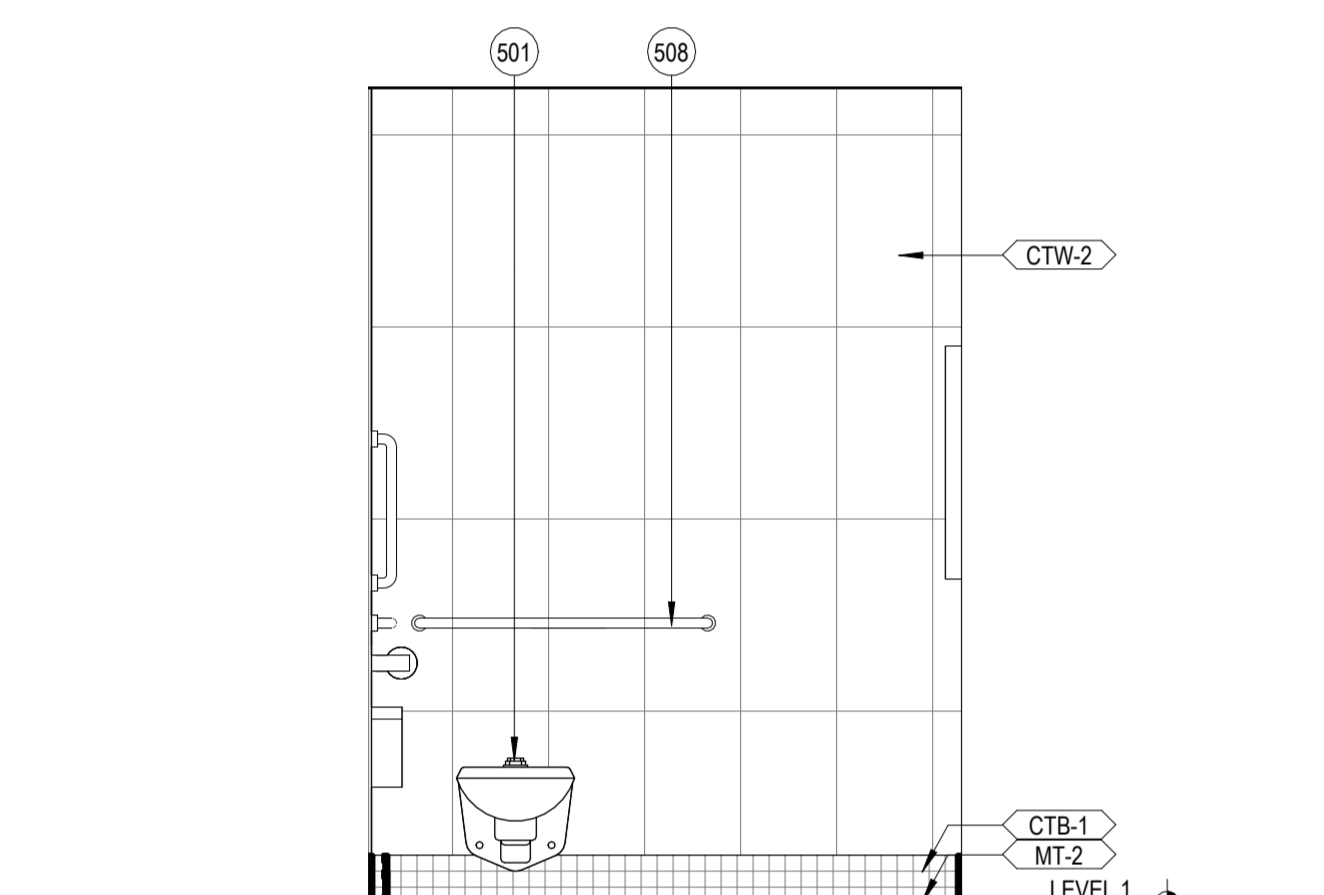
6 SINGLE USER TOILET - SIDE WALL  
A411 1/2" = 1'-0"



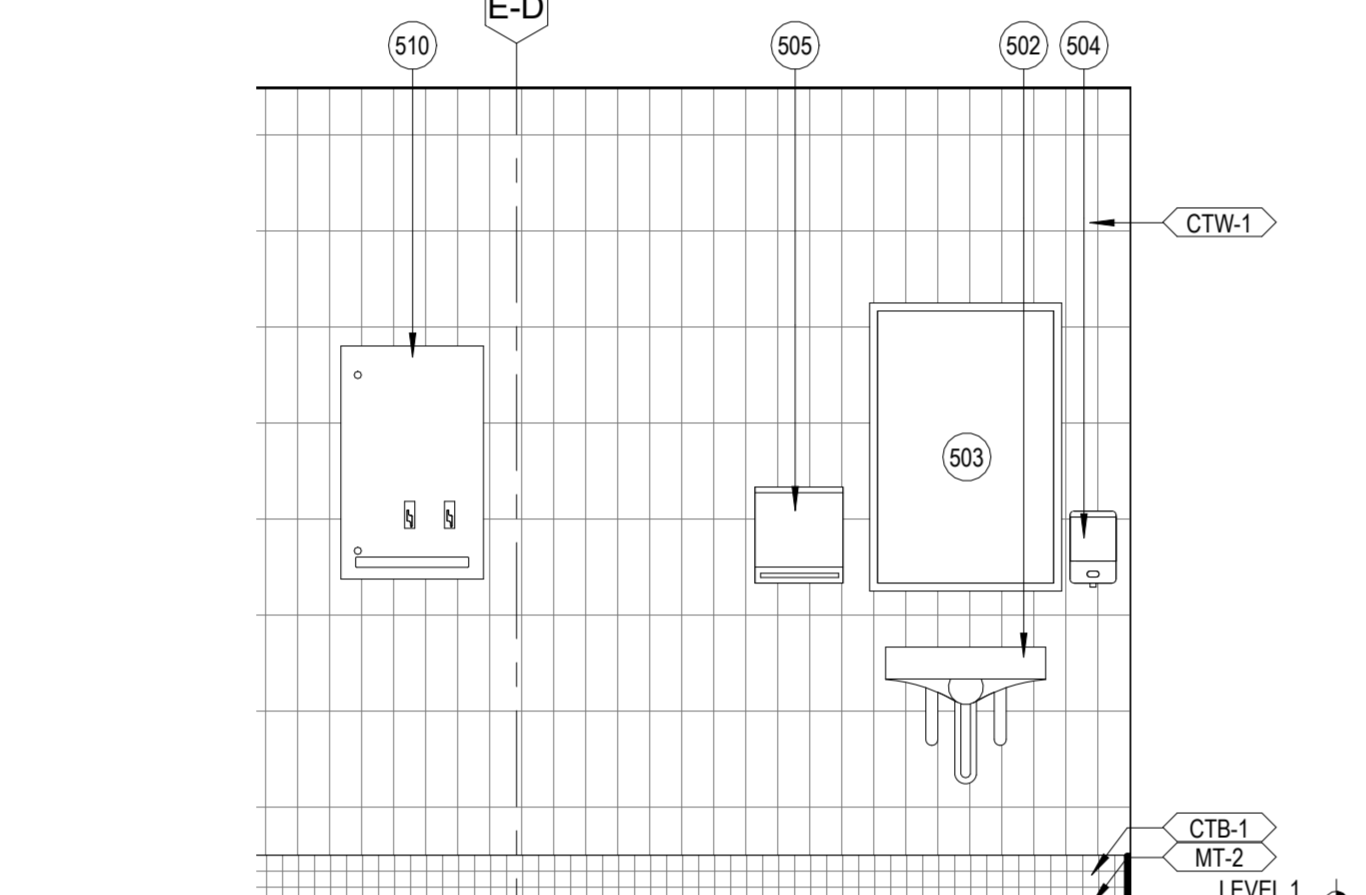
7 AMB TOILET - WET WALL  
A411 1/2" = 1'-0"



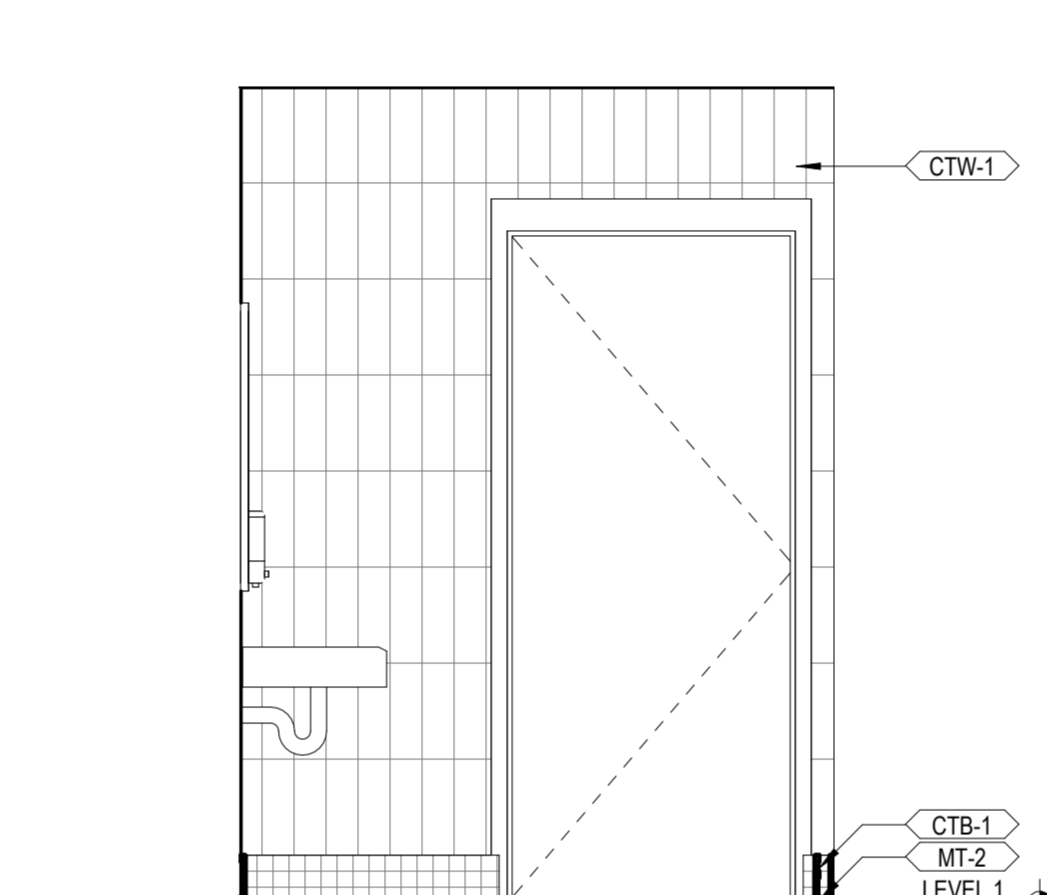
8 AMB TOILET - SIDE WALL  
A411 1/2" = 1'-0"



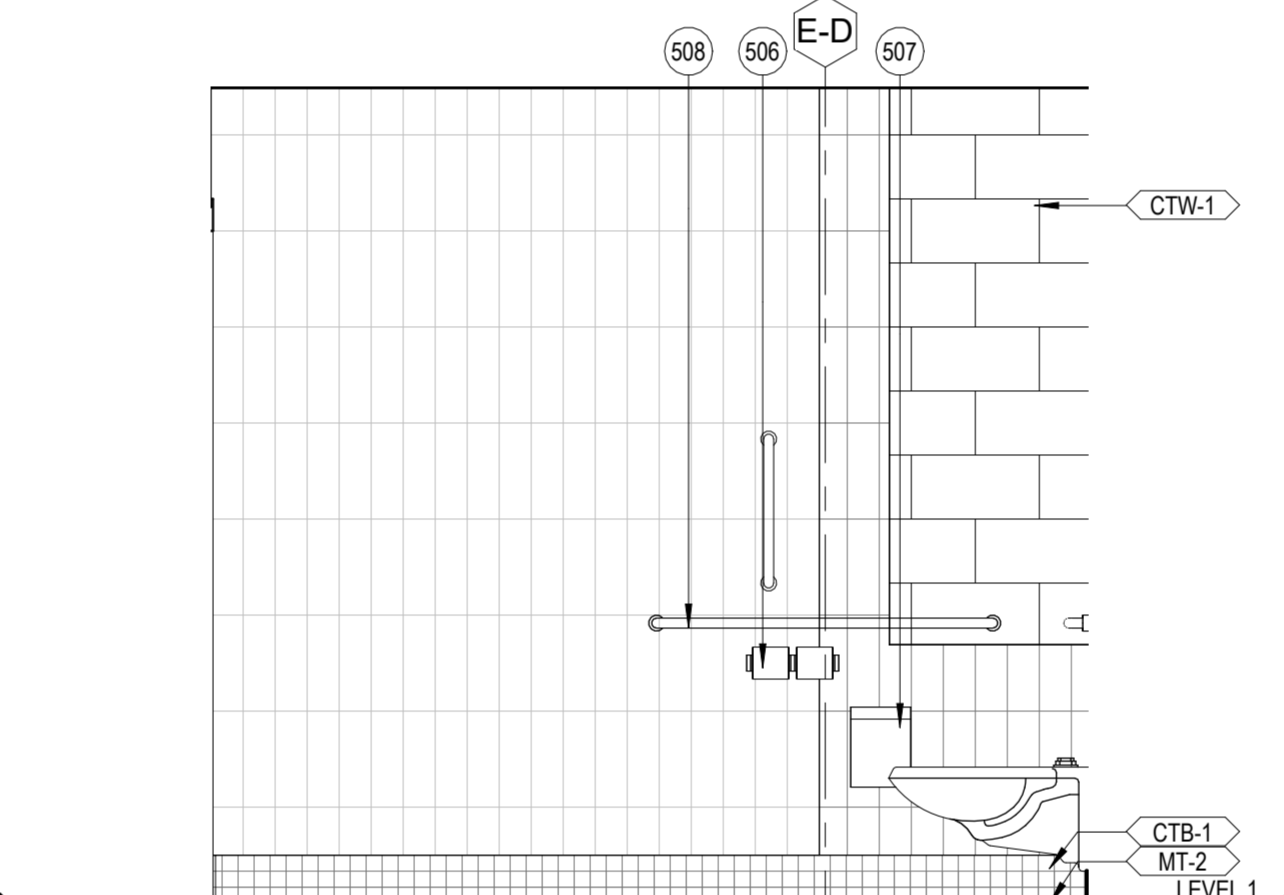
9 TOILET 184C - N WALL  
A411 1/2" = 1'-0"



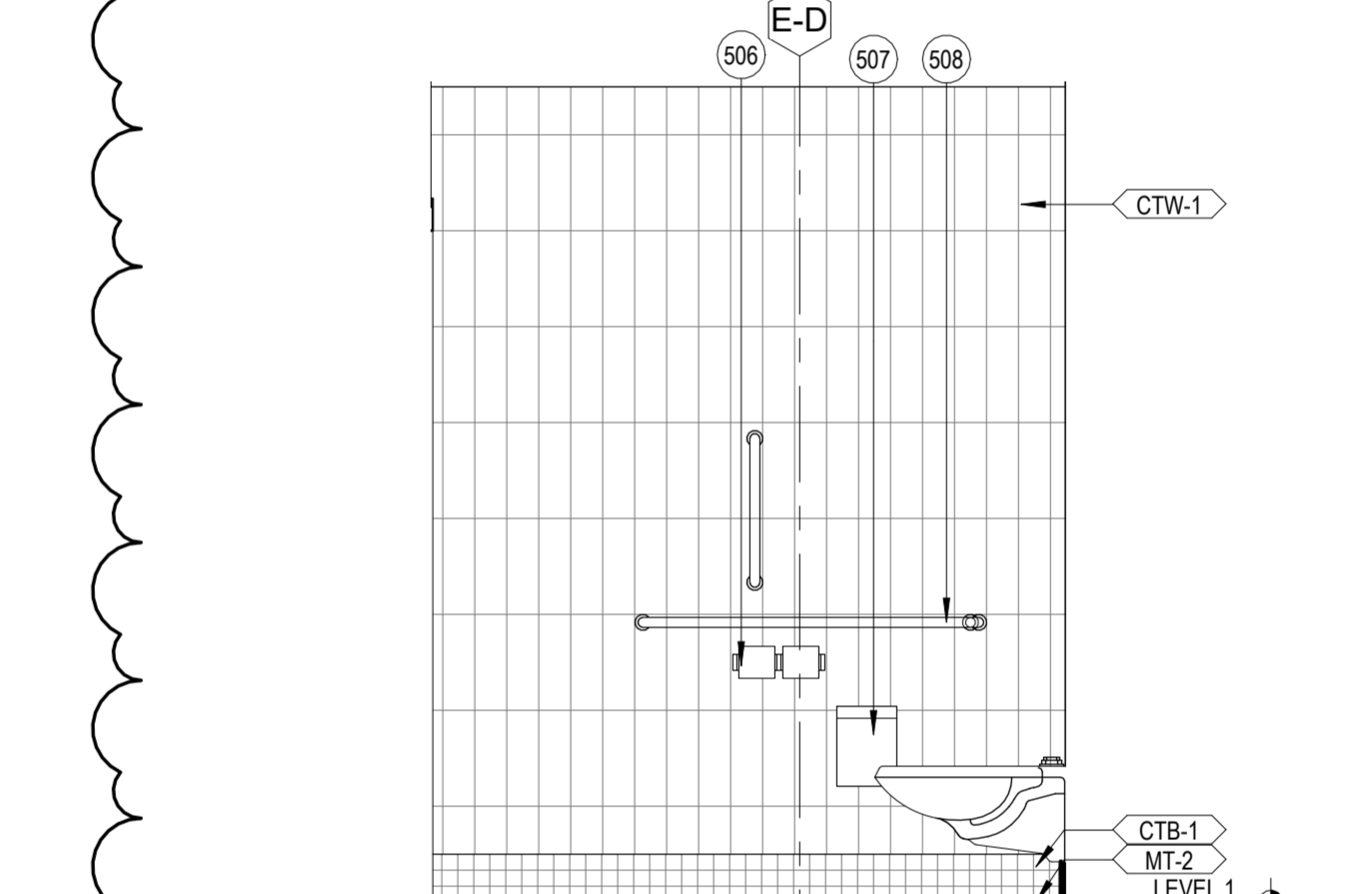
10 TOILET 184C - E WALL  
A411 1/2" = 1'-0"



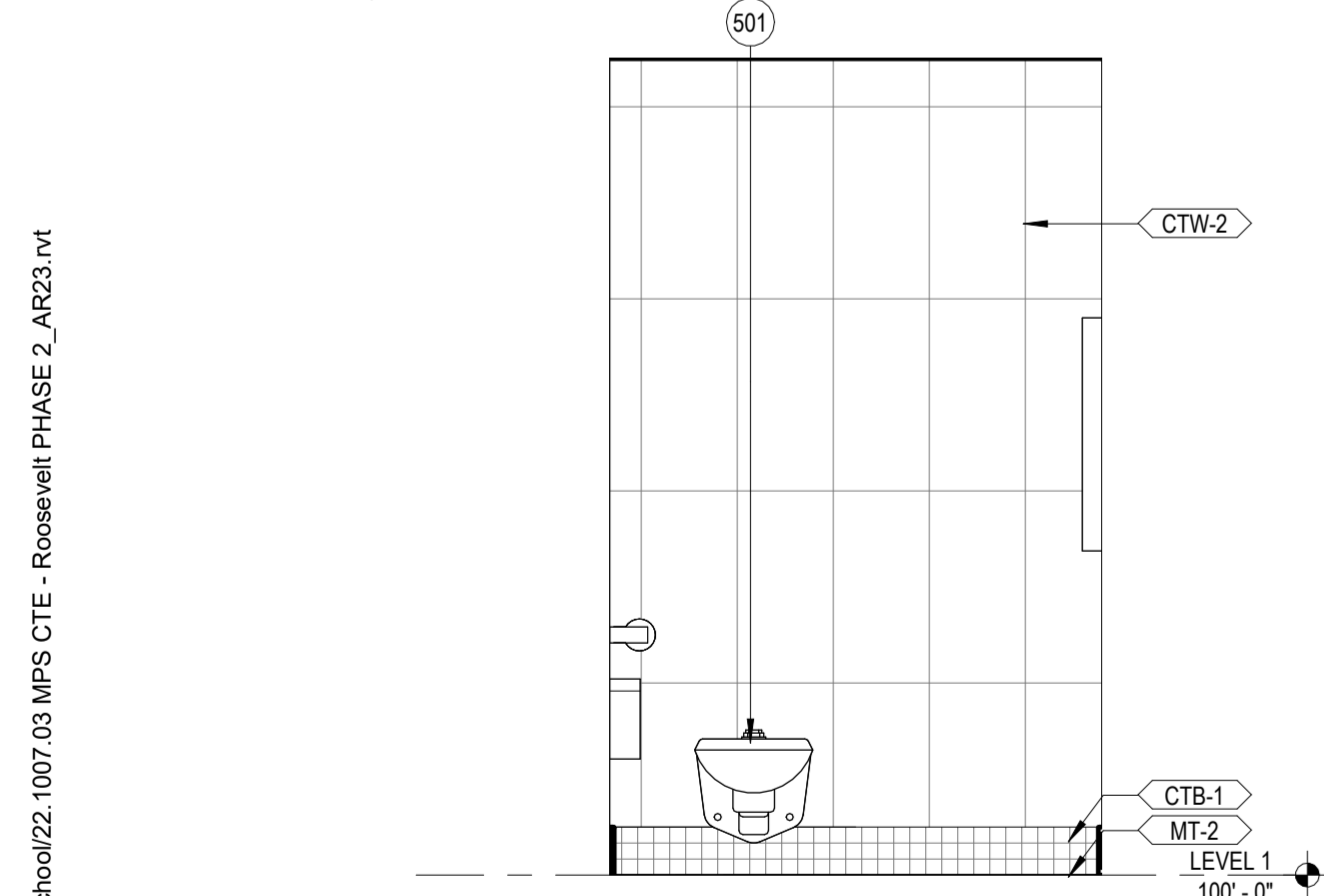
11 TOILET 184C - S WALL  
A411 1/2" = 1'-0"



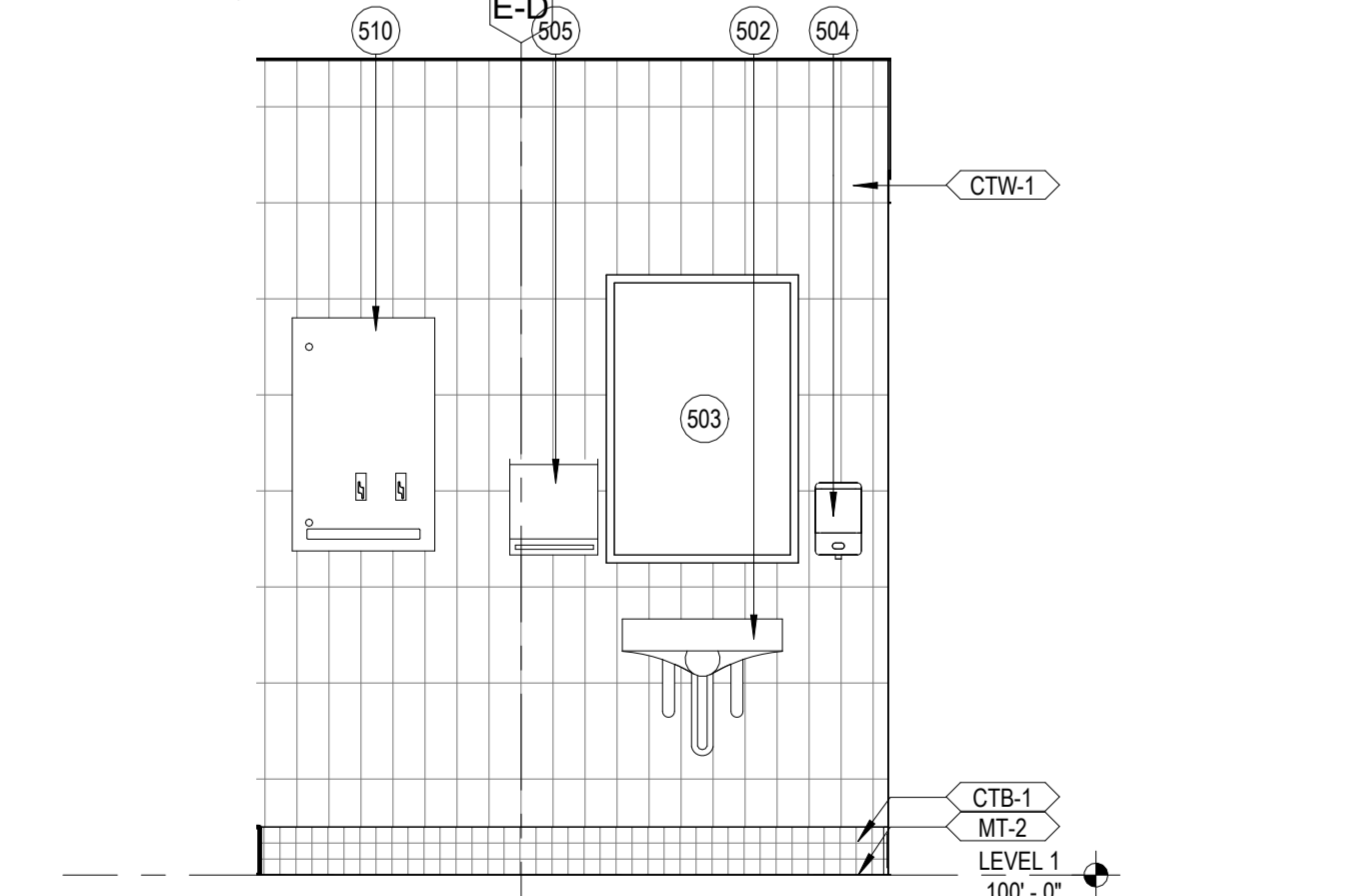
12 TOILET 184C - W WALL  
A411 1/2" = 1'-0"



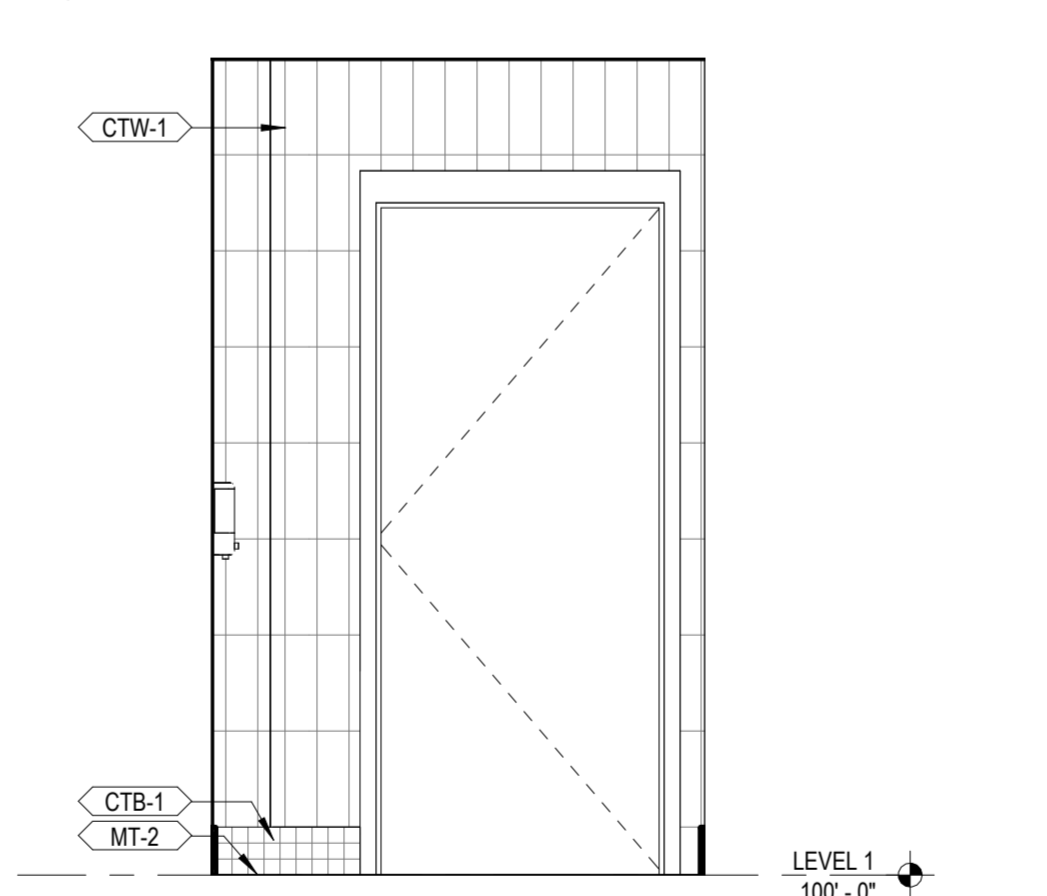
21 TOILET 190K - W WALL  
A411 1/2" = 1'-0"



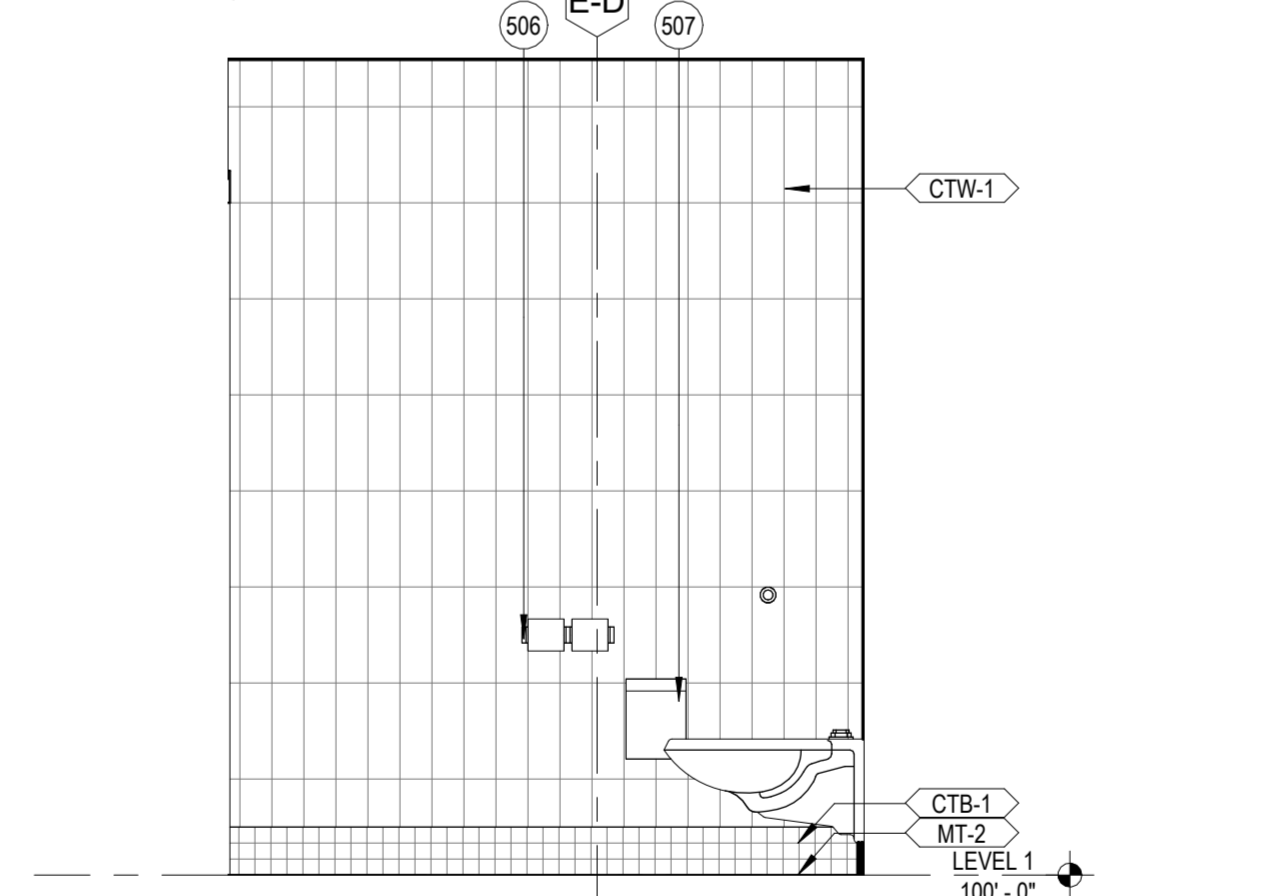
13 TOILET 184H - N WALL  
A411 1/2" = 1'-0"



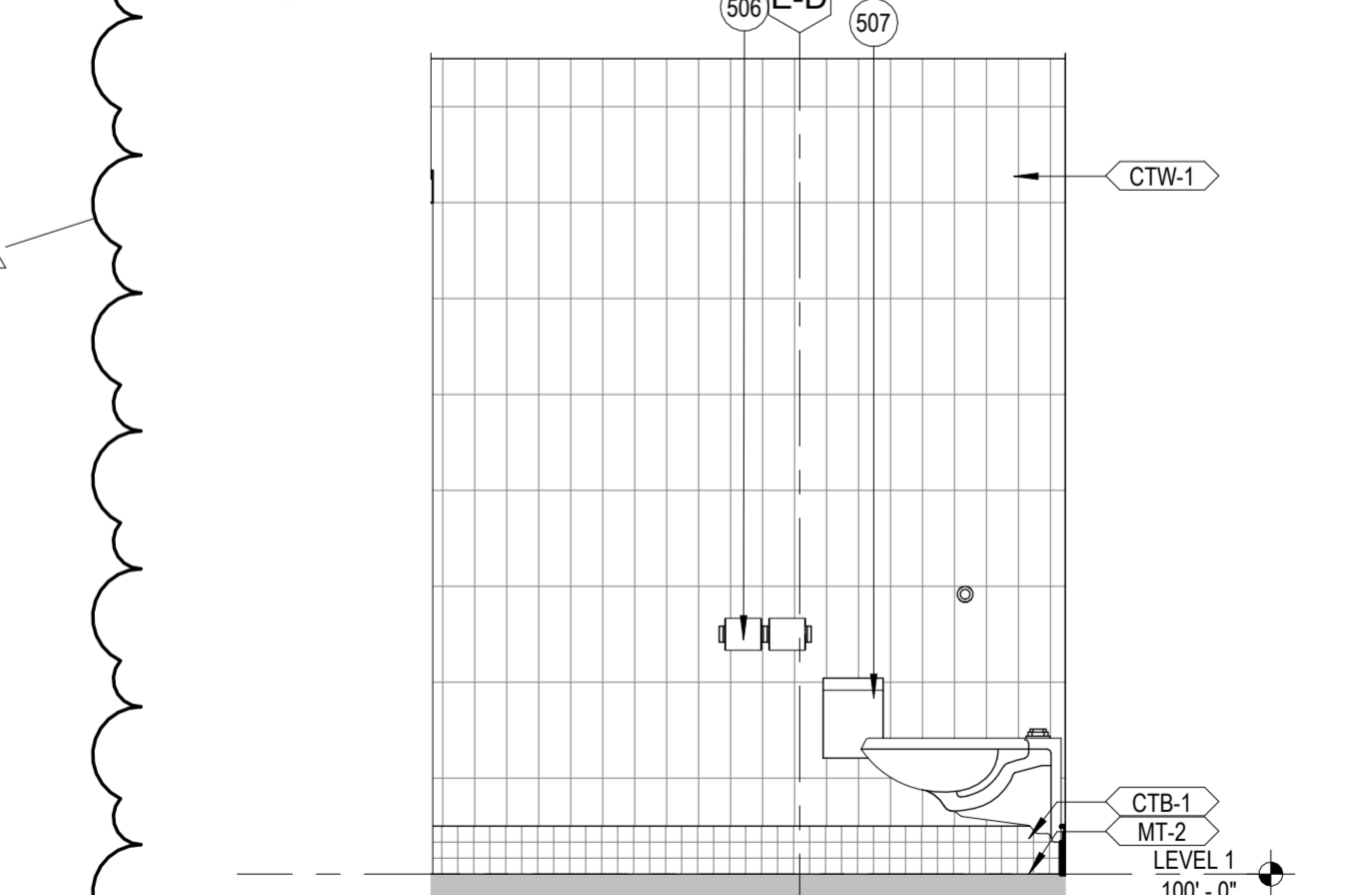
14 TOILET 184H - E WALL  
A411 1/2" = 1'-0"



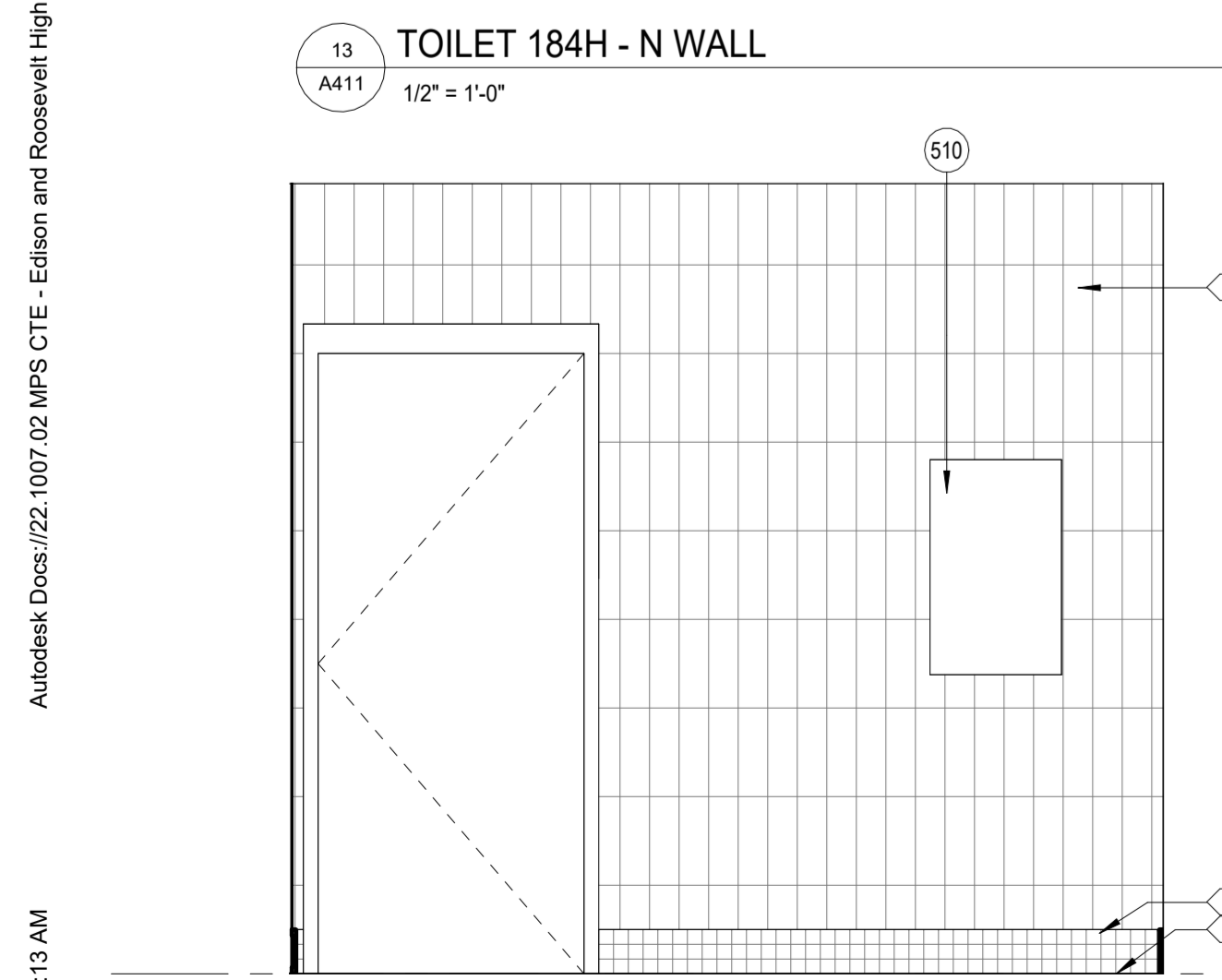
15 TOILET 184H - S WALL  
A411 1/2" = 1'-0"



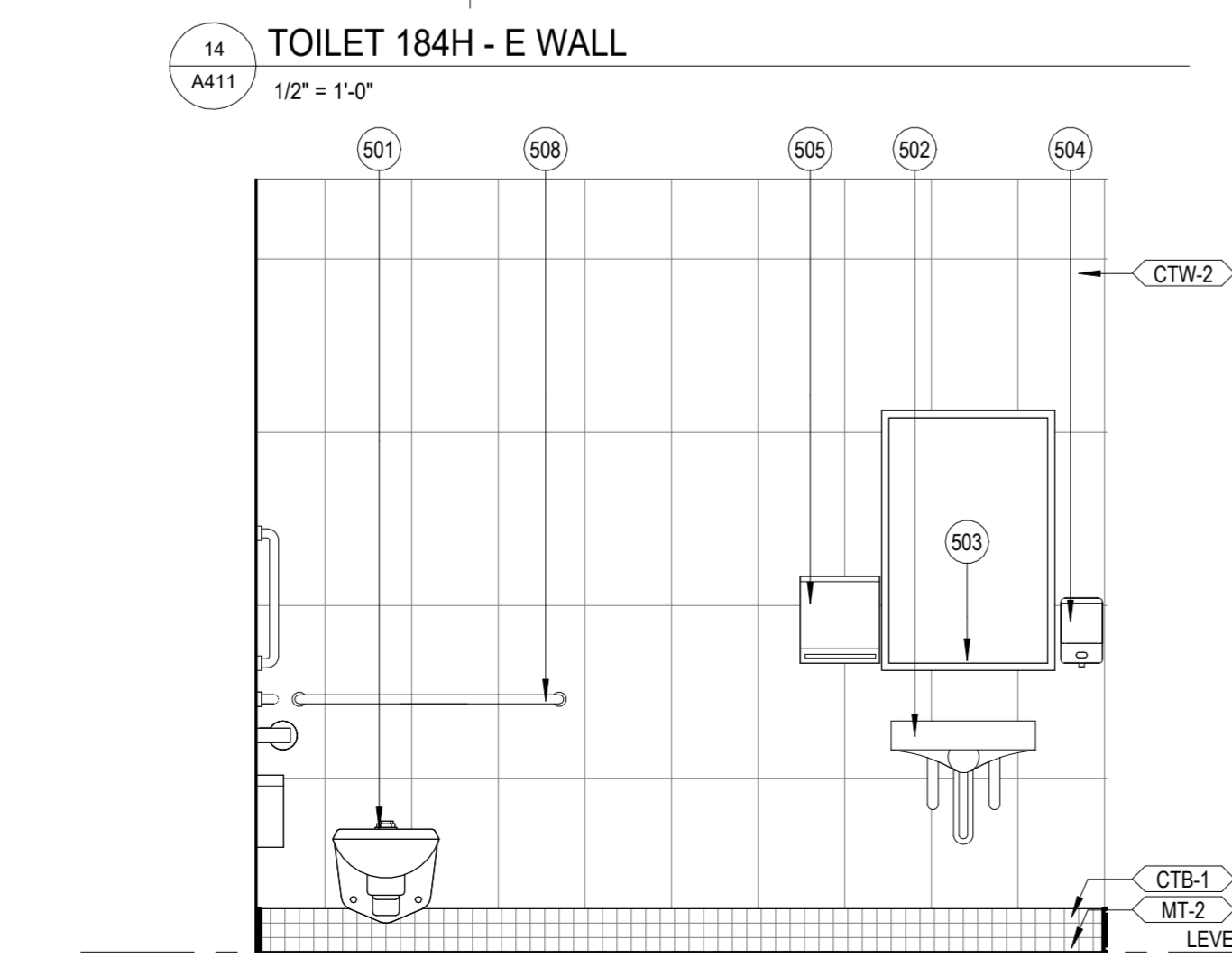
16 TOILET 184H - W WALL  
A411 1/2" = 1'-0"



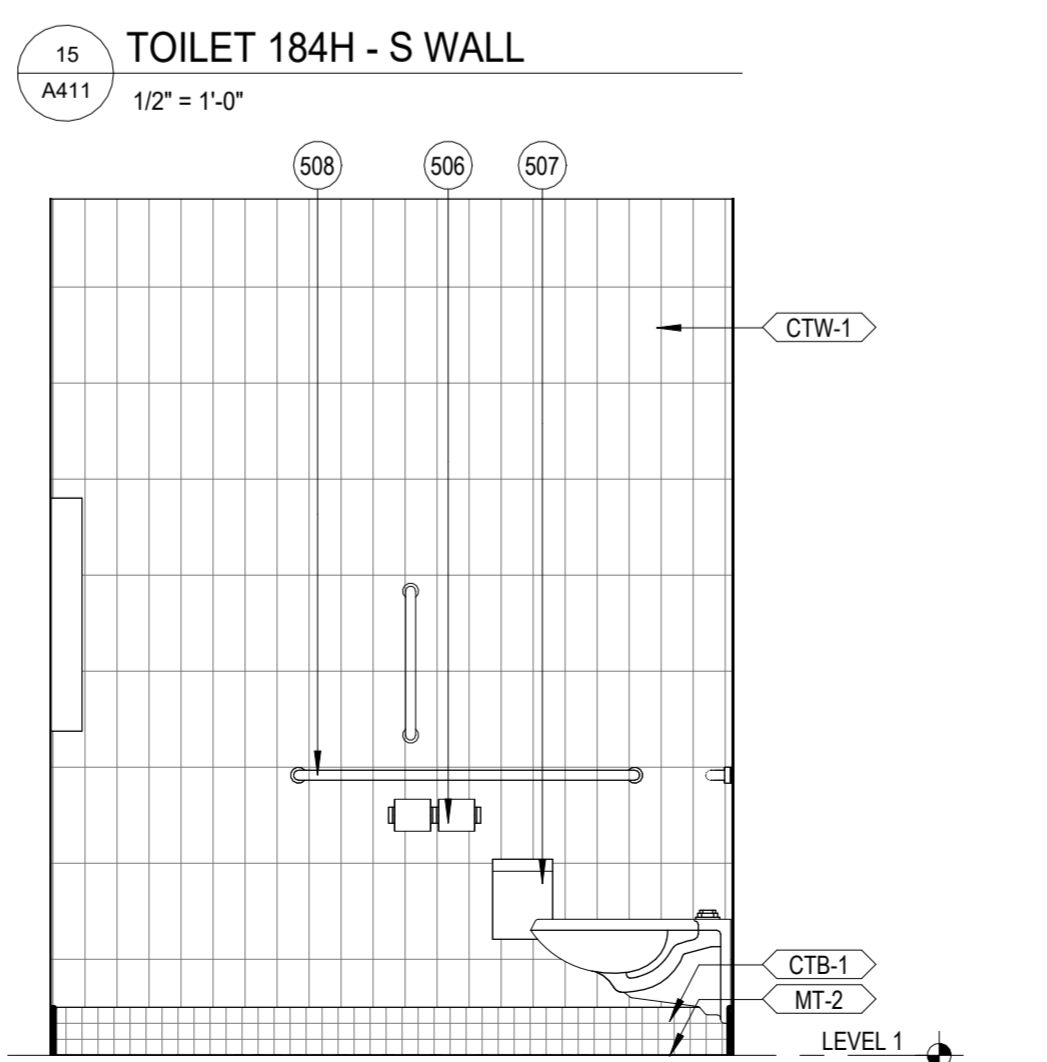
22 TOILET 190D - 190E - 190F - W WALL  
A411 1/2" = 1'-0"



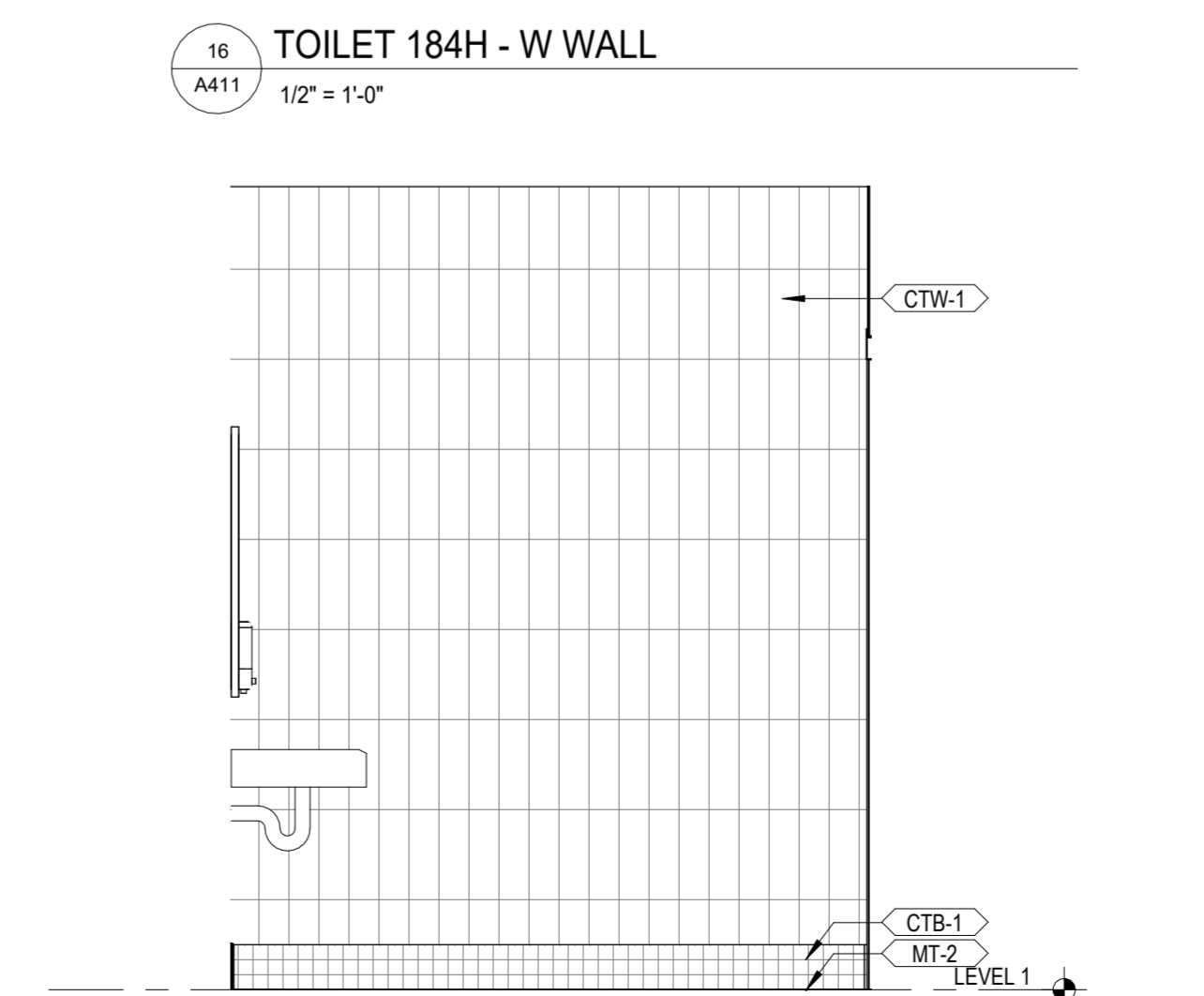
17 STAFF TOILET - SOUTH WALL  
A411 1/2" = 1'-0"



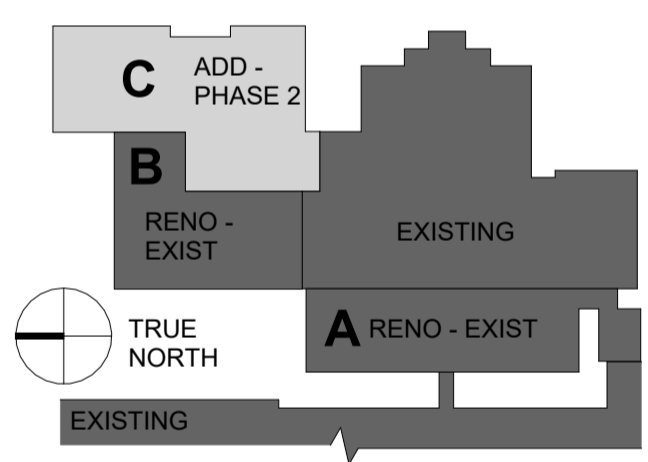
18 STAFF TOILET - NORTH WALL  
A411 1/2" = 1'-0"



19 STAFF TOILET - WEST WALL  
A411 1/2" = 1'-0"



20 STAFF TOILET - EAST WALL  
A411 1/2" = 1'-0"



Key Plan

No.	Date	Revision Description
	04.14.2026	BID SET
3	05.05.2026	ADD.#3

**BID SET**  
**TOILET ELEVATIONS**

KEYNOTE LEGEND	
Key Value	Keynote Text
501	WALL MOUNTED TOILET
502	WALL MOUNTED LAVATORY
503	WALL MOUNTED MIRROR
504	SOAP DISPENSER - BY OWNER, INSTALLED BY CONTRACTOR SEE TA-4
505	PAPER TOWEL DISPENSER - BY OWNER, INSTALLED BY CONTRACTOR SEE TA-3
506	TOILET PAPER DISPENSER - BY OWNER, INSTALLED BY CONTRACTOR
507	SANITARY NAPKIN DISPOSAL
508	GRAB BARS
510	SANITARY PRODUCTS DISPENSER
511	MULTI-STATION WASH FOUNTAIN

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## **ADDENDUM No. 3**

# **MPS Roosevelt High School CTE Center**

**4029 S. 28<sup>th</sup> Ave**  
**Minneapolis, MN 55406**

HEI Project Number: R23-4815.001

Hallberg Engineering  
1750 Commerce Court  
White Bear Lake, MN 55110

May 05, 2026

This Addendum forms a part of the Contract Documents and modifies the original Bidding Documents dated April 14, 2026.

Acknowledge receipt of this Addendum in the space provided on the Bid Form. Failure to do so may subject Bidder to disqualification.

This Addendum consists of Twelve (12) sheets and zero (0) specification sections. Reference made to the Project Manual and Drawings shall be used as a guide only. Bidders shall determine the work affected by Addendum items.

### **CHANGES TO THE MECHANICAL SPECIFICATIONS**

#### **1. 23 09 00 – BUILDING AUTOMATION SYSTEM**

- a. Delete issued specification section and replace with new section 23 09 00 included with this addendum.

### **CHANGES TO THE MECHANICAL DRAWINGS**

#### **2. MH111 – LEVEL 1 VENTILATION PLAN**

- b. Delete issued drawing and replace with new drawing MH111 included with this addendum.

#### **3. M502 –MECHANICAL DETAILS**

- c. Delete issued drawing and replace with new drawing M502 included with this addendum.

#### **4. M503 – MECHANICAL SCHEDULES**

- d. Delete issued drawing and replace with new drawing M503 included with this addendum.

**END OF ADDENDUM**

**SECTION 230900  
BUILDING AUTOMATION SYSTEM**

**PART 1 - GENERAL**

**1.01 MECHANICAL GENERAL PROVISIONS**

- A. This contractor shall conform to the General and Supplementary Conditions Provisions under Division 1 of the Specifications.
- B. This contractor shall conform to the Specifications Section 23 00 00: General Requirements.
- C. This contractor shall conform to Division 26 Specifications.

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. Products Supplied But Not Installed Under This Section:
  - 1. Control valves.
  - 2. Flow switches.
  - 3. Wells, sockets and other inline hardware for water sensors (temperature, pressure, flow).
  - 4. Automatic control dampers, where not supplied with equipment.
  - 5. Terminal unit controllers and actuators, when installed by terminal unit manufacturer.
  - 6. Variable Frequency Drives. (This does not include VFDs integral to machinery such as chillers or boilers)
- B. Products Installed But Not Supplied Under This Section: none
- C. Products Not Furnished or Installed But Integrated with the Work of This Section:
  - 1. Boiler Control Systems
  - 2. Smoke Detectors: through alarm relay contacts
  - 3. VFD's provided and installed by the electrical contractor
- D. Work Required Under Division 23 Related to This Section:
  - 1. Power wiring to line side of motor starters, disconnects or variable frequency drives.
  - 2. Provision and wiring of smoke detectors and other devices relating to fire alarm system.
  - 3. Campus LAN (Ethernet) connection adjacent to JACE network management controller.
  - 4. Campus LAN (Ethernet) connection adjacent to each LonWorks, BACnet or Modbus Open Protocol Integration Device

**1.03 SUMMARY**

- A. Scope: Furnish all labor, materials and equipment necessary for a complete and operating Building Automation System (BAS), utilizing Direct Digital Controls as shown on the drawings and as described herein. Drawings are diagrammatic only. All controllers furnished in this section shall communicate on a peer-to-peer bus over a single LonTalk open protocol bus.
  - 1. The intent of this specification is to provide a system that is consistent with BAS systems throughout the owner's facilities running the Niagara 4™ Framework.
  - 2. System architecture shall fully support a multi-vendor environment and be able to integrate third party systems via existing vendor protocols including, as a minimum, LonTalk, BACnet, and Modbus.
  - 3. System architecture shall provide secure Web access using any of the current versions of Microsoft Internet Explorer, Mozilla Firefox, or Google Chrome browsers from any computer on the owner's LAN.
  - 4. All control devices furnished with this Section shall be programmable directly from the Niagara 4™ Workbench embedded toolset upon completion of this project. The use of configurable or programmable controllers that require additional software tools for post-installation maintenance shall not be acceptable.
  - 5. Any control vendor that must provide additional BAS server software shall be unacceptable. Only systems that utilize the Honeywell WEBS-N4 software platform built on the Niagara 4™ Framework shall satisfy the requirements of this section.

6. The BAS server shall host all graphic files for the control system. All graphics and navigation schemes for this project shall match those that are on the existing campus Honeywell WEBs-N4 Supervisor.
  7. OPEN NIC STATEMENTS - All Honeywell WEBs-N4, Niagara 4™ software licenses shall have the following NiCS: "accept.station.in=\*"; "accept.station.out=\*" and "accept.wb.in=\*" and "accept.wb.out=\*". All open NIC statements shall follow WEBs-N4, Niagara 4™ Open NIC specifications.
  8. The district has a central server located in the district Server Room loaded with Honeywell WEBs-N4 Supervisor software, WEB-S-UNL-N4.
- B. Approved Manufacturers:
1. Honeywell WEBs-N4 (Contractor Must be Certified by Tridium as a Honeywell Niagara 4™ Framework Systems Integrator).
- C. Installation Contractor Requirements:
1. Prime contractor needs to be Honeywell ACI or BCS certified.
  2. Prime contractor needs to have completed a minimum of 5 Honeywell WEBs-N4, Niagara 4™ installations, with at least one of these installations having in excess of five (5) JACE controllers.
  3. Prime contractor needs to have the ability to provide 24/7 response in under 4 hours during the project by a Niagara 4™ certified technician.
  4. Prime contractor shall have in excess of four (4) Niagara 4™ certified staff members and be located within a 50 mile radius of Minneapolis.
- D. Pre-Approved Installation Contractors:
1. Harris Controls
  2. Minnesota Controls, Inc.
  3. Or MPS approved equal

**1.04 SUBMITTALS: BIDDER MUST UTILIZE MPS'S "PRIOR APPROVAL FORM" TO REQUEST CONSIDERATION PRIOR TO BID OPENING. SEE 00 21 13B INSTRUCTIONS TO BIDDERS - REQUEST FOR PRIOR APPROVAL FORM.**

- A. Submit documentation of contractor qualifications, including those indicated in paragraph 1.9 "Quality Assurance" if requested by the A-E.
- B. Two copies of shop drawings of the entire control system shall be submitted and shall consist of a complete list of equipment and materials, including manufacturers' catalog data sheets and installation instructions. Samples of written Controller Checkout Sheets and Performance Verification Procedures for applications similar in scope shall be included for approval.
- C. Shop drawings shall also contain complete wiring and schematic diagrams, sequences of operation, control system bus layout and any other details required to demonstrate that the system has been coordinated and will properly function as a system. Terminal identification for all control wiring shall be shown on the shop drawings.
- D. Upon completion of the work, provide one complete printed set of 'as-built' drawings and other project-specific documentation to MPS. Provide a printed copy of 'as-built' control shop drawings for all Level 1 control cabinets. Provide an electronic copy of all 'as built' drawings to MPS.
- E. Any deviations from these specifications or the work indicated on the drawings shall be clearly identified in the Submittals.

**1.05 AGENCY AND CODE APPROVALS**

- A. All products of the BAS shall be provided with the following agency approvals. Verification that the approvals exist for all submitted products shall be provided on request, with the submittal package. Systems or products not currently offering the following approvals are not acceptable.
  1. Federal Communications Commission (FCC), Rules and Regulations, Volume II -July 1986 Part 15 Class A Radio Frequency Devices

2. FCC, Part 15, Subpart B, Class B
3. FCC, Part 15, Subpart C
4. FCC, Part 15, Subpart J, Class A Computing Devices
5. UL 504 - Industrial Control Equipment
6. UL 506 - Specialty Transformers
7. UL 910 - Test Method for Fire and Smoke Characteristics of Electrical and Optical-Fiber Cables Used in Air-Handling Spaces
8. UL 916 - Energy Management Systems All
9. UL 1449 - Transient Voltage Suppression
10. Standard Test for Flame Propagation Height of Electrical and Optical - Fiber Cables Installed Vertically in Shafts
11. EIA/ANSI 232-E - Interface Between Data Technical Equipment and Data Circuit Terminal Equipment Employing Serial Binary Data Interchange
12. EIA 455 - Standard Test Procedures for Fiber Optic Fibers, Cables, Transducers, Connecting and Terminating Devices
13. IEEE C62.41- Surge Voltages in Low-Voltage AC Power Circuits
14. IEEE 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems
  - a. NEMA 250 - Enclosures for Electrical Equipment
15. NEMA ICS 1 - Industrial Controls and Systems
16. NEMA ST 1 - Specialty Transformers
17. NCSBC Compliance, Energy: Performance of control system shall meet or surpass the requirements of ASHRAE/IESNA 90.1 (Most Current Edition).
18. CE 61326
19. C-Tick
20. cUL

#### **1.06 SOFTWARE OWNERSHIP**

- A. The Owner shall have full ownership and full access rights for all network management, operating system server, engineering and programming software required for the ongoing maintenance and operation of the BAS.

#### **1.07 DELIVERY, STORAGE AND HANDLING**

- A. Maintain integrity of shipping cartons for each piece of equipment and control device through shipping, storage, and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

#### **1.08 JOB CONDITIONS**

- A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to insure that the Work will be carried out in an orderly fashion. It shall be this Contractor's responsibility to check the Contract Documents for possible conflicts between his Work and that of other crafts in equipment location, pipe, duct and conduit runs, electrical outlets and fixtures, air diffusers, and structural and architectural features.
- B. Contractor shall provide sufficient access, hardware, software, and programming for TAB contractor and Commissioning contractor to fulfill their services in a timely manner. At no added expense to parties involved.

#### **1.09 QUALITY ASSURANCE**

- A. The manufacturer of the BAS digital controllers shall, if requested, provide documentation supporting compliance with ISO-9001 (Model for Quality Assurance in Design/Development, Production, Installation and Servicing).
- B. The Control System Contractor shall have a full service DDC office within 50 miles of the job site. This office shall be staffed with applications engineers, software engineers and field technicians. This office shall maintain parts inventory and shall have all testing and diagnostic equipment necessary to support this Work, as well as staff trained in the use of this equipment.

- C. Single Source Responsibility of Supplier: The Control System Contractor shall be responsible for the complete installation and proper operation of the control system. The Control System Contractor shall exclusively be in the regular and customary business of design, installation and service of computerized building management systems similar in size and complexity to the system specified. The Control System Contractor shall be the manufacturer of the primary DDC system components or shall have been the authorized representative for the primary DDC components manufacturer for at least 5 years. All control panels shall be assembled by the Control System Contractor in accordance with UL-Certified 508A.
- D. Equipment and Materials: Equipment and materials shall be cataloged products of manufacturers regularly engaged in the production and installation of HVAC control systems. Products shall be manufacturer's latest standard design and have been tested and proven in actual use.
- E. Please note - Commissioning System Consultant will coordinate and review commissioning requirements with MPS. Intent of System Commissioning is to assure delivery to the Owner of systems which are fully functioning in accordance with all specifications and which the Owner's personnel are fully trained and equipped to operate, maintain and troubleshoot. The Contractor shall execute the Commissioning Program that delivers the intended results of a System Commissioning, using whatever personnel, time, and resources are required. Final test on all equipment to be made in the presence of engineer and owner.

**1.10 SPECIFICATION NOMENCLATURE - ACRONYMS USED IN THIS SPECIFICATION ARE AS FOLLOWS:**

- A. Actuator: Control device that opens or closes valve or damper in response to control signal.
- B. AI: Analog Input
- C. AO: Analog Output
- D. Analog: Continuously variable state over stated range of values
- E. BAS: Building Automation System
- F. DDC: Direct Digital Control
- G. Discrete: Binary or digital state
- H. DI: Discrete Input
- I. DO: Discrete Output
- J. FC: Fail Closed position of control device or actuator. Device moves to closed position on loss of control signal or energy source.
- K. FO: Fail open (position of control device or actuator). Device moves to open  
1. position on loss of control signal or energy source.
- L. GUI: Graphical User Interface
- M. HVAC: Heating, Ventilating and Air Conditioning
- N. IDC: Interoperable Digital Controller
- O. ILC: Interoperable Lon Controller
- P. LAN: Local Area Network
- Q. Modulating Movement of a control device through an entire range of values, proportional to an infinitely variable input value.
- R. Motorized Control device with actuator
- S. NAC: Network Area Controller
- T. NC: Normally closed position of switch after control signal is removed or normally closed position of manually operated valves or dampers.

- U. NO: Normally open position of switch after control signal is removed; or the open position of a controlled valve or damper after the control signal is removed; or the usual position of a manually operated valve.
- V. OSS: Operating System Server, host for system graphics, alarms, trends, etc.
- W. Operator: Same as actuator
- X. PC: Personal Computer
- Y. Peer to Peer: Mode of communication between controllers in which each device connected to network has equal status and each shares its database values with all other devices connected to network
- Z. P: Proportional control; control mode with continuous linear relationship between observed input signal and final controlled output element.
- AA. PI: Proportional-Integral control, control mode with continuous proportional output plus additional change in output based on both amount and duration of change in controller variable (reset control).
- BB. PICS: BACnet Product Interoperability Compliance Statement
- CC. PID: Proportional-Integral-Derivative control, control mode with continuous correction of final controller output element versus input signal based on proportional error, its time history (reset) and rate at which it's changing (derivative).
- DD. Point: Analog or discrete instrument with addressable database value
- EE. WAN: Wide Area Network

## **PART 2 - MATERIALS**

### **2.01 GENERAL**

- A. The Building Automation System (BAS) shall be comprised of a network of interoperable, stand-alone digital controllers, a network area controller, graphics and programming, and other control devices for a complete system as specified herein.
- B. The installed system shall provide secure password access to all features, functions and data contained in the overall BAS.

### **2.02 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURE**

- A. The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system utilizing the LonWorks technology communication protocol in one open, interoperable system.
- B. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. Physical connection of any BACnet® or LonWorks® or Modbus® control equipment, such as chillers, VFD's, Boilers, Computer Room Air Conditioning Units, Variable Refrigerant Flow Units, Main Electrical Distribution Panels, shall be via Ethernet.
- C. All air handlers, even if packaged controls exist, shall be fitted with District standard level 1 or level 2 controllers. Existing packaged controls may be used to control DX compressor(s) only.
- D. The supplied system must incorporate the ability to access all data web enabled browsers without requiring plug-ins or proprietary operator interface and configuration programs. An Open Database Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on the existing Operating System Server currently located in the Facilities Office on the LAN. Systems requiring proprietary database and user interface programs shall not be acceptable.
- E. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network. Systems employing a "flat" single tiered architecture shall not be acceptable.

1. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.
  2. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.
- F. Level 1 controllers shall provide overall system coordination, accept control programs, perform automated DDC and energy management functions, control peripheral devices, and perform all necessary mathematical functions.
1. Level 1 controllers shall permit multi-user operation from workstations and laptop computers connected either locally or over the Level 1 network.
  2. Level 1 controllers shall be housed in a locking enclosure. The enclosure will include knockouts on all sides of the cabinet for connection to field and power wiring.
  3. The 120VAC power wiring to each Level 1 controller shall be a dedicated run with a separate breaker. Each run will include a separate hot, neutral, and ground wire. The ground wire will terminate at the breaker panel ground. This circuit will not feed any other circuit or device. Multiple Level 1 controllers in the same cabinet may utilize the same circuit.
  4. All level 1 controllers shall have a dedicated battery backup in a separate enclosure. Pre-approved product is Altronix eFlow3N with substitutions upon approval.
- G. Level 2 controllers shall provide intelligent stand-alone control of HVAC. Each unit shall have its own internal RAM memory and will continue to operate all local control functions in the event of a failure to any Level 1 controller. In addition, it shall be able to share information with and from the entire network for full global control.
- H. Level 1 controllers shall be JACE 8000-O JACE Controllers with a minimum of:
1. WEB-8000 Base unit includes two RS485 ports, two 10/100MB Ethernet ports, USB Backup & Restore and WiFi.
  2. Required Selections of Device/Point Core (NC-8005, NC-8010, NC-8025, NC-8100 or NC-8200) and Upgrade Device/Point Packs (DEVICE-10, DEVICE-25 or DEVICE-50) as required to support all connected Level 2 controllers.
  3. Software Maintenance Agreement (SMA) to provide five (5) years of coverage for all software updates, patches and revision upgrades based on Device/Point quantity. (SMA-8005-5YR, SMA-8010-5YR, SMA-8025-5YR, SMA-80100-5YR or SMA-8200-5YR)
  4. If LonWorks devices are to be connected, include one (1) NPB-8000-LON add on single port LON FTT10A module to support a maximum of fifty (50) LonWorks devices per wired communication bus segment. Provide additional modules as required.
- I. Each site will have a minimum of one Level 1 controller. All Level 1 controllers shall be commissioned with the version to match the current version of Honeywell WEBs-N4 Supervisor.

### **2.03 SYSTEM NETWORK CONTROLLER (SNC)**

- A. Level One - These controllers are designed to manage communications between the programmable equipment controllers (PEC), application specific controllers (ASC), and advanced unitary controllers (AUC) which are connected to its communications trunks, manage communications between itself and other system network controllers (SNC) and with any operator workstations (OWS) that are part of the BAS, and perform control and operating strategies for the system based on information from any controller connected to the BAS.
- B. The controllers must be fully programmable to meet the unique requirements of the facility it must control.
- C. The controllers must be capable of peer-to-peer communications with other SNC's and with any OWS connected to the BAS, whether the OWS is directly connected, connected via modem or connected via the Internet.

- D. The communication protocols utilized for peer-to-peer communications between SNC's shall be FOX, Tridiums TCP/IP based protocol included with Niagara 4 Framework. Use of any other proprietary communication protocol for peer-to-peer communications between SNC's is not allowed.
- E. The SNC shall be capable of executing application control programs to provide:
  - 1. Calendar functions
  - 2. Scheduling
  - 3. Trending
  - 4. Alarm monitoring and routing
  - 5. Time synchronization
  - 6. Integration of LonWorks, BACnet, and ModBus controller data
  - 7. Network management functions for all SNC, PEC and ASC based devices
- F. The SNC must provide the following hardware features as a minimum:
  - 1. Two Ethernet Port-10/100 Mbps
  - 2. Two isolated RS-485 port
  - 3. Capability to add LonWorks Interface Port - 78KB FTT-10A if required
  - 4. 1GB DDR3 SDRAM
  - 5. Integrated 24VAC/DC Global Power Supply
  - 6. 4GB Flash Total Storage / 2GB User Storage
  - 7. WiFi (client or WAP)
- G. The SNC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 16 simultaneous users.
- H. The SNC shall provide alarm recognition, storage, routing, management and analysis to supplement distributed capabilities of equipment or application specific controllers.
- I. The SNC shall be able to route any alarm condition to any defined user location whether connected to a local network, or wide-area network.
  - 1. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but not limited to:
    - a. Alarm,
    - b. Return to normal,
    - c. To default.
  - 2. Alarms shall be annunciated in any of the following manners as defined by the user:
    - a. Screen message text,
    - b. Email of complete alarm message to multiple recipients.
    - c. Pagers via paging services that initiate a page on receipt of email message.
    - d. Graphics with flashing alarm object(s).
  - 3. The following shall be recorded by the SNC for each alarm (at a minimum):
    - a. Time and date
    - b. Equipment (air handler #, accessway, etc.)
    - c. Acknowledge time, date, and user who issued acknowledgement.
- J. Programming software and all controllers "Setup Wizards" shall be embedded into the SNC.
- K. Level 2 controllers prequalified are:
  - 1. Spyder Syk Enhanced
  - 2. Spyder Micro
- L. Level 2 controllers shall provide stand-alone control of HVAC control. Each controller shall have its own control programs and will continue to operate in the event of a failure to its associated Level 1 controller.
- M. Each piece of HVAC equipment will have its points and programs contained in a single Level 2 controller. Equipment programming may not extend across multiple controllers. Level 1 controllers may be used in lieu of Level 2 controllers.

- N. Each Level 2 controller shall be able to have its program edited and/or modified either locally through a laptop computer or through a workstation connected to a Level 1 controller. Each Level 2 controller shall complete its internal scan in less than one second. Each scan shall consist of updating of inputs, importing of data from other controllers, performing mathematical calculations, and sequencing appropriate outputs for local loop control.
- O. POWER SUPPLY:
  - 1. The Level 2 controller shall have a built-in supply operating at 24 VAC 50/60 Hz with an accuracy of  $\pm 20\%$ .
  - 2. Power supplies should have a built in breaker to protect transformers.
  - 3. When using power supplies sharing 24Vac to power level 2 controllers power supplies should be labeled to what they serve.
  - 4. The 120VAC power wiring to Level 2 controllers shall be a dedicated run, with a separate breaker. Each run will include a separate hot, neutral, and ground wire. The ground wire will terminate at the breaker panel ground. This circuit will not feed any other circuit or device.
  - 5. A true earth ground must be available in the building. Do not use a corroded or galvanized pipe, or structural steel.
- P. Level 2 controllers shall be housed in a panel mounted enclosure. The enclosure will include a removable cover for access to field and power wiring.

#### **2.04 PROGRAMMABLE EQUIPMENT CONTROLLER (PEC)**

- A. Level Two - HVAC control shall be accomplished using LonMark based devices where the application has a LonMark profile defined. Where LonMark devices are not available for a particular application, devices based on LonWorks shall be acceptable. For each LonWorks device that does not have LonMark certification, the device supplier must provide an XIF file for the device. The controller platform shall provide options and advanced system functions, programmable and configurable using the Honeywell WEBs-N4 software platform built on the Niagara 4™ Framework, that allow standard and customizable control solutions required in executing the "Sequence of Operation". Spyder Independent License Controller (ILC) option is not required.
- B. All PECs shall be application programmable and shall at all times maintain their LonMark certification. All control sequences within or programmed into the ILC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained.
- C. The PECs shall communicate with the SNC at a baud rate of not less than 78.8K baud. The PEC shall provide LED indication of communication and controller performance to the technician, without cover removal.
- D. The following integral and remote Inputs/Outputs shall be supported per each PEC:
  - 1. Eight integral dry contact digital inputs.
  - 2. Any two digital inputs may be configured as pulse counters with a maximum pulse read rate of 15 Hz.
  - 3. Eight integral analog inputs (configurable as 0-10V, 0-10,000 ohm or, 20K NTC).
  - 4. Six integral 4-20 ma analog outputs.
  - 5. Eight integral 24 Vac Triac digital outputs, configurable as maintained or floating motor control outputs.
  - 6. One integral 20 Vdc, 65-mA power supply for auxiliary devices.
  - 7. If a 20 Vdc 65-mA power supply terminal is not integral to the ILC, provide at each PEC a separate, fully isolated, enclosed, current limited and regulated UL listed auxiliary power supply for power to auxiliary devices
- E. Each PEC shall have expansion ability to support additional I/O requirements through the use of remote input/output modules
- F. PEC Controllers shall support the following control techniques:
  - 1. Ten configurable general-purpose control loops that can incorporate Demand Limit Control strategies, Setpoint reset, adaptive intelligent recovery, and time of day bypass.

2. Ten general-purpose, non-linear control loops.
3. Eight start/stop Loops.
4. Thirty-two If/Then/Else logic loops.
5. Thirty six Math Function loops (MIN, MAX, AVG, SUM, SUB, SQRT, MUL, DIV, ENTHALPY).

## 2.05 ADVANCED UNITARY CONTROLLER

- A. Level Two - The advanced unitary controller (AUC) platform shall be designed specifically to control HVAC - ventilation, filtration, heating, cooling, humidification, and distribution. Equipment includes: constant volume air handlers, VAV air handlers, packaged RTU, heat pumps, unit vents, fan coils, natural convection units, and radiant panels. The controller platform shall provide options and advanced system functions, programmable and configurable using the Honeywell WEBs-N4 software platform built on the Niagara 4™ Framework, that allow standard and customizable control solutions required in executing the "Sequence of Operation". Spyder Independent License Controller (ILC) option is not required.
- B. Minimum Requirements:
  1. The controller shall be fully programmable with full functionality on Honeywell WEBs-N4 software platform built on the Niagara 4 Framework.
    - a. Support downloads and uploads using WEBs-N4 Supervisor or WEBs-N4 Supervisor Workbench via WEB-8000 JACE controller connected to TCP/IP network.
    - b. Support online and offline simulation/debug mode of the controller.
    - c. Maintain native GUI.
    - d. Native function-block programming within the Niagara 4 environment.
  2. The controller shall be capable of either integrating with other devices or stand-alone operation.
  3. The controller shall have two microprocessors. The Host processor contains on-chip FLASH program memory, FLASH information memory, and RAM to run the main HVAC application. The second processor for network communications. Controller memory minimum requirements include:
    - a. FLASH Memory Capacity: 60 Kilobytes with 8 Kilobytes for application program.
    - b. FLASH Memory settings retained for ten years.
    - c. RAM: 2 Kilobytes
  4. The controller shall have an FTT transformer-coupled communications port interface for common mode-noise rejection and DC isolation.
  5. The controller shall have an internal time clock with the ability to automatically revert from a master time clock on failure.
    - a. Operating Range: 24 hour, 365 day, multi-year calendar including day of week and configuration for automatic day-light savings time adjustment to occur on configured start and stop dates.
    - b. Accuracy: ±1 minute per month at 77° F (25° C).
    - c. Power Failure Backup: 24 hours at 32° to 122° F (0° to 50° C).
  6. The controller shall have Significant Event Notification, Periodic Update capability, and Failure Detect when network inputs fail to be detected within their configurable time frame.
  7. The controller shall have an internal DC power supply to power external sensors.
    - a. Power Output: 20 VDC ±10% at 75 mA.
  8. The controller shall have a visual indication (LED) of the status of the device:
    - a. Controller operating normally.
    - b. Controller in process of download.
    - c. Controller in manual mode under control of software tool.
    - d. Controller lost its configuration.
    - e. No power to controller, low voltage, or controller damage.
    - f. Processor and/or controller are not operating.
  9. The minimum controller Environmental ratings
    - a. Operating Temperature Ambient Rating: -40° to 150° F (-40° to 65.5° C).

- b. Storage Temperature Ambient Rating: -40° to 150° F (-40° to 65.5° C).
  - c. Relative Humidity: 5% to 95% non-condensing.
10. The controller shall have the additional approval requirements, listings, and approvals:
    - a. UL/cUL (E87741) listed under UL916 (Standard for Open Energy Management Equipment) with plenum rating.
    - b. CSA (LR95329-3) Listed
    - c. Meets FCC Part 15, Subpart B, Class B (radiated emissions) requirements.
    - d. Meets Canadian standard C108.8 (radiated emissions).
    - e. Conforms requirements European Consortium standard EN 61000-6-1; 2001 (EU Immunity)
    - f. Conforms requirements European Consortium standard EN 61000-6-3; 2001 (EU Emission)
  11. The controller housing shall be UL plenum rated mounting to either a panel or DIN rail (standard EN50022; 7.5mm x 35mm).
  12. The controller shall have a mix of digital inputs (DI), digital Triac outputs (DO), analog outputs (AO), and universal inputs (UI).
    - a. Analog outputs (AO) shall be capable of being configured as digital outputs (DO)
    - b. Input and Output wiring terminal strips shall be removable from the controller without disconnecting wiring.
    - c. Input and Output wiring terminals shall be designated with color coded labels.
    - d. Universal inputs shall be capable of being configured as binary inputs, resistive inputs, voltage inputs (0-10 VDC), or current inputs (4-20 mA)
  13. The controller shall provide for “user defined” Network Variables (NV) for customized configurations and naming using Niagara 4™ Framework.
    - a. The controller shall support 62 Network Variables with a byte count of 31 per variable.
    - b. The controller shall support 1,922 separate data values.
  14. The controller shall be capable of continuous automated loop tuning with an Adaptive Integral Algorithm Control Loop.
  15. Timed local override switches should be installed on air handlers which may be needed to run occasionally after hours.
  16. The controller platform shall have standard HVAC application programs that are modifiable to support both the traditional and specialized “sequence of operations” as outlined in Section 4.
    - a. Discharge air control and low limit
    - b. Pressure-dependent dual duct without flow mixing.
    - c. Variable air volume with return flow tracking.
    - d. Economizer with differential enthalpy.
    - e. Minimum airflow coordinated with CO2.
    - f. Unit ventilator cycle (1,2,3) 2-pipe.
    - g. Unit ventilator cycle (1,2,3) 2-pipe with face/bypass.
    - h. Unit ventilator cycle (1,2,3) 4-pipe.
    - i. Unit ventilator cycle (1,2,3) 4-pipe with EOC valve.

## **2.06 ADVANCED VARIABLE AIR VOLUME CONTROLLER**

- A. Level Two - The advanced VAV controller platform shall be designed specifically for room-level VAV control - pressure-independent air flow control, pressure dependent damper control, supply and exhaust pressurization/de-pressurization control; temperature, humidity, complex CO<sub>2</sub>, occupancy, and emergency control. Equipment includes: VAV terminal unit, VAV terminal unit with reheat, Series fan powered terminal unit, Parallel fan powered terminal unit, Supply and Exhaust air volume terminals, and Constant volume dual-duct terminal unit. The controller platform shall provide options and advanced system functions, programmable and configurable using the Honeywell WEBs-N4 software platform built on the Niagara 4™ Framework, that allow standard and customizable control solutions required in executing the "Sequence of Operation". Spyder Independent License Controller (ILC) option is not required.
- B. Minimum Requirements:
1. The controller shall be fully programmable with full functionality on Honeywell WEBs-N4 software platform built on the Niagara 4 Framework.
    - a. Support downloads and uploads using WEBs-N4 Supervisor or WEBs-N4 Supervisor Workbench via WEB-8000 JACE controller connected to TCP/IP network.
    - b. Support online and offline simulation/debug mode of the controller.
    - c. Maintain native GUI.
    - d. Native function-block programming within the Niagara 4 environment.
  2. The controller shall be capable of either integrating with other devices or stand-alone room-level control operation.
  3. The controller shall have an internal velocity pressure sensor.
    - a. Sensor Type: Microbridge air flow sensor with dual integral restrictors.
    - b. Operating Range: 0 to 1.5 in. H<sub>2</sub>O (0 to 374 Pa).
    - c. Accuracy: ±2% of full scale at 32° to 122° F (0° to 50° C); ±1% of full scale at null pressure.
  4. The controller shall have two microprocessors. The Host processor contains on-chip FLASH program memory, FLASH information memory, and RAM to run the main HVAC application. The second processor for network communications.
    - a. FLASH Memory Capacity: 60 Kilobytes with 8 Kilobytes for application program.
    - b. FLASH Memory settings retained for ten years.
    - c. RAM: 2 Kilobytes
  5. The controller shall have an FTT transformer-coupled communications port interface for common mode-noise rejection and DC isolation.
  6. The controller shall have an internal time clock with the ability to automatically revert from a master time clock on failure.
    - a. Operating Range: 24 hour, 365 day, multi-year calendar including day of week and configuration for automatic day-light savings time adjustment to occur on configured start and stop dates.
    - b. Accuracy: ±1 minute per month at 77° F (25° C).
    - c. Power Failure Backup: 24 hours at 32° to 122° F (0° to 50° C).
  7. The controller shall have Significant Event Notification, Periodic Update capability, and Failure Detect when network inputs fail to be detected within their configurable time frame.
  8. The controller shall have an internal DC power supply to power external sensors.
    - a. Power Output: 20 VDC ±10% at 75 mA.
  9. The controller shall have a visual indication (LED) of the status of the device:
    - a. Controller operating normally.
    - b. Controller in process of download.
    - c. Controller in manual mode under control of software tool.
    - d. Controller lost its configuration.
    - e. No power to controller, low voltage, or controller damage.
    - f. Processor and/or controller are not operating.
  10. The minimum controller Environmental ratings:
    - a. Operating Temperature Ambient Rating: 32° to 122° F (0° to 50° C).

- b. Storage Temperature Ambient Rating: 32° to 122° F (0° to 50° C).
  - c. Relative Humidity: 5% to 95% non-condensing.
11. The controller shall have the additional approval requirements, listings, and approvals:
    - a. UL/cUL (E87741) listed under UL916 (Standard for Open Energy Management Equipment) with plenum rating.
    - b. CSA (LR95329-3) Listed
    - c. Meets FCC Part 15, Subpart B, Class B (radiated emissions) requirements.
    - d. Meets Canadian standard C108.8 (radiated emissions).
    - e. Conforms requirements European Consortium standard EN 61000-6-1; 2001 (EU Immunity)
    - f. Conforms requirements European Consortium standard EN 61000-6-3; 2001 (EU Emission)
  12. The controller housing shall be UL plenum rated mounting to either a panel or DIN rail (standard EN50022; 7.5mm x 35mm).
  13. The controller shall provide an integrated actuator option.
    - a. Actuator type: Series 60 Floating.
    - b. Rotation stroke: 95° ±3° for CW or CCW opening dampers.
    - c. Torque rating: 44 lb-in. (5 Nm).
    - d. Run time for 90° rotation: 90 seconds at 60 Hz.
  14. The controller shall have four digital inputs (DI), eight digital Triac outputs (DO) or six digital Triac outputs (DO) with Integrated Actuator, three analog outputs (AO), and six universal inputs (UI).
    - a. Analog outputs (AO) shall be capable of being configured as digital outputs (DO).
    - b. Input and Output wiring terminal strips shall be removable from the controller without disconnecting wiring.
    - c. Input and Output wiring terminals shall be designated with color coded labels.
  15. The controller shall provide for user defined Network Variables (NV) for customized configurations and naming using Niagara 4™ Framework.
    - a. The controller shall support a range of Network Variables to 62 with a byte count of 31 per variable.
    - b. The controller shall support 1,922 separate data values.
  16. The controller shall be capable of continuous automated loop tuning with an Adaptive Integral Algorithm Control Loop.
  17. The controller shall have a loop execution response time of 1 second.
  18. The controller platform shall have standard HVAC application programs that are modifiable to support both the traditional and specialized “sequence of operations” as outlined in Section 4.
    - a. VAV terminal unit.
    - b. VAV terminal unit fan speed control.
    - c. Series fan.
    - d. Parallel fan.
    - e. Regulated air volume (room pressurization/de-pressurization).
    - f. CV dual-duct
    - g. Room CO2 control
    - h. Room Humidity
    - i. TOD occupancy sensor stand-by setpoints

## 2.07 OTHER CONTROL SYSTEM HARDWARE

- A. Motorized control dampers that will not be integral to the equipment shall be furnished by the Control System Contractor. Control damper frames shall be constructed of galvanized steel, formed into channels and welded or riveted. Dampers shall be galvanized, with nylon bearings. Blade edge seals shall be vinyl. Blade edge and tip seals shall be included for all dampers. Blades shall be 16-gauge minimum and 6 inches wide maximum and frame shall be of welded channel iron. Damper leakage shall not exceed 10 CFM per square foot, at 1.5-inches water gauge static pressure.
1. Where pneumatic controls are present, copper tubing shall be used to all smoke damper EP's.
  2. Combustion air damper motors (pneumatic style) shall not be located in cold air stream.
  3. Combustion air damper motors (electric style) shall be two position direct mount fast acting type with a full stroke time no greater than 20 seconds.
- B. Control damper actuators shall be Belimo - furnished by the Control System Contractor. Two-position or proportional electric actuators shall be direct-mount type sized to provide a minimum of 5 in-lb torque per square foot of damper area. Damper actuators shall be spring return type. Operators shall be heavy-duty electronic type for positioning automatic dampers in response to a control signal. Motor shall be of sufficient size to operate damper positively and smoothly to obtain correct sequence as indicated. All applications requiring proportional operation shall utilize truly proportional electric actuators.
- C. VAV Reheat, FTR, CUH, system bypass, etc. Control Valves: Control valves shall be 2-way or 3-way pattern as shown and constructed for tight shutoff at the pump shut-off head or steam relief valve pressure. Control valves shall operate satisfactorily against system pressures and differentials. Two-position valves shall be 'line' size. Proportional control valves shall be sized for a maximum pressure drop of 5.0 psi at rated flow (unless otherwise noted or scheduled on the drawings). Valves with sizes up to and including 2 inches shall be "screwed" configuration and 2-1/2 inch and larger valves shall be "flanged" configuration. All control valves, including terminal unit valves, less than 2 inch shall be ball valves. Electrically-actuated control valves shall include spring return type actuators sized for tight shut-off against system pressures (as specified above) and, when specified, shall be furnished with integral switches for indication of valve position (open-closed). Pneumatic actuators for valves, when utilized, shall be sized for tight shut-off against system pressures (as specified above).
- D. AHU Heating and Chilled Water Control Valves: Valves shall be 2-way pressure independent and constructed for tight shutoff at the pump shut-off head. Control valves shall operate satisfactorily against system pressures and differentials. Valves with sizes up to and including 2 inches shall be "screwed" configuration and 2-1/2 inch and larger valves shall be "flanged" configuration. Valves shall be permanently tagged and have test ports.
1. Manufacturer: Delta P, Belimo, or MPS approved equal.
- E. Control Valve Actuators:
1. All actuators shall have inherent current limiting motor protection.
  2. Valve actuators shall be 24-volt, electronic type, modulating or two-position as required for the correct operating sequence.
  3. Modulating valves shall be positive positioning in response to the signal.
  4. All valve actuators shall be UL listed.
  5. All control valves 2 1/2" or larger shall have position indication.
  6. All perimeter radiation and AHU/RTU hot water control valves shall be Normally-Open arrangement with spring-return operation for fail-safe operation; all chilled water control valves shall be Normally-Closed arrangement with spring-return operation, by-pass control valves shall fail in place.
- F. Approved Sensors
1. Honeywell C7041B2013 Duct Sensor - 20K OHM, 12 in.
  2. Honeywell C7041R2000 20K NTC 12 ft. Rigid Copper Averaging Sensor
  3. Honeywell TR-21 20K NTC Temperature Sensor only. No network jack.
  4. Honeywell C7041R2018 20K NTC 24 ft. Rigid Copper Averaging Sensor

5. Honeywell C7042D2001 Immersion Sensor - 20K OHM
  6. Veris CDLSXX Duct Mounted CO2 sensor
  7. Veris CWE Standard Wall CO2 Sensor
  8. KMC STE-1451 10k Ohm Outside Air Temperature
  9. KMC STE-1414 10k Ohm 20-foot Duct Averaging (Copper)
  10. KMC STE-1413 10k Ohm 24-foot Duct Averaging (Copper)
  11. KMC STE-1404 10k Ohm 12-inch Duct Rigid
  12. KMC STE-1430 10k Ohm Room Sensor Flat Stainless-Steel Plate
  13. KMC STE-1154 10k Ohm 2-inch Strap-On Temperature
  14. ACI A/FLS-20-A DPDT Auto Reset Freeze Stat
- G. Wall Mount Room Temperature sensors: Each room temperature sensor shall provide temperature indication to the digital controller. Room Temperature Sensors shall be 20,000-ohm thermistor type with a temperature range of -40 to 140 degrees F. The sensor shall be complete with a decorative cover and suitable for mounting over a standard electrical utility box. The sensor shall be sealed as to not allow air from the wall cavity to infiltrate the sensor. These devices shall have an accuracy of 0.5 degrees, F., over the entire range. Install protective guards on all thermostats in all Gyms, locker rooms, Auditoriums, Media Centers, corridors, and rest rooms.
1. Architectural housing for space mounting.
  2. Provide stainless-steel plate type sensors in public areas where sensors are subject to damage. These areas include gymnasiums, locker rooms, auditoriums, media centers, corridors, lunch rooms and other areas as indicated on drawings.
  3. Weatherproof/sunshield housing for outdoors.
  4. Thermal well housing for water applications.
  5. Protective housing for duct mounting.
  6. Sensors shall be mounted 60" above finished floor.
- H. Duct-mounted and Outside Air Temperature Sensors: 20,000-ohm thermistor temperature sensors with an accuracy of  $\pm 0.2^{\circ}\text{C}$ . Outside air sensors shall include an integral sun shield. Duct-mounted sensors shall have an insertion measuring probe of a length appropriate for the duct size, with a temperature range of -40 to 160 degrees F. The sensor shall include a utility box and a gasket to prevent air leakage and vibration noise. For all mixed air and preheat air applications, install bendable averaging duct sensors with a minimum 8 - foot long sensor element. These devices shall have accuracy of 0.5 degrees, F., over the entire range.
- I. Humidity sensors shall be thin-film capacitive type sensor with on-board nonvolatile memory, accuracy to plus or minus two percent (2%) at 0 to 90% RH, 12 - 30 VDC input voltage, analog output (0 - 10 VDC or 4 - 20mA output). Operating range shall be 0 to 100% RH and 32 to 140 degree F. Sensors shall be selected for duct or outdoor type installation as appropriate.
- J. Carbon Dioxide Sensors (CO2): Sensors shall utilize Non-dispersive infrared technology (N.D.I.R.), repeatable to plus or minus 20 PPM. Sensor range shall be 0 - 2000 PPM. Accuracy shall be plus or minus five percent (5%) or 75 PPM, whichever is greater. Response shall be less than one minute. Input voltage shall be 20 to 30 VAC or DC. Output shall be 0 - 10 VDC. Sensor shall be wall or duct mounted type, as appropriate for the application, housed in a high impact plastic enclosure and mounted in the return duct.
- K. Current Sensitive Switches: Solid state, split core current switch that operates when the current level (sensed by the internal current transformer) exceeds the adjustable trip point. Current switch to include an integral LED for indication of trip condition and a current level below trip set point.
1. For motor status (pumps, fans, etc.).
  2. Current sensing switch shall be an adjustable current operated, solid-state relay for switching AC current in response to the current in a monitored AC circuit.
  3. Provide a normally open or normally closed switch, as required.

- L. Differential Analog Pressure Transmitters Provide a pressure transmitter with integral capacitance type sensing and solid-state circuitry. Accuracy shall be plus or minus 1% of full range; range shall be selected for the specific application. Provide zero and span adjustment capability. Device shall have integral static pickup tube.
1. °F for space temperature in the 0-130°F range.
  2. °F for duct temperatures in the 40 to 130°F range.
  3. °F for outside air temperatures in the -30 to 230°F range.
  4. °F for water temperatures in the 30 to 230°F range.
  5. ±1% for KWH and KW monitoring.
  6. ±5% for relative humidity in the 10 to 90% range.
  7. inches for static pressure over 0-5 inch water gauge.
  8. inch for filter status differential over a 0-2 inch range.
  9. ±1 for pressure switches.
  10. ±1% for air flow.
  11. ±3 for water flow.
  12. ±1 for differential water pressure.
- M. Differential Air Pressure Switches: Provide SPDT type installed in supply and return ducts at mechanical equipment, UL-approved, and selected for the appropriate operating range where applied. Switches shall have adjustable setpoints and barbed pressure tips.
1. Minimum 3½" diaphragm.
  2. Select range from 0.07 - 20.0" WC.
  3. Contact rating is 15A at 120 VAC.
  4. Manual reset for safety application, including switch, duct pressure sensor, tubing, and tubing adapters.
  5. Provide contacts for remote status/alarm monitoring application.
- N. Freeze Protection Thermostat:
1. Where applicable, apply a software freeze shutdown of the fan unit.
  2. The fan unit will shut down if the discharge air temp drops below 34 degrees (adj)
  3. Provide an automatic restart of the unit when temperatures in plenum rise sufficiently for normal operation.
  4. Upon the third (adj.) trip within and 60-minute period (adj) lock out the fan operation until a software reset is applied.
- O. Water Flow Sensors:
1. Manufacturer: Onicon, Inc.
  2. Technology: Electromagnetic sensor with an accuracy of plus or minus 1 percent from 2 to 20 ft/sec.
  3. Sensor must be located such that there are appropriate numbers of pipe diameters up and down stream of sensor to ensure laminar flow. Follow manufacturer recommendations.
  4. Sensor shall be sized and scaled appropriately for specific application.
- P. Water Flow Switches: Provide a SPST type contact switch with bronze paddle blade, sized for the actual pipe size at the location. If installed outdoors, provide a NEMA-4 enclosure. Flow switch shall be UL listed.
- Q. Temperature Control Panels: Furnish temperature control panels of code gauge steel with locking doors for mounting all devices as shown. All electrical devices within a control panel shall be assembled in accordance with UL-508A. A complete set of 'as-built' control drawings (relating to the controls within that panel) shall be furnished within each control panel.
- R. Pipe and Duct Temperature sensing elements: 20,000-ohm thermistor temperature sensors with and accuracy of ±1% accuracy. Their range shall be -5 to 250 deg. F. Limited range sensors shall be acceptable provided they are capable of sensing the range expected for the point at the specified accuracy. Thermal wells with heat conductive gel shall be included.
- S. Low Air Temperature Sensors: Provide DPDT type switch, with 15 to 55 degrees F. range, Vapor Filled, Copper Capillary Tube. ACI A/FLS-20-A or owner approved equivalent.

- T. Relays: Start/stop relay model shall provide either momentary or maintained switching action as appropriate for the motor being started. All relays shall be plugged in, interchangeable, mounted on a subbase and wired to numbered terminals strips. Relays installed in panels shall all be DPDT with indicating lamp. Relays installed outside of controlled devices shall be enclosed in a NEMA enclosure suitable for the location. Relays shall be labeled with UR symbol. RIB-style relays are acceptable for remote enable/disable.
- U. Emergency Stop Switches: Provide toggle-type switch with normally-closed contact. Switch shall be labeled "AIR HANDLER EMERGENCY SHUTOFF, NORMAL - OFF."
- V. Transducers: Differential pressure transducers shall be electronic with a 4-20 mA. output signal compatible to the Direct Digital Controller. Wetted parts shall be stainless steel. Unit shall be designed to operate in the pressure ranges involved.
- W. Control Power Transformers: Provide step-down transformers for all DDC controllers and devices as required. Transformers shall be sized for the load, but shall be sized for 50 watts, minimum. Transformers shall be UL listed Class 2 type, for 120VAC/24VAC operation.
- X. Line voltage protection: All DDC system control panels that are powered by 120 VAC circuits shall be provided with surge protection. This protection is in addition to any internal protection provided by the manufacturer. The protection shall meet UL, ULC 1449, IEEE C62.41B. A grounding conductor, (minimum 12 AWG), shall be brought to each control panel.
- Y. General Purpose Electric Thermostat:
  1. Provide duct (bulb), pipe (aquastat), or wall (space) mounted thermostat, as required.
  2. Select range from -50oF to 250oF.
  3. Contact rating is 15A at 120 VAC.
  4. Space mounted thermostats shall have beige plastic covers, with concealed setting dial and conceal adjustment feature.
  5. Manual reset-safety application, as required.
- Z. Differential Water Pressure Switch:
  1. For pump flow status.
  2. Construct of brass for all wetted parts, provide packless construction. Provide paddle with removable segments for pipe size and flow velocity. Provide vapor proof electrical compartment for switches mounted on cold hydronic piping systems. Furnish switches for 115 volt, 60 cycle, single phase with 7.4 amp rating; or otherwise as required.
- AA. Pneumatic Comments - Where Applicable
  1. Where pneumatic controls are present, temperature control air compressor should be duplex type with alternator. Provide contracts for remote monitoring.
  2. Pneumatic tubing shall be fire retardant urethane tubing or copper.
  3. Where pneumatic controls are present, copper tubing shall be used inside of heating units or FTR enclosure where it is hot and to all smoke damper EP's.
  4. Combustion air damper motors (pneumatic style) shall not be located in cold air stream.
  5. Transducers may be supplied as an integral unit with the field sensor, or mounted separately in a field interface panel, or as part of the controller. All transducers will be calibrated and be a Honeywell RP7515A. Electric to pneumatic transducers shall operate from either a PWM or analog signal. E/P transducers shall be rated for 0-20 psi operation and accurate to 2% of full scale. E/P transducers shall have a maximum air consumption of 100 SCIM.
  6. Electric solenoid operated pneumatic valves (EP's) shall have a three port operation: Common, normally open, and normally closed. They shall be rated for 50 psig when used for 25 psig or less applications, or rated for 150 psig when used for 100 psig or less applications. The coils shall be equipped with transient suppression devices to limit transients to 150 percent of the rated coil voltage.
- BB. Airflow Measuring System(s)
  1. **All airflow monitoring stations shall be scheduled into the project documents.**

2. **All airflow monitoring stations shall be shown and/or noted on the control documents.**
3. MPS requires all installations shall meet or exceed the manufacturer's published installation requirements.
4. Minimum installation requirements shall be provided on detail sheets and/or on duct layout plans.
5. Projects at MPS should incorporate the minimum number of airflow stations required to achieve operational design intent. MPS project team shall be consulted if more than outdoor airflow stations are needed for system sequence of operation.
6. Provide where indicated and scheduled airflow measuring system(s) capable of continuously monitoring the duct capacities (air volume) they serve. Each airflow measuring system shall consist of an airflow measuring station and transmitter. In order to guarantee the overall accuracy and performance of the airflow measuring system, the airflow measuring station and transmitter shall be by the same manufacturer. Airflow measuring stations shall be provided by the BAS contractor. Installation of the probes/stations/sensors shall be coordinated between the BAS contractor, Mechanical contractor, and the Electrical contractor.
7. No use of air straightening or honeycomb devices will be allowed.
8. Airflow stations require maintenance and/or cleaning. Access doors of appropriate size and location shall be provided by the Mechanical Contractor. **This shall be detailed and/or noted on the plans.** Controller shall not be mounted in the airstream.
9. Controller shall not be mounted in the airstream. The Display/Controller shall be mounted 60 inches above finished floor in an readily accessible location.
10. MPS preference is a voltage signal from the transmitter to the BAS system.
11. Airflow stations must be function tested by Controls Contractor before calibration process is scheduled.
12. Verification/calibration of airflow stations shall be a combined effort between the BAS contractor and the TAB contractor and witnessed by the commissioning agent. The verification/calibration of the airflow station shall be reported in the MPS building startup format to allow data to be shared with the construction team.
13. Approved Manufacturers:
  - a. Air Monitor Corporation (**Basis of Design**)
  - b. Ebtron Gold Series
  - c. MPS Approved equal
    - 1) Prior written approval by MPS is required for all alternate manufacturers. Approvals must be provided via written addendum. Alternate manufacturer must provide complete system submittals including minimum installation requirements for each specific application and location on the proposed project, certified flow performance data, dimensional drawings, system accuracy statements, wiring diagrams, and interface details. Alternate manufacture must provide a list of at least 5 similar installations within the Twin Cities metro area including: models used and installation type, project name and location, architect and engineer contacts, installing contractor contact, balancing contractor contact, and commissioning agent contact information. Provide line-by-line compliance and/or deviation from the specifications.

## 2.08 SPARE CONTROLS HARDWARE

- A. The BAS Contractor shall provide one spare of each type of Level 2 controller used in the project.

## PART 3 - BAS SERVER & WEB BROWSER GRAPHICAL USER INTERFACE (GUI)

### 3.01 SYSTEM OVERVIEW

- A. The BAS Contractor shall provide system software based on server/thin-client architecture, designed around the open standards of web technology. The BAS server shall communicate using Ethernet and TCP. Server shall be accessed using a web browser over Owner intranet and remotely over the Internet.
- B. The intent of the thin-client architecture is to provide the operator(s) complete access to the BAS system via a web browser. The thin-client web browser Graphical User Interface (GUI) shall be browser and operating system agnostic, meaning it will support Microsoft and Mozilla Firefox browsers (latest versions), and Windows as well as non-Windows operating systems. No special software or plug-ins, other than free public domain programs shall be required to be installed on PC's used to access the BAS via a web browser.
- C. The BAS server software must support at least the following server platforms (Windows, and/or Linux). The BAS server software shall be developed and tested by the manufacturer of the system stand-alone controllers and network controllers/routers.
- D. The web browser GUI shall provide a completely interactive user interface and must offer and be configured with the following features as a minimum:
  - 1. Trending
  - 2. Scheduling
  - 3. Electrical demand limiting
  - 4. Duty Cycling
  - 5. Downloading Memory to field devices
  - 6. Real time 'live' Graphic Programs
  - 7. Tree Navigation
  - 8. Parameter change of properties
  - 9. Setpoint Adjustments
  - 10. Alarm / Event information
  - 11. Configuration of operators
  - 12. Execution of global commands
  - 13. Add, delete, and modify graphics and displayed data
- E. Software Components: All software shall be the most current version. All software components of the BAS system software shall be provided and installed as part of this project .BAS software components shall include:
  - 1. Server Software, Database and Web Browser Graphical User Interface
  - 2. System Configuration Utilities for future modifications to the system, and controllers.
  - 3. Graphical Programming Tools
  - 4. Direct Digital Control software
  - 5. Application Software
  - 6. Any required third party software
  - 7. If licensing credits are required provide a minimum of 10% additional to as built control system requires.
- F. BAS Server Database: The BAS server software shall utilize the integral database installed during the loading of the WEBS-N4 Supervisor software included with the Honeywell WEBS-N4 software platform built on the Niagara 4™ Framework. BAS systems written to other Non - Standard and/or Proprietary databases are not acceptable.
- G. Database Open Connectivity: The BAS server database shall allow real time access of data via the following standard mechanisms:
  - 1. Open protocol standard like SOAP
  - 2. OLE/OPC (for Microsoft Client's/Server platform only)
  - 3. Import/Export of the database from or to XML (extensible Mark-up Language)
- H. Communication Protocol(s): The native protocol for the BAS server software shall be TCP/IP over Ethernet. Proprietary protocols over TCP/IP, other than FOX are not acceptable.
- I. Thin Client - Web Browser Based: The GUI shall be browser based.

### 3.02 WEB BROWSER GRAPHICAL USER INTERFACE

- A. Web Browser Navigation: The Thin Client web browser GUI shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed to “feel” like a single application, and provide a complete and intuitive mouse/menu driven operator interface. It shall be possible to navigate through the system using a web browser to accomplish requirements of this specification. The Web Browser GUI shall (as a minimum) provide for navigation, and for display of animated graphics, schedules, alarms/events, live graphic programs, active graphic setpoint controls, configuration menus for operator access, reports, and reporting actions for events.
- B. Login: On launching the web browser and selecting the appropriate domain name or IP address, the operator shall be presented with a login page that will require a login name and password. Navigation in the system shall be dependent on the operator’s role privileges, and geographic area of responsibility.
- C. Navigation: Navigation through the GUI shall be accomplished by clicking on appropriate level of a navigation tree (consisting of expandable and collapsible tree control like Microsoft’s Explorer program), and/or by selecting dynamic links to other system graphics. Both the navigation tree and action pane shall be displayed simultaneously, enabling the operator to select a specific system or equipment, and view the corresponding graphic. The navigation tree shall as a minimum provide the following views: Geographic, Network, Groups and Configuration.
  - 1. Geographic View shall display a logical geographic hierarchy of the system including: cities, sites, buildings, building systems, floors, equipment and objects.
  - 2. Groups View shall display Scheduled Groups and custom reports.
  - 3. Configuration View shall display all the configuration categories (Operators, Schedule, Event, Reporting and Roles).
- D. Action Panel: The Action Pane shall provide several functional views for each HVAC or mechanical/electrical subsystem specified. A functional view shall be accessed by clicking on the corresponding button:
  - 1. Graphics: Using graphical format suitable for display in a web browser, graphics shall include aerial building/campus views, color building floor-plans, equipment drawings, active graphic setpoint controls, web content, and other valid HTML elements. The data on each graphic page shall automatically refresh.
  - 2. Properties: Shall include graphic controls and text for the following: Locking or overriding objects, demand strategies, and any other valid data required for setup. Changes made to the properties pages shall require the operator to depress an ‘accept/cancel’ button.
  - 3. Schedules: Shall be used to create, modify/edit and view schedules based on the systems geographical hierarchy (using the navigation tree).
  - 4. Alarms: Shall be used to view alarm information geographically (using the navigation tree), acknowledge alarms, sort alarms by category, actions and verify reporting actions.
  - 5. Trends: Shall be used to display associated trend and historical data, modify colors, date range, axis and scaling
  - 6. Logic - Live Graphic Programs: Shall be used to display ‘live’ graphic programs of the control algorithm, (micro block programming) for the mechanical/electrical system selected in the navigation tree.
  - 7. Other actions such as Print, Help, Command, and Logout shall be available via a drop-down window.
- E. Color Graphics: The Web Browser GUI shall make extensive use of color in the graphic pane to communicate information related to setpoints and comfort. Animated .gifs or .jpg, vector scalable, active setpoint graphic controls shall be used to enhance usability. Graphics tools used to create Web Browser graphics shall be non-proprietary and conform to the following basic criteria:

1. Display Size: The GUI workstation software shall graphically display in a minimum of 1024 by 768 pixels 24 bit True Color. Match standard graphic sizing already implemented on WEBS-N4 Supervisor.
2. General Graphic: General area maps shall show locations of controlled buildings in relation to local landmarks.
3. Color Floor Plans: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, as selected by Owner. Provide a visual display of temperature relative to their respective setpoints. The colors shall be updated dynamically as a zone's actual comfort condition changes.
4. Global HVAC Air Balancing Table: A graphic showing the HVAC System, i.e. all VAV boxes on their individual air handling system, on the same screen with the individual VAV Name, AHU served by, Room Served, Occ\_mode, Rm Temp, Current STP, Valve Pos, Valve OVR, FTR Vlv Pos, FTR Vlv OVR, DMPR Pos, Damper OVR, Air Flow CFM showing. The purpose for this graphic is to open all of the boxes to their maximum cooling CFM settings and minimum CFM settings so the duct static pressure setting can be optimized and airflow stations can be checked, from that of the design value. Single-press graphic buttons shall be provided on this page that set all VAV boxes served by the same air handling system to maximum airflow setpoints and to minimum airflow setpoints. (Fan specific, global override located on fan graphic for VAV's served by associated fan) See exhibit below.
5. Global HVAC Hot Water Balancing Table: A graphic showing the Boiler System, i.e. all heating coils on their individual pumping system, on the same screen with the individual GPM values showing, if available. The purpose for this graphic is to open all of the hot water valves to their maximum settings so the heating piping pressure setting can be optimized, from that of the design value. Single-press graphic button shall be provided on this page that sets all hydronic control valves (excluding bypass valves) to full-open position. (pump specific, global override located on fan graphic for coils served by associated pump).
6. Mechanical Components: Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability. If there are more than one fan or pump, all fans or pumps must be shown, if there are multiple coils or dampers, all of these components must be shown.
  - a. Each piece of equipment monitored or controlled including each terminal unit
  - b. Each HVAC mechanical system: chiller-pumps, boiler-pumps, AHU-EF-VAV, ventilation
7. Minimum System Color Graphics: Color graphics shall be selected and displayed via a web browser for the following:
  - a. Each building
  - b. Each floor and zone controlled, with alarm representations when space temperatures go outside of the set limits
  - c. Graphics shall incorporate room numbers
  - d. Backgrounds on the graphics shall not be on a white background. Dark background colors are not acceptable.
8. Example of Global HVAC Balancing Table Located on the BAS System
9. Example of HVAC Air Handling System Graphic(s) and Provide on the Mechanical Plan Sheets
10. Example of HVAC Boiler and Chilled Water System Graphic(s) and Show on the Mechanical Plan Sheets

11. Hierarchical Schedules: Utilizing the Navigation Tree displayed in the web browser GUI, an operator (with password access) shall be able to define a Normal, Holiday or Override schedule for an individual piece of equipment or room, or choose to apply a hierarchical schedule to the entire system, site or floor area. For example, Independence Day 'Holiday' for every level in the system would be created by clicking at the top of the geographic hierarchy defined in the Navigation Tree. No further operator intervention would be required and every control module in the system with would be automatically downloaded with the 'Independence Day' Holiday. All schedules that affect the system/area/equipment highlighted in the Navigation Tree shall be shown in a summary schedule table and graph.
  - a. Schedules: Schedules shall comply with the LonWorks standards, (Schedule Object, Calendar Object, Weekly Schedule property and Exception Schedule property) and shall allow events to be scheduled based on:
    - 1) Types of schedule shall be Normal, Holiday or Override
    - 2) A specific date,
    - 3) A range of dates,
    - 4) Any combination of Month of Year (1-12, any), Week of Month (1-5, last, any), Day of Week (M-Sun, Any)
    - 5) Wildcard (example, allow combinations like second Tuesday of every month).
    - (a) Schedule Categories: The system shall allow operators to define and edit scheduling categories (different types of "things" to be scheduled; for example, lighting, HVAC occupancy, etc.). The categories shall include: name, description, icon (to display in the hierarchy tree when icon option is selected) and type of value to be scheduled.
      - (1) Schedule Groups: In addition to hierarchical scheduling, operators shall be able to define functional Schedule Groups, comprised of an arbitrary group of areas/rooms/equipment scattered throughout the facility and site. For example, the operator shall be able to define an 'individual tenant' group - who may occupy different areas within a building or buildings. Schedules applied to the 'tenant group' shall automatically be downloaded to control modules affecting spaces occupied by the 'tenant group'
      - (2) Intelligent Scheduling: The control system shall be intelligent enough to automatically turn on any supporting equipment needed to control the environment in an occupied space. If the operator schedules an individual room in a VAV system for occupancy, for example, the control logic shall automatically turn on the VAV air handling unit, chiller, boiler, and/or any other equipment required to maintain the specified comfort and environmental conditions within the room.
      - (3) Partial Day Exceptions: Schedule events shall be able to accommodate a time range specified by the operator (ex: board meeting from 6 pm to 9 pm overrides Normal schedule for conference room).
      - (4) Schedule Summary Graph: The schedule summary graph shall clearly show Normal versus Holiday versus Override Schedules, and the net operating schedule that results from all contributing schedules. Note: In case of priority conflict between schedules at the different geographic hierarchy, the schedule for the more detailed geographic level shall apply.
12. Alarms: Alarms associated with a specific system, area, or equipment selected in the Navigation Tree, shall be displayed in the Action Pane by selecting an 'Alarms' view. Alarms, and reporting actions shall have the following capabilities:

- a. Alarms View: Each Alarm shall display an Alarms Category (using a different icon for each alarm category), date/time of occurrence, current status, alarm report, and a bold URL link to the associated graphic for the selected system, area or equipment. The URL link shall indicate the system location, address and other pertinent information. An operator shall easily be able to sort events, edit event templates and categories, acknowledge or force a return to normal in the Events View as specified in this section.
- b. Alarm Categories: The operator shall be able to create, edit or delete alarm categories such as HVAC, Maintenance, Fire, or Generator. An icon shall be associated with each alarm category, enabling the operator to easily sort through multiple events displayed.
- c. Alarm Templates: Alarm template shall define different types of alarms and their associated properties. As a minimum, properties shall include a reference name, verbose description, severity of alarm, acknowledgement requirements, and high/low limit and out of range information.
- d. Alarm Areas: Alarm Areas enable an operator to assign specific Alarm Categories to specific Alarm Reporting Actions. For example, it shall be possible for an operator to assign all HVAC Maintenance Alarm on the 1st floor of a building to email the technician responsible for maintenance. The Navigation Tree shall be used to setup Alarm Areas in the Graphic Pane.
- e. Alarm Time/Date Stamp: All events shall be generated at the DDC control module level and comprise the Time/Date Stamp using the standalone control module time and date.
- f. Alarm Configuration: Operators shall be able to define the type of Alarm generated per object. A 'network' view of the Navigation Tree shall expose all objects and their respective Alarm Configuration. Configuration shall include assignment of Alarm, type of Acknowledgement and notification for return to normal or fault status.
- g. Alarm Summary Counter: The view of Alarm in the Graphic Pane shall provide a numeric counter, indicating how many Alarms are active (in alarm), require acknowledgement, and total number of Alarms in the BAS Server database.
- h. Alarm Auto-Deletion: Alarms that are acknowledged and closed shall be auto-deleted from the database and archived to a text file after an operator defined period.
- i. Alarm Reporting Actions: Alarm Reporting Actions specified shall be automatically launched (under certain conditions) after an Alarm is received by the BAS server software. Operators shall be able to easily define these Reporting Actions using the Navigation Tree and Graphic Pane through the web browser GUI. Reporting Actions shall be as follows:
  - 1) Print: Alarm information shall be printed to the BAS server's PC or a networked printer.
  - 2) Email: Email shall be sent via any POP3-compatible e-mail server (most Internet Service Providers use POP3). Email messages may be copied to several email accounts. Note: Email reporting action shall also be used to support alphanumeric paging services, where email servers support pagers.
  - 3) File Write: The ASCII File write reporting action shall enable the operator to append operator defined alarm information to any alarm through a text file. The alarm information that is written to the file shall be completely definable by the operator. The operator may enter text or attach other data point information (such as AHU discharge temperature and fan condition upon a high room temperature alarm).
  - 4) Write Property: The write property reporting action updates a property value in a hardware module.
  - 5) SNMP: The Simple Network Management Protocol (SNMP) reporting action sends an SNMP trap to a network in response to receiving an alarm.
  - 6) Run External Program: The Run External Program reporting action launches specified program in response to an event.

13. Trends: Trends shall both be displayed and user configurable through the Web Browser GUI. Trends shall comprise analog, digital or calculated points simultaneously. A trend log's properties shall be editable using the Navigation Tree and Graphic Pane.
  - a. Viewing Trends: The operator shall have the ability to view trends by using the Navigation Tree and selecting a Trends button in the Graphic Pane. The system shall allow y- and x-axis maximum ranges to be specified and shall be able to simultaneously graphically display multiple trends per graph.
  - b. Local Trends: Trend data shall be collected locally by Multi-Equipment/Single Equipment general-purpose controllers, and periodically uploaded to the BAS server if historical trending is enabled for the object. Trend data, including run time hours and start time date shall be retained in non-volatile module memory. Systems that rely on a gateway/router to run trends are NOT acceptable.
  - c. Resolution. Sample intervals shall be as small as one second. Each trended point will have the ability to be trended at a different trend interval. When multiple points are selected for displays that have different trend intervals, the system will automatically scale the axis.
  - d. Dynamic Update. Trends shall be able to dynamically update at operator-defined intervals.
  - e. Zoom/Pan. It shall be possible to zoom-in on a particular section of a trend for more detailed examination and 'pan through' historical data by simply scrolling the mouse.
  - f. Numeric Value Display. It shall be possible to pick any sample on a trend and have the numerical value displayed.
  - g. Copy/Paste. The operator must have the ability to pan through a historical trend and copy the data viewed to the clipboard using standard keystrokes (i.e. CTRL+C, CTRL+V).
14. Security Access: Systems that Security access from the web browser GUI to BAS server shall require a Login Name and Password. Access to different areas of the BAS system shall be defined in terms of Roles, Privileges and geographic area of responsibility as specified:
  - a. Roles: Roles shall reflect the actual roles of different types of operators. Each role shall comprise a set of 'easily understood English language' privileges. Roles shall be defined in terms of View, Edit and Function Privileges.
    - 1) View Privileges shall comprise: Navigation, Network, and Configuration Trees, Operators, Roles and Privileges, Alarm/Event Template and Reporting Action.
    - 2) Edit Privileges shall comprise: Setpoint, Tuning and Logic, Manual Override, and Point Assignment Parameters.
    - 3) Function Privileges shall comprise: Alarm/Event Acknowledgement, Control Module Memory Download, Upload, Schedules, Schedule Groups, Manual Commands, Print, and Alarm/Event Maintenance.
      - (a) Geographic Assignment of Roles: Roles shall be geographically assigned using a similar expandable/collapsible navigation tree. For example, it shall be possible to assign two HVAC Technicians with similar competencies (and the same operator defined HVAC Role) to different areas of the system.

### 3.03 GRAPHICAL PROGRAMMING

- A. The system software shall include a Graphic Programming Language (GPL) for all DDC control algorithms resident in all control modules. Any system that does not use a drag and drop method of graphical icon programming shall not be accepted. All systems shall use a GPL is a method used to create a sequence of operations by assembling graphic microblocks that represent each of the commands or functions necessary to complete a control sequence. Microblocks represent common logical control devices used in conventional control systems, such as relays, switches, high signal selectors, etc., in addition to the more complex DDC and energy management strategies such as PID loops and optimum start. Each microblock shall be interactive and contain the programming necessary to execute the function of the device it represents.
- B. Graphic programming shall be performed while on screen and using a mouse; each microblock shall be selected from a microblock library and assembled with other microblocks necessary to complete the specified sequence. Microblocks are then interconnected on screen using graphic "wires," each forming a logical connection. Once assembled, each logical grouping of microblocks and their interconnecting wires then forms a graphic function block which may be used to control any piece of equipment with a similar point configuration and sequence of operation.
- C. Graphic Sequence: The clarity of the graphic sequence must be such that the operator has the ability to verify that system programming meets the specifications, without having to learn or interpret a manufacturer's unique programming language. The graphic programming must be self-documenting and provide the operator with an understandable and exact representation of each sequence of operation. Graphics and navigation shall follow existing MPS standards. See drawings and the example below.
- D. GPL Capabilities: The following is a minimum definition of the capabilities of the Graphic Programming software:
1. Function Block (FB): Shall be a collection of points, microblocks and wires which have been connected together for the specific purpose of controlling a piece of HVAC equipment or a single mechanical system.
  2. Logical I/O: Input/Output points shall interface with the control modules in order to read various signals and/or values or to transmit signal or values to controlled devices.
  3. Microblocks: Shall be software devices that are represented graphically and may be connected together to perform a specified sequence. A library of microblocks shall be submitted with the control contractors bid.
  4. Wires: Shall be Graphical elements used to form logical connections between microblocks and between logical I/O.
  5. Reference Labels: Labels shall be similar to wires in that they are used to form logical connections between two points. Labels shall form a connection by reference instead of a visual connection, i.e. two points labeled 'A' on a drawing are logically connected even though there is no wire between them.
  6. Parameter: A parameter shall be a value that may be tied to the input of a microblock.
  7. Properties: Dialog boxes shall appear after a microblock has been inserted which has editable parameters associated with it. Default parameter dialog boxes shall contain various editable and non-editable fields, and shall contain 'push buttons' for the purpose of selecting default parameter settings.
  8. Icon: An icon shall be graphic representation of a software program. Each graphic microblock has an icon associated with it that graphically describes its function.
  9. Menu-bar Icon: Shall be an icon that is displayed on the menu bar on the GPL screen, which represents its associated graphic microblock.
  10. Live Graphical Programs: The Graphic Programming software must support a 'live' mode, where all input/output data, calculated data, and setpoints shall be displayed in a 'live' real-time mode.
  11. All BAS Control Sequences will be shown on a separate Mechanical Plan Sheet. Examples are shown below.

### 3.04 LONWORKS NETWORK MANAGEMENT

- A. Systems requiring the use of third party LonWorks network management tools shall not be accepted.
- B. Network management shall include the following services: device identification, device installation, device configuration, device diagnostics, device maintenance and network variable binding.
- C. The Network configuration tool shall also provide diagnostics to identify devices on the network, to reset devices, and to view health and status counters within devices.
- D. These tools shall provide the ability to “learn” an existing LonWorks network, regardless of what network management tool(s) were used to install the existing network, so that existing LonWorks devices and newly added devices are part of a single network management database.
- E. The network management database shall be resident in the Network Area Controller (NAC), ensuring that anyone with proper authorization has access to the network management database at all times. Systems employing network management databases that are not resident, at all times, within the control system shall not be accepted.

### 3.05 SEQUENCE OF OPERATIONS AND DDC POINTS LISTS

#### **AIR HANDLING UNITS (SINGLE ZONE, CONSTANT AIR VOLUME, HOT WATER HEATING):**

- A. Application:
  - 1. Outdoor roof mounted air handling units: RTU-4, RTU-5, RTU-8 and RTU-9
  - 2. Return air fans: integral with unit.
- B. Time Schedule: Start and stop supply and return fans. Determine fan status by current sensors. Signal alarm if fan fails to start as commanded.
  - 1. Safety Devices:
    - a. Freeze Protection: Stop supply and return fans and close outside air dampers if discharge air temperature falls below 40 degrees F; signal alarm. Provide a 180 second delay. Freeze stat is not to be energized unless fan is running. Provide a reset via the software to allow the operator to reset the system from the BAS workstation.
- C. Morning Warm-up (heating mode only):
  - 1. Start the unit fan variable speed drives and hold the return dampers fully open and the outdoor air dampers fully-closed. Until the supply and return fans are at full operating capacity, lock-out the outdoor air dampers (hold fully-closed) until the space temperature reaches 72 degrees F (adjustable). When the space temperature reaches the desired ‘occupied’ setpoint, the outdoor air dampers are to be ‘enabled’ to start their respective ‘delayed damper’ sequence.
- D. Delayed Outdoor Air Damper operation:
  - 1. Sequence is to follow the “morning warm-up” sequence and if the space temperatures are satisfied and have reached setpoints.
  - 2. Provide a damper restrictor to obtain a slow-opening process of the outside air damper (minimum 180 seconds).
- E. Economizer Sequence:
  - 1. Provide a mixed air temperature (MAT) sensor.
  - 2. Economizer is to be enabled and have priority in occupied heating modes.
  - 3. Economizer ‘heating’ mode is to have priority over CO2 control sequence.
  - 4. The outside air damper and return air damper will be controlled by separate signals, but will operate inversely proportional of each other.
  - 5. Economizer is enabled when the outdoor air enthalpy is less than return air enthalpy with a 2 btu/lb (adj.) dead-band and the outdoor air enthalpy is less than 28 btu/lb (adj.) with a 2 btu/lb (adj.) dead-band OR the outdoor air temperature is below 55 F (adj.) with a 4 F (adj.) dead-band.

- 1) Economizer mode will be selectable from the graphics so that it can be the above listed enthalpy sequence, or a dry bulb only economizer control sequence.
  - 2) While in economizer mode, the outside/return air dampers will modulate to maintain mixed air temperature set point.
    - (a) The mixed air temperature set point will be reset based on the difference between discharge air temperature and discharge air temperature set point.
    - (b) The dampers will control the maximum of the economizer demand or the minimum outside air damper position.
  6. For outside air temperatures above 79 degrees F and 55% relative humidity:
    - 1) Enable occupied cooling mode.
  7. Economizer Fault Detection and Diagnostics (FDD)
    - 1) The following temperature sensors shall be permanently installed to monitor system operation:
      - (a) Outdoor air
      - (b) Supply air
      - (c) Return air, where required for economized control
    - 2) The system shall have the capability of displaying the value of each sensor
    - 3) The FDD system or unit controls shall be capable of and configured to provide system status by indicating the following”
      - (a) Free cooling available
      - (b) Economizer enabled
      - (c) Compressor enabled
      - (d) Heating enabled
      - (e) Mixed-air low-limit cycle active
    - 4) The FDD system or unit controls shall have provisions to manually initiate each operating mode so hat the operation of compressors, economizers, fans, and the heating system can be independently tested and verified.
    - 5) The FDD system shall be capable of and configured to detect the following faults:
      - (a) Air temperature sensor failure/fault
      - (b) Not economizing when the unit should be economizing
      - (c) Economizing when the unit should not be economizing
      - (d) Damper not modulation
      - (e) Excess outdoor air
    - 6) The FDD system shall be capable of and configured to report faults to a fault management application or DDC system accessible by operation or service personnel, or annunciated locally on zone thermostats.
- F. Demand-Control Ventilation:
1. Provide a return duct-mounted carbon dioxide sensor.
  2. The CO2 sensor is to modulate the outside air damper open (to the CFM amount indicated on the schedules) in order to maintain CO2 levels in the occupied spaces no greater than 1000 PPM (adjustable).
  3. In the heating mode, when the CO2 sensor is satisfied, the CO2 sensor is to override the MAT or enthalpy controls (if temperatures are satisfied) and close the outdoor air dampers to an arbitrary 10% outdoor air minimum. In this mode, satisfying space temperature using outdoor air (economizer) is to have priority. The demand control ventilation sequence is to be locked-out in unoccupied modes.
  4. The Carbon dioxide (CO2) sensor is to be locked-out when the system is in economizer mode. This would apply to heating occupied mode.
- G. Occupied Heating:
1. Supply fan is to be on.

2. Modulate the outside air damper and return air dampers in sequence in order to meet the minimum outside airflow cfm setpoint of the Outside Airflow Measuring Station. The outdoor air dampers should not be allowed to close beyond minimum setpoint unless controlled by the Demand Control Ventilation sequence.
  3. Modulate the air handling unit heating coil valve to maintain discharge air temperature setpoint.
  4. The discharge air temperature (DAT) sensor is to modulate the heating coil valve to maintain heating discharge air temperature setpoint. The discharge air temperature sensor set point is to be reset by the space sensor.
  5. If CO2 levels in the space rise, modulate the outdoor air dampers open and close the return dampers in sequence as required to satisfy the CO2 sensor settings.
  6. Under this sequence, the outdoor air dampers are to be modulated open and not to exceed the cfm scheduled "minimum outside air cfm". Economizer sequence is to have priority over CO2 sequence.
- H. Unoccupied Heating:
1. Supply fan is to be off.
  2. Hot water coil valve to be fully-closed to coil and locked-out.
  3. Outside air and relief/exhaust dampers are to be fully closed and the return air dampers are to be fully-open.
  4. Cycle supply fan and modulate the heating coil valve to maintain reduced space temperature (adjustable).
- I. Building Area Pressure/Space Pressure Relief:
1. Application: Return/relief fans.
  2. Ramp the return/relief fan (ECM) based on the building pressure.
  3. Control the space to a positive building pressure of +0.05" w.c. (adjustable). Provide outdoor pressure reference point on the roof with appropriate protection from wind and elements
- J. Outside Air and Supply Air Flow Monitoring:
1. Measure the outside air and supply air via an airflow measuring station (AFMS).
  2. Provide the capability of monitoring the outside air and supply air volumes.
  3. Outside air flow measuring will be used to control the outdoor air dampers. The outside air cfm will have a set point which is to be reset based on the various modes of this air handling unit's sequence.
- K. Exhaust Systems: Provide interlock between each individual RTU and with respective exhaust systems serving the shop spaces to ensure RTU ~~minimum~~ OA volume is delivered to ~~equal~~ ~~make-up-air~~ exhaust air volumes **for exhaust systems serving the shop spaces.**
- L. Miscellaneous:
1. Provide 'occupied/unoccupied' switching and 'heat' switching capabilities.
  2. Provide night setback temperature capability.
  3. The air handling unit is to have a physical and graphical "Emergency Shutdown Switch".
- M. Unit shall be provided with the following quantity of points:
- a. Points list:
    - Supply fan start/stop (DO)
    - Supply fan status, current sensor (DI)
    - Supply fan VFD modulation (DI)
    - Supply duct static pressure (AI)
    - Heat coil valve modulation (AO)
    - Supply/Discharge air temperature (AI) coil DAT (serpentine-type sensor)
    - Supply air temperature (AI) remote duct-mounted sensor
    - Return air temperature (AI)
    - Mixed air temperature (AI)
    - Space Temperature (AI)
    - Space Humidity (AI)
    - Return duct carbon dioxide (CO2) sensor (AI)

- Outside air damper modulation (AO)
- Return air damper modulation (AO)
- Return/relief fan start/stop (DO)
- Return/relief fan status, current sensor (DI)
- Relief fan (ECM) modulation (DI)
- Interior Space pressure (AI)
- Outdoor atmospheric pressure (AI) (compared to the interior space pressure being served by the respective air handler)
- Freeze stat/protection (DI)
- Outside air CFM (AI)
- Supply air CFM (AI)

**ROOFTOP AIR HANDLING UNITS – PACKAGED DX (SINGLEZONE, VARIABLE AIR VOLUME, DX COOLING, HOT WATER HEATING AND TOTAL ENERGY RECOVERY WHEELS):**

A. Application:

1. Rooftop units: RTU-6.
2. Return/relief air fans: Integral with the rooftop units.
3. Variable air volume boxes.
4. Total energy recovery wheels.

B. Time Schedule: Start and stop supply and return fans. Determine fan status by current sensors. Signal alarm if fan fails to start as commanded.

C. Safety Devices:

1. Freeze Protection: Stop supply and return fans and close outside air dampers if discharge air temperature falls below 40 degrees F; signal alarm. Provide a 180 second delay. Freeze stat is not to be energized unless fan is running. Provide a reset via the software to allow the operator to reset the system from the BAS workstation.

D. Variable Air Volume Supply and Return/Relief Fan Control:

1. Provide a duct pressure sensor two-thirds downstream of the supply blower ductwork. The duct pressure sensor is to ramp the supply blower VFD to maintain a set supply duct static pressure.
2. Provide a duct pressure sensor in the ductwork downstream of the return air blower. The duct pressure sensor is to ramp the return blower VFD to maintain a set return/exhaust duct static pressure. Refer to the relief/exhaust damper sequence associated with this control. The controls contractor is to coordinate and work with the balancing contractor in order to set and calibrate the return duct static pressure setpoint to allow ramping of the return blower VFD.

E. Morning Warm-up (heating mode only):

1. Start the unit fan variable speed drives and hold the return dampers fully open and the outdoor air dampers fully-closed. Until the supply and return fans are at full operating capacity, lock-out the outdoor air dampers (hold fully-closed) until the space temperature reaches 72 degrees F (adjustable). When the space temperature reaches the desired 'occupied' setpoint, the outdoor air dampers are to be 'enabled' to start their respective 'delayed damper' sequence.
2. Cooling sequence is to be locked-out.

F. Delayed Outdoor Air Damper operation:

1. Sequence is to follow the "morning warm-up" sequence and if the space temperatures are satisfied and have reached setpoints.

2. Provide a damper restrictor to obtain a slow-opening process of the outside air damper (minimum 180 seconds).

G. Economizer Sequence:

1. Provide a mixed air temperature (MAT) sensor.
2. Economizer is to be enabled and have priority in both occupied heating and cooling modes.
3. Economizer 'cooling' and 'heating' mode is to have priority over CO2 control sequence.
4. Provide enthalpy control.
  - a. When the outside air temperature is between 55 and 79 degrees F, compare return and outside air temperatures along with relative humidity. If return air temperature and humidity is lower:
    - 1) Enable occupied cooling mode.
    - 2) Energy recovery bypass dampers are to be open (in full bypass) and energy recovery rotor to be off (rotating at a very low RPM). It is the intent that the wheel turns at all times to obtain at least a small volume of airflow through the wheel.
  - b. When the outside air temperature is between 55 and 79 degrees F, compare return and outside air temperatures. If return air temperature and humidity is higher:
    - 1) Modulate the outside air dampers open and close the return air dampers to maintain a discharge air temperature. Discharge air temperature is to be reset by the space temperature sensor.
    - 2) Energy recovery bypass dampers are to be open (in full bypass) and energy recovery rotor to be off (rotating at a very low RPM). It is the intent that the wheel turns at all times to obtain at least a small volume of airflow through the wheel.
5. For outside air temperatures above 79 degrees F and 55% relative humidity:
  - a. Enable occupied cooling mode.
  - b. Energy recovery bypass dampers are to be fully-closed. Energy recovery unit wheel to be on and rotating. Modulate rotor speed in sequence with the cooling valves to maintain discharge air temperature setpoint.

H. Demand-Control Ventilation:

1. Provide a return duct-mounted carbon dioxide sensor.
2. The CO2 sensor is to modulate the outside air damper open (to the CFM amount indicated on the schedules) in order to maintain CO2 levels in the occupied spaces no greater than 1000 PPM (adjustable).
3. In both the heating and cooling modes, when the CO2 sensor is satisfied, the CO2 sensor is to override the MAT or enthalpy controls (if temperatures are satisfied) and close the outdoor air dampers to an arbitrary 5% outdoor air minimum. In this mode, satisfying space temperature using outdoor air (economizer) is to have priority. The demand control ventilation sequence is to be locked-out in unoccupied modes.
4. The Carbon dioxide (CO2) sensor is to be locked-out when the system is in economizer mode. This would apply to both heating and cooling occupied modes.

I. Occupied Cooling:

1. Supply and return fans are to be on.
2. The Pre-Heating coil valve is to be fully-closed to the coil and/or in coil by-pass.
3. When the outside air temperature is above 79 degrees F and 55% relative humidity, drive the outside air damper to a minimum position (10%) and open the return damper.

4. Energy recovery bypass dampers are to be fully-closed. Energy recovery unit wheel to be on and rotating. Modulate rotor speed in sequence with the cooling valves to maintain discharge air temperature setpoint.
  5. DX cooling:
    - a. Unit will be equipped with packaged DX cooling. The units will be provided with interlaced coils served by multiple scroll-type compressors. The coils and compressors will be dual-circuited with digital-pulse scroll technology on the first priority circuit. The units are to be factory wired to allow compressor control/staging by the controls contractor.
    - b. Provide downstream of the supply blower, a discharge air temperature sensor. The discharge air temperature is to be reset by the space temperature sensor calling for the most cooling.
    - c. The discharge air temperature sensor is to stage the compressors in order to maintain DAT setpoint. The first priority compressor is to utilize digital pulse control in order to obtain capacity reduction ability. As the load increases, the second stage compressor is to be staged in tandem with the first priority compressor. As the discharge air temperature becomes satisfied, the reverse sequence is to apply.
  6. Humidity Control (Cooling Mode Only):
    - a. Provide space relative humidity (RH) sensors (separate from the space temperature sensors) and locate the sensors in the area in which the unit serves. Each of the RH sensors are to send a signal to obtain an average humidity reading/level for the area. On a rise in humidity (55% or higher), re-set the DAT sensor to maintain a constant discharge temperature of 55F.
    - b. Under the humidity control sequence (when enabled), the discharge air temperature sensor is to maintain a constant discharge air temperature of 55F to 60F (adjustable). When humidity levels have reached setpoint (54%) or are lower, the discharge air temperature sensor shall return to controlling the compressors to maintain DAT setpoint.
    - c. Under this sequence, the VAV box heating coil control valves are to be modulated by their respective space sensor to maintain/satisfy space temperature setpoint. This sequence will have priority over the occupied cooling sequence. As space humidity (RH) levels are lowered and the RH sensors become satisfied, the reverse sequence is to apply and the occupied cooling sequence is to be engaged.
    - d. The Humidity Control sequence is to be locked-out in Heating Mode.
    - e. If CO2 levels in the space rise, modulate the outdoor air dampers open and close the return dampers in sequence, as required to satisfy the CO2 sensor settings. Under this sequence, the outdoor air dampers are to be modulated open and not to exceed the cfm scheduled "minimum outside air cfm.
- J. Unoccupied Cooling:
1. Supply and return fans are to be off.
  2. The compressors are to remain off and be locked-out.
  3. The Pre-Heating coil valve, as applicable, is to be fully-closed to coil and/or in coil by-pass.
  4. Energy recovery unit wheel to be off and the bypass dampers are to be fully-open to bypass.
  5. Outside air and relief/exhaust dampers are to be fully-closed and the return damper is to be fully-open.
- K. Occupied Heating:
1. Supply and return fans are to be on.

2. Energy recovery unit bypass dampers are to be closed. Energy recovery unit wheel to be on and rotating. Ramp the rotor speed in sequence with the pre-heating coil valves to maintain discharge air temperature setpoint. Provide a DAT sensor on the discharge side of the wheel. The sensor is to ramp the wheel speed to obtain frost control/defrosting. When the outdoor air temperature is 55F or above (adjustable), the energy recovery unit is to be off and the bypass dampers are to be open (full bypass).
  3. Modulate the outside air damper and return air dampers in sequence in order to meet a mixed air temperature (MAT) setpoint of 55F. The outdoor air dampers should not be allowed to close beyond a 10% minimum.
  4. The discharge air temperature (DAT) sensor is to modulate the preheating coil valve as second-priority to the energy wheel. The pre-heat coil is to be utilized as 'lag' to the wheel in order to maintain a set DAT. The discharge air temperature sensor set point is to be reset by the space sensor calling for the most heat. The discharge air temperature (DAT) is not to be allowed to exceed 55F.
  5. If CO2 levels in the space rise, modulate the outdoor air dampers open and close the return dampers in sequence as required to satisfy the CO2 sensor settings.
    - a. Under this sequence, the outdoor air dampers are to be modulated open and not to exceed the cfm scheduled "minimum outside air cfm". Economizer sequence is to have priority over CO2 sequence.
  6. Cooling is to be locked-out.
- L. Unoccupied Heating:
1. Supply and return fans are to be off.
  2. Pre-heat coil valve to be fully-closed to coil and locked-out.
  3. Energy recovery unit wheel to be off and the bypass dampers are to be fully-open to bypass.
  4. Outside air and relief/exhaust dampers are to be fully closed and the return air dampers are to be fully-open.
  5. Any VAV box space sensor calling for heat, at a reduced temperature setpoint (adjustable), is to cycle the supply and return fans. When the call for heat is satisfied, the reverse sequence is to be applied.
  6. Cooling is to be locked-out.
- M. Building Area Pressure/Space Pressure Relief:
1. Modulate, independently and reactively, the relief/exhaust damper (located in the rooftop unit) based on the building pressure. The relief dampers are to be controlled reactively to the interior space pressure conditions.
  2. The system return/relief fan VFD is to be controlled and ramped by a duct static pressure sensor located on the discharge side of the return fan. Refer to the return fan sequence for this control.
  3. Modulate the outside air damper to maintain building a positive building pressure of +0.05" w.g. (adjustable), subject to freeze protection device.
  4. Provide a means to compare the designated interior space pressure of the area(s) served by the respective air handler to the adjacent corridor space pressure.
- N. Outside Air and Supply Air Flow Monitoring:
1. Measure the outside air and supply air via an airflow measuring station (AFMS).
  2. Provide an air flow measuring station in the outdoor air intake duct and an air flow measuring station at the supply fan inlet. Refer to Section 25 35 00.

3. Provide the capability of monitoring the outside air and supply air volumes.
4. Air flow measuring will be for monitoring only and not be used to control the dampers.

O. Exhaust Systems: Provide interlock between each individual RTU and respective exhaust systems serving the spaces to ensure RTU minimum OA volume is delivered to equal make-up air exhaust air volumes for exhaust systems serving the spaces.

P. Miscellaneous:

1. Provide 'occupied/unoccupied' switching and 'heat/cool' switching capabilities.
2. Provide night setback temperature capability.

Q. Unit shall be provided with the following quantity of points:

1. Points list:

- Supply fan start/stop (DO)
- Supply fan status, current sensor (DI)
- Supply fan VFD modulation (DI)
- Return fan start/stop (DO)
- Return fan status, current sensor (DI)
- Return fan VFD modulation (DI)
- Return/exhaust duct static pressure (AI)
- Supply duct static pressure (AI)
- Preheat coil valve modulation (AO)
- First priority digital scroll compressor (AO) 1<sup>st</sup> stage
- Second stage compressors (AO) 2<sup>nd</sup> stage
- Supply/Discharge air temperature (AI)
- Energy Recovery unit wheel start/stop (DO)
- Energy Recovery rotor status, current sensor (DI)
- Energy Recovery unit VSD modulation (AO)
- Energy Recovery unit bypass dampers, two-position (DO)
- Energy Recovery section discharge air temperature (AI) - utilized for defrost mode
- Return air temperature (AI)
- Mixed air temperature (AI)
- Space Temperature (AI)
- Space Humidity (AI)
- Return duct carbon dioxide (CO<sub>2</sub>) sensor (AI)
- Outside air damper modulation (AO)
- Return air damper modulation (AO)
- Relief air damper modulation (AO) (independently controlled)
- Interior Space pressure (AI)
- Adjacent corridor space pressure (AI) (compared to the interior space pressure being served by the respective air handler)
- Freeze stat/protection (DI)
- Outside air CFM (AI) monitoring only
- Supply air CFM (AI) monitoring only

**ROOFTOP AIR HANDLING UNITS – PACKAGED DX (SINGLEZONE, VARIABLE AIR VOLUME, DX COOLING AND HOT WATER HEATING):**

A. Application:

1. Rooftop Air handling units – RTU-7
2. Return/relief air fans: Integral with the rooftop units.
3. Variable air volume boxes.

- B. Time Schedule: Start and stop supply and return fans. Determine fan status by current sensors. Signal alarm if fan fails to start as commanded.
- C. Safety Devices:
1. Freeze Protection: Stop supply and return fans and close outside air dampers if discharge air temperature falls below 40 degrees F; signal alarm. Provide a 180 second delay. Freeze stat is not to be energized unless fan is running. Provide a reset via the software to allow the operator to reset the system from the BAS workstation.
- D. Variable Air Volume Supply and Return/Relief Fan Control:
1. Provide a duct pressure sensor two-thirds downstream of the supply blower ductwork. The duct pressure sensor is to ramp the supply blower VFD to maintain a set supply duct static pressure.
  2. Provide a duct pressure sensor in the ductwork downstream of the return air blower. The duct pressure sensor is to ramp the return blower VFD to maintain a set return/exhaust duct static pressure. Refer to the relief/exhaust damper sequence associated with this control. The controls contractor is to coordinate and work with the balancing contractor in order to set and calibrate the return duct static pressure setpoint to allow ramping of the return blower VFD.
- E. Morning Warm-up (heating mode only):
1. Start the unit fan variable speed drives and hold the return dampers fully open and the outdoor air dampers fully-closed. Until the supply and return fans are at full operating capacity, lock-out the outdoor air dampers (hold fully-closed) until the space temperature reaches 72 degrees F (adjustable). When the space temperature reaches the desired 'occupied' setpoint, the outdoor air dampers are to be 'enabled' to start their respective 'delayed damper' sequence.
  2. Cooling sequence is to be locked-out.
- F. Delayed Outdoor Air Damper operation:
1. Sequence is to follow the "morning warm-up" sequence and if the space temperatures are satisfied and have reached setpoints.
  2. Provide a damper restrictor to obtain a slow-opening process of the outside air damper (minimum 180 seconds).
- G. Economizer Sequence:
1. Provide a mixed air temperature (MAT) sensor.
  2. Economizer is to be enabled and have priority in both occupied heating and cooling modes.
  3. Economizer 'cooling' and 'heating' mode is to have priority over CO2 control sequence.
  4. Provide enthalpy control.
    - a. When the outside air temperature is between 55 and 79 degrees F, compare return and outside air temperatures along with relative humidity. If return air temperature and humidity is lower:
      - 1) Enable occupied cooling mode.
    - b. When the outside air temperature is between 55 and 79 degrees F, compare return and outside air temperatures. If return air temperature and humidity is higher:
      - 1) Modulate the outside air dampers open and close the return air dampers to maintain a discharge air temperature. Discharge air temperature is to be reset by the space temperature sensor.
  5. For outside air temperatures above 79 degrees F and 55% relative humidity:
    - a. Enable occupied cooling mode.

#### H. Demand-Control Ventilation:

1. Provide a return duct-mounted carbon dioxide sensor.
2. The CO2 sensor is to modulate the outside air damper open (to the CFM amount indicated on the schedules) in order to maintain CO2 levels in the occupied spaces no greater than 1000 PPM (adjustable).
3. In both the heating and cooling modes, when the CO2 sensor is satisfied, the CO2 sensor is to override the MAT or enthalpy controls (if temperatures are satisfied) and close the outdoor air dampers to an arbitrary 5% outdoor air minimum. In this mode, satisfying space temperature using outdoor air (economizer) is to have priority. The demand control ventilation sequence is to be locked-out in unoccupied modes.
4. The Carbon dioxide (CO2) sensor is to be locked-out when the system is in economizer mode. This would apply to both heating and cooling occupied modes.

#### I. Occupied Cooling:

1. Supply and return fans are to be on.
2. The Pre-Heating coil valve is to be fully-closed to the coil and/or in coil by-pass.
3. When the outside air temperature is above 79 degrees F and 55% relative humidity, drive the outside air damper to a minimum position (10%) and open the return damper.
4. DX cooling:
  - a. Unit will be equipped with packaged DX cooling. The units will be provided with interlaced coils served by multiple scroll-type compressors. The coils and compressors will be dual-circuited with digital-pulse scroll technology on the first priority circuit. The units are to be factory wired to allow compressor control/staging by the controls contractor.
  - b. Provide downstream of the supply blower, a discharge air temperature sensor. The discharge air temperature is to be reset by the space temperature sensor calling for the most cooling.
  - c. The discharge air temperature sensor is to stage the compressors in order to maintain DAT setpoint. The first priority compressor is to utilize digital pulse control in order to obtain capacity reduction ability. As the load increases, the second stage compressor is to be staged in tandem with the first priority compressor. As the discharge air temperature becomes satisfied, the reverse sequence is to apply.
5. Humidity Control (Cooling Mode Only):
  - a. Provide space relative humidity (RH) sensors (separate from the space temperature sensors) and locate the sensors in the area in which the unit serves. Each of the RH sensors are to send a signal to obtain an average humidity reading/level for the area. On a rise in humidity (55% or higher), re-set the DAT sensor to maintain a constant discharge temperature of 55F.
  - b. Under the humidity control sequence (when enabled), the discharge air temperature sensor is to maintain a constant discharge air temperature of 55F to 60F (adjustable). When humidity levels have reached setpoint (54%) or are lower, the discharge air temperature sensor shall return to controlling the compressors to maintain DAT setpoint.
  - c. Under this sequence, the VAV box heating coil control valves are to be modulated by their respective space sensor to maintain/satisfy space temperature setpoint. This sequence will have priority over the occupied cooling sequence. As space humidity (RH) levels are lowered and the RH sensors become satisfied, the reverse sequence is to apply and the occupied cooling sequence is to be engaged.
  - d. The Humidity Control sequence is to be locked-out in Heating Mode.

- e. If CO2 levels in the space rise, modulate the outdoor air dampers open and close the return dampers in sequence, as required to satisfy the CO2 sensor settings. Under this sequence, the outdoor air dampers are to be modulated open and not to exceed the cfm scheduled "minimum outside air cfm."

J. Unoccupied Cooling:

1. Supply and return fans are to be off.
2. The compressors are to remain off and be locked-out.
3. The Pre-Heating coil valve, as applicable, is to be fully-closed to coil and/or in coil by-pass.
4. Outside air and relief/exhaust dampers are to be fully-closed and the return damper is to be fully-open.

K. Occupied Heating:

1. Supply and return fans are to be on.
2. Modulate the outside air damper and return air dampers in sequence in order to meet a mixed air temperature (MAT) setpoint of 55F. The outdoor air dampers should not be allowed to close beyond a 10% minimum.
3. The discharge air temperature (DAT) sensor is to modulate the preheating coil valve as second-priority to the energy wheel. The pre-heat coil is to be utilized as 'lag' to the wheel in order to maintain a set DAT. The discharge air temperature sensor set point is to be reset by the space sensor calling for the most heat. The discharge air temperature (DAT) is not to be allowed to exceed 55F.
4. If CO2 levels in the space rise, modulate the outdoor air dampers open and close the return dampers in sequence as required to satisfy the CO2 sensor settings.
  - a. Under this sequence, the outdoor air dampers are to be modulated open and not to exceed the cfm scheduled "minimum outside air cfm". Economizer sequence is to have priority over CO2 sequence.
5. Cooling is to be locked-out.

L. Unoccupied Heating:

1. Supply and return fans are to be off.
2. Pre-heat coil valve to be fully-closed to coil and locked-out.
3. Outside air and relief/exhaust dampers are to be fully closed and the return air dampers are to be fully-open.
4. Any VAV box space sensor calling for heat, at a reduced temperature setpoint (adjustable), is to cycle the supply and return fans. When the call for heat is satisfied, the reverse sequence is to be applied.
5. Cooling is to be locked-out.

M. Building Area Pressure/Space Pressure Relief:

1. Modulate, independently and reactively, the relief/exhaust damper (located in the rooftop unit) based on the building pressure. The relief dampers are to be controlled reactively to the interior space pressure conditions.
2. The system return/relief fan VFD is to be controlled and ramped by a duct static pressure sensor located on the discharge side of the return fan. Refer to the return fan sequence for this control.
3. Modulate the outside air damper to maintain building a positive building pressure of +0.05" w.g. (adjustable), subject to freeze protection device.

4. Provide a means to compare the designated interior space pressure of the area(s) served by the respective air handler to the adjacent corridor space pressure.

N. Outside Air and Supply Air Flow Monitoring:

1. Measure the outside air and supply air via an airflow measuring station (AFMS).
2. Provide an air flow measuring station in the outdoor air intake duct and an air flow measuring station at the supply fan inlet. Refer to Section 25 35 00.
3. Provide the capability of monitoring the outside air and supply air volumes.
4. Air flow measuring will be for monitoring only and not be used to control the dampers.

O. Exhaust Systems: Provide interlock between each individual RTU and respective exhaust systems serving the spaces to ensure RTU minimum OA volume is delivered to equal make-up air exhaust air volumes for exhaust systems serving the spaces.

P. Miscellaneous:

1. Provide 'occupied/unoccupied' switching and 'heat/cool' switching capabilities.
2. Provide night setback temperature capability.

Q. Unit shall be provided with the following quantity of points:

1. Points list:
  - Supply fan start/stop (DO)
  - Supply fan status, current sensor (DI)
  - Supply fan VFD modulation (DI)
  - Supply duct static pressure (AI)
  - Return fan start/stop (DO)
  - Return fan status, current sensor (DI)
  - Return fan VFD modulation (DI)
  - Return/exhaust duct static pressure (AI)
  - Heating coil valve modulation (AO)
  - First priority digital scroll compressor (AO) 1<sup>st</sup> stage
  - Second stage compressors (AO) 2<sup>nd</sup> stage
  - Supply/Discharge air temperature (AI)
  - Return air temperature (AI)
  - Mixed air temperature (AI)
  - Space Temperature (AI)
  - Return Air Humidity (AI)
  - Return duct carbon dioxide (CO2) sensor (AI)
  - Outside air damper modulation (AO)
  - Return air damper modulation (AO)
  - Relief air damper modulation (AO) (independently controlled)
  - Interior Space pressure (AI)
  - Adjacent corridor space pressure (AI)
  - Freeze stat/protection (DI)
  - Cooling coil condensate pan water level detection (DI)
  - Outside air CFM (AI) monitoring only
  - Supply air CFM (AI) monitoring only

### VAV SEQUENCE OF OPERATIONS

1. Application: All variable air volume (VAV) boxes.
2. Minneapolis Public Schools has a standard VAV box control sequence.
3. Provide all control components necessary and field mount the components on each box.

4. Each air handling unit (AHU) is to be linked on the graphics and controlled with its respective group of VAV boxes which serve the air handling system to allow independent graphic control for each VAV system.
5. The VAV will be controlled off of space temperature. The damper will modulate to maintain the airflow set point and discharge air temperature set point.
  - a. In the cooling mode, the airflow set point will modulate between the cooling minimum and maximum limits to maintain the room temperature at set point and the reheat valve and radiation valve will be closed. The VAV goes into cooling mode when the space temperature rises above the cooling temperature set point. The cooling set point will be 76 F. The unoccupied cooling set point will be 83 F.
  - b. In the heating mode, the reheat valve will modulate from 0-100% as necessary to maintain/achieve discharge air temperature set point. (The fin tube radiation control valve is to modulate to control room temperature set point). While in this stage, the airflow set-point will remain constant (80%, adj.). The VAV goes into heating mode when the space temperature drops below the heating temperature set point. The heating set point will be 68 F. The unoccupied heating set point will be 60 F.
  - c. Cooling mode and heating mode are dependent solely on the individual VAV box and whether or not the space requires heating or cooling.
6. When the AHU goes into morning warm up, the VAV will also go into morning warm up.

#### **EXHAUST FANS (SCHEDULE ACTIVATED)**

1. Application:
  - a. All new power roof ventilators (PRVs), inline exhaust fans (EFs), and utility set type fans (USFs). Refer to the equipment schedule for units with this type of control.
  - b. Local motor starter switch provided by Division 26 (as applicable).
  - c. Provide relays and wiring necessary for exhaust fan power interface.
2. 'Enable/disable' designated fan based on occupancy schedule (software adjustable). Units to be controlled in a 'sweep on/sweep off' mode.
  - a. Various exhaust fans are to be interlocked with VAV boxes. Refer to the VAV box schedule for interlocks with designated VAVs.
  - b. Various exhaust fans/utility sets are intended to operate 24/7 such as Flammable Storage Room 192C and Acetylene and Argon Storage Room 188A. These fans are still intended to have scheduling capabilities regardless. The fans serving these spaces are also to be provided with an alarm thru the BAS system when they are not operating due to motor/power failure.
4. Points list:
  - a. Fan enable/disable (DO) – typical for each unit
  - b. Fan status, current sensor (DI) – typical for each unit

#### **EXHAUST FANS (SPACE THERMOSTAT ACTIVATED)**

1. Application:
  - a. All new power roof ventilators (PRVs), inline exhaust fans (EFs), and utility set type fans (USFs). Refer to the equipment schedule for units with this type of control.
  - b. Provide electric controls.
  - c. Local motor starter switch provided by Division 26 (as applicable). Refer to the schedules.
2. Provide relays and wiring necessary for exhaust fan power interface. Provide, where indicated, actuators for remote make-up air dampers. The dampers will be provided by the sheetmetal contractor. The controls contractor is to provide the necessary wiring to the actuator and complete controls to integrate the damper with the exhaust fan control. Damper actuation to be 2-position. Actuator to be manufactured by Belimo. Refer to the drawings for locations.
3. 'Enable/disable' designated fan based on occupancy schedule (software adjustable). Units to be controlled in a 'sweep on/sweep off' mode.

4. Provide localized reverse acting thermostats. On a rise in space temperature, the thermostat is to energize the fan. When the space temperature is satisfied, the reverse sequence is to apply. This contractor is to provide all necessary wiring.
5. Points list:
  - a. Fan enable/disable (DO) – typical for each unit (Exhaust and Transfer Fans)
  - b. Fan status, current sensor (DI) – typical for each unit (Exhaust and Transfer Fans)
  - c. Space temperature/reverse-acting thermostat (AI) – typical for each unit

### **ACETYLENE AND ARGON GAS ALARMS**

- A. Provide both Acetylene and Argon gas sensors and controllers for Acetylene and Argon Storage Room 188A.
- B. Provide audible and visual alarm.
- C. Provide uninterruptible power supply.
- D. The Division 25 contractor is to provide all power connections, transformers and low voltage wiring to install the controllers, sensors, and power supply.
  1. Controllers to send a signal/alarm to BAS.
  2. On a Acetylene or Argon gas sensor alarm, the controller is to energize the fan if disabled. When the Acetylene or Argon gas sensor level is satisfied, the reverse sequence is to apply. This contractor is to provide all necessary wiring.
- E. Points list:
  - Acetylene Gas Alarm (DI)
  - Argon Gas Alarm (DI)
  - Fan enable/disable (DO) – typical for each unit (Exhaust Fan)
  - Fan status, current sensor (DI) – typical for each unit (Exhaust Fan)

### **GASOLINE (COMBUSTIBLE) GAS ALARMS**

- F. Provide gasoline (combustible) gas sensors and controllers for Flammable Storage Room 192C.
- G. Provide audible and visual alarm.
- H. Provide uninterruptible power supply.
- I. The Division 25 contractor is to provide all power connections, transformers and low voltage wiring to install the controllers, sensors, and power supply.
  1. Controllers to send a signal/alarm to BAS.
  2. On a gasoline (combustible) gas sensor alarm, the controller is to energize the fan if disabled. When the gasoline (combustible) gas sensor level is satisfied, the reverse sequence is to apply. This contractor is to provide all necessary wiring.
- J. Points list:
  - Gasoline (combustible) Alarm (DI)
  - Fan enable/disable (DO) – typical for each unit (Exhaust Fan)
  - Fan status, current sensor (DI) – typical for each unit (Exhaust Fan)

### **HYDROGEN GAS ALARMS**

- K. Provide hydrogen sensors and controllers for Electrical Room 191L.
- L. Provide audible and visual alarm.
- M. Provide uninterruptible power supply.

N. The Division 25 contractor is to provide all power connections, transformers and low voltage wiring to install the hydrogen controllers, sensors, and power supply.

1. Controllers to send a signal/alarm to BAS.
2. On a hydrogen sensor alarm, the controller is to energize the fan. When the hydrogen sensor level is satisfied, the reverse sequence is to apply. This contractor is to provide all necessary wiring.

O. Points list:

- Hydrogen Alarm (DI)
- Fan enable/disable (DO) – typical for each unit (Exhaust and Transfer Fans)
- Fan status, current sensor (DI) – typical for each unit (Exhaust and Transfer Fans)

### **FINNED TUBE RADIATION**

1. Application: Finned Tube Radiation (FTR).

- a. Provide DDC controls and new valves
- b. Occupied heating: The respective space sensor is to modulate the radiation heating valve to maintain space temperature of 75 degrees (adjustable). When the radiation serves the same space served by a VAV box, sequence the radiation control with the VAV box reheat coils, refer to VAV sequence.
- c. Unoccupied heating: The respective space sensor is to modulate the radiation heating valve to maintain a reduced space temperature of 60 degrees (adjustable).
- d. Cooling Mode: Valves are to be fully-closed to the radiation and locked-out
- e. Unit to be provided with the following quantity of point:
  - 1) Points list:
    - Space temperature (AI)
    - Heating valve modulation (AO)

### **UNIT HEATERS**

1. Application: unit heaters (i.e.: cabinet-type, horizontal-type and vertical-type)
  - a. Provide a 2-way control valve to the piping contractor for installation.
  - b. Provide an aquastat installed on the unit coil **return** pipe. Provide all necessary wiring from aquastat to unit fan motor.
  - c. The wall-mounted electric thermostat, on a call for heat, is to open the two-way heating valve serving the unit heater coil. On a signal from the coil return pipe aquastat, the elevated temperature is to cycle the fan on. When the space temperature reaches setpoint, the coil valve is to close, the return pipe temperature cools and the reverse sequence is to be applied.
  - d. The Division 23 contractor is to provide all necessary control wiring and components in order to provide a complete control sequence for each unit.

### **BUILT-UP AIR HANDLING UNIT/DUCT-MOUNTED HOT WATER HEATING COILS**

A. Application: SF-01/DHC-01.

1. Supply Fan is to be enabled and on during occupied hours.
2. Duct-mounted hot water heating coil serving built-up AHU (consisting of supply fan and duct mounted heating coil).
3. Provide all control components necessary and as follows:

4. The air handler is to be linked on the graphics and controlled with its respective group of duct-mounted hot water heating coils which service the air handler system to allow independent graphic control for each system. The heating coils are to be integrated into the controls of the air handling unit.
5. In heating mode:
  - a. The heating coil control valve is to be modulated by the space temperature sensor in order to maintain the space temperature sensor setpoint. When the space temperature sensor becomes satisfied, the reverse sequence is to apply.
6. Points for each hot water heating coil:
  - Space temperature (AI) per space
  - Heat coil valve modulation (AO) per space/zone
  - Coil discharge air temperature (AI) per coil

#### **REPLACEMENT HEATING COIL IN EXISTING AIR HANDLING UNIT (HOT WATER HEATING COIL)**

##### **A. Application: Existing Air Handling Unit (Science).**

1. Project scope includes replacement of existing steam heating coil in existing air handling unit. New heating coil is to be a hot water heating coil. Intent is for existing control sequences in-place to be maintained.

##### **B. Provide all control components necessary.**

#### **DESTRATIFICATION FANS**

##### **A. Application: Destratification Fans (refer to notes on schedule).**

1. Provide relays and wiring necessary for destratification fan power interface.
2. 'Enable/disable' designated fan based on occupancy schedule (software adjustable). Units to be controlled in a 'sweep on/sweep off' mode.
3. Destratification fans are to be interlocked with their respective air handler system serving the common space in order to have the same scheduling. These fans are to have speed control through the BAS. All of these fans will control to the same speed setpoint.

##### **B. Each fan unit to be provided with the following quantity of points:**

1. Points list:
  - Fan enable/disable (DO) – typical for each unit
  - Fan status, current sensor (DI) – typical for each unit
  - Fan speed, (DO)

#### **HEATING PUMPS (VARIABLE SPEED PUMPING)**

##### **A. Application:**

1. Heating Pumps HWP-1 and HWP-2.

##### **B. Utilize the pump start/stop operation through the building automation system. Utilize the pump status by current sensing devices. Signal alarm if pump fails to start as commanded.**

##### **C. Heating Mode:**

1. Pumps are to be operated in a primary mode. Each pump to alternate as stand-by to the other for 100% redundancy. Ramp each pump's variable speed drive in order to maintain system pressure setpoint as controlled by the remote pressure differential pressure sensors.
2. Provide a remote pressure differential sensor on the supply and return piping. Signal an alarm if pressure/flow drops below minimum setpoint (adjustable).

3. Pump variable speed drives are to receive a signal from the remote loop pressure differential pressure sensor(s). The signal is to control the pump variable speed drive to maintain a pressure setpoint. The remote pump differential pressure sensors are to be supplied by the controls contractor for installation by the piping contractor. The controls contractor will be responsible for providing the control wiring and the installation of the wiring between each remote pressure sensor and the respective pump VFD controls. Wiring to be routed through a dedicated metallic EMT conduit.

D. Cooling Mode:

1. Pumps are to be off and locked-out.

E. Unit to be provided with the following quantity of points:

1. Points List:
  - Pump start/stop (DO) per pump
  - Pump status, current sensor (DI) per pump
  - Pressure differential sensor (DI)

### **STEAM TO WATER HEAT EXCHANGER**

A. Application:

1. Heat exchanger: HX-1.
2. Heating pumps: Refer to Heating Pumps Sequence.

B. Provide DDC controls.

C. In both Cooling and Heating Mode:

1. Enable and start the respective water heating pump (HWP-1 or 2) in order to circulate heating water thru the heat exchanger.
2. On a sense of flow from the heating pump, enable the heat exchanger sequence.
3. Provide heating water supply and return temperature sensing capability. Signal an alarm of high priority to BAS terminal if supply water temperature falls below setpoint (adjustable).
4. The heating supply water temperature sensor is to modulate the 2-way steam control valve(s) in sequence to maintain a re-set water supply water temperature setpoint (adj). The sequence is to be based on a master-outdoor reset schedule based on the colder the outdoor temperature, the greater the heating water temperature and the warmer the outdoor temperature, the less intensity of heating water temperature. This contractor to provide the steam control valve(s) to the piping contractor for installation. The steam control valves are to be provided to fail-closed under power loss.

D. System to be provided with the following quantity of points:

1. Points list:
  - Steam Heating valve modulation (AO), per valve
  - Supply water temperature (AI)
  - Return water temperature (AI)
  - Pump control enable/disable (DO) interlock with heat exchanger

### **SPACE CO DETECTION**

A. Application:

1. Space carbon monoxide detection.

B. Provide DDC controls

- C. Provide carbon monoxide sensors in sufficient quantities to provide proper coverage in the following spaces:
  - 1. Existing Boiler Room
- D. Signal alarm when carbon monoxide is sensed.
- E. Points for each carbon monoxide detector:
  - Carbon monoxide sensor (AI) per sensor

## MONITORING POINTS

- 1. Provide the following general points, which are to be utilized for all applicable equipment or general knowledge. Display values on the BAS graphics screen upon demand from the system operator.
- 2. Points list:
  - Outside air temperature (AI)
  - Outside air humidity (AI)
  - Outside air dewpoint (AI)
  - Outdoor atmospheric pressure
  - Server 181A temperature (AI)
  - Server 181A high space temperature alarm (DI)
  - Water Service 191K temperature (AI)
  - Water Service 191K high space temperature alarm (DI)
  - Electrical 191L temperature (AI)
  - Electrical 191L high space temperature alarm (DI)
  - Vestibules/Storage Rms low space temperature alarm (DI) – Quantity 4
  - Vestibules/Storage Rms space temperature (AI) – Quantity 4

## MISCELLANEOUS

- 1. Provide the following modes for each air handling system (modes accessible by toggling a software switch on front end computer):
  - a. Normal mode: Systems operate as described in sequence of operations.
  - b. No-student day mode: Systems shall operate as described in sequence of operations. Outside air shall be reduced to a fixed 5% of the full air volume. Systems shall revert to normal mode after twenty-four (24) hours (adjustable).
  - c. Cleaning mode: Systems shall operate as described in sequence of operation. Outside air shall be indexed to 100% of the full air volume. Systems shall revert to normal mode after twenty-four (24) hours (adjustable).
  - d. Drying mode (during the cooling season): Systems shall operate as described in sequence of operations. Outside air shall be reduced to 5% of the full air volume. Systems shall revert to normal mode after twenty-four (24) hours (adjustable).
  
- A. All Sequence of Operations and all DDC Points Lists shall be located on the Plan Sheets.
- B. The Sequence of Operations and the associated DDC Points List shall be in the same table, as shown below.
- C. EXAMPLE: VFD - CONTROL BLOCK: Integration to BMA - BACnet, Lonworks, Modbus - BAS to Open Protocol Points List



D. EXAMPLE: VAV AHU RUN ENABLE - CONTROL BLOCK: Sequence of Operations and Points Listing

COMPONENT SEQUENCE OF CONTROL BLOCKS		Hardware Points							Software Points									
		AI = Analog Input						CV = Calculated Value										
		AO = Analog Output						HA = High Alarm										
		DI = Digital Input						LA = Low Alarm										
		DO = Digital Output						OP = Open Protocol - BACnet, LON, Other										
		HIL = Hardwired Interlock to a Motor Starter						SA = Status Alarm										
								SC = Schedule										
								SIL = Software Interlock										
								SP = Setpoint										
								TL = Trend Log										
VAV AHU RUN ENABLE CONDITIONS BLOCK																		
SEQUENCES		POINTS		HARDWARE							SOFTWARE							OTHER
		AI	AO	DI	DO	HIL	CV	HA	LA	OP	SA	SC	SIL	SP	TL	SHOW ON GRAPHIC		
1.	Unit shall be automatically or manually enabled to run in Occupied or Unoccupied mode as follows:																	
	a. Automatic operation in Occupied/Unoccupied modes shall be as defined below in the VAV Zone Terminal Unit Interface, Fan Control and Outdoor Air Control Sections				X											X		
	b. OR Manually selected by user from graphic interface.			X							X					X		
	c. When the unit is stopped (manually, automatically in unoccupied, or from safety functions), the fans shall be de-energized, the minimum and economizer outside air (OA) dampers shall close, the exhaust air (EA) damper shall close and return air (RA) dampers shall open.				X											X		
	d. At a minimum, all VAV terminal units served by an AHU shall be linked with associated VAV AHU controller to perform the following functions.			X							X					X		
	d1. Zone occupancy schedule (user defined from graphic interface) shall normally automatically select the Occupied or Unoccupied operating mode of air handling unit.				X											X		
	d2. Activation of timed override switch on zone thermostats (if present) shall only reset zone heating and cooling setpoints to "occupied" values, but shall not affect otherwise scheduled Unoccupied operating mode of air handling unit.			X							X					X		
	d3. VAV Terminal Minimum Reset for pressure relief: If a majority of VAV terminal units on a fan system have the ability to reset to full shutoff during normal occupied periods (such as in "Standby" mode), then if the actual duct static pressure exceeds the maximum static pressure setpoint with fan at minimum speed, then disable resetting VAV terminal unit airflow minimums to 0 and maintain at normal minimum occupied airflow.																	
2.	AHU Optimal Start: During this warm-up/cool-down mode, the unit air mixing dampers shall operate as described in the Unoccupied mode. The AHU shall be started upon request from any of its associated air terminal unit controllers with Zone level optimal start.							X										
	AHU Unoccupied Mode: a. Multiple space VAV air terminal unit application: The AHU unit shall normally be off and be enabled as necessary to satisfy a user definable minimum number of zone heating or cooling requests. The Supply Air Fan shall operate under normal fan control; the return or relief fans shall track the supply air with a differential. The fans shall run for a minimum of 30 minutes (adj.) or until there are no zone heating/cooling requests as defined at the VAV Terminal Unit control level.							X										
	(Comments and Notes for the DDC Programmer) All schedules are being set to specific spaces rather than equipment. Spaces require occupancy, and equipment should just follow and serve the proper spaces as required. This is contradictory than the way equipment schedules have been applied for years. Can be challenging to communicate to programmer. "Big-Picture" understanding of building is required to accomplish this, not always understood. Consideration must be given to minimum capacity of equipment. For example, it may be necessary to enable several VAV's if a single VAV is activated to maintain unocc temp in it's zone. This will force at least minimum airflow from AHU to allow it to run properly.										X							
	VAV Optimum Start: Control is Defined in the VAV Zone Control Block																	



ZONE VAV AIR TERMINAL UNIT INTERFACE BLOCK																		
SEQUENCES		POINTS	HARDWARE							SOFTWARE							OTHER SHOW GRAPH	
			AI	AO	DI	DO	HIL	CV	HA	LA	OP	SA	SC	SIL	SP	TL		
1	At a minimum, all VAV terminal units served by an AHU shall be linked with associated VAV AHU controller to perform the following functions.	VAV BOX - TEMP SENSOR	X					X										X
2	Zone occupancy schedule (user defined from graphic interface) shall normally automatically select the Occupied or Unoccupied operating mode of air handling unit.																	
3	Activation of timed override switch on zone thermostats (if present) shall only reset zone heating and cooling setpoints to "occupied" values, but shall not affect otherwise scheduled Unoccupied operating mode of air handling unit.																	
4	Duct static pressure reset as described in Fan Control section.																	
5	Discharge air temperature setpoint – as described in the Discharge Temperature Control section.																	
6	When AHU is in economizer mode, minimum occupied airflow setpoint on VAV terminals shall be automatically reset based on percentage of outside air above design minimum.																	
7	As percentage of OA increases at AHU (with minimum OA damper at 100% and as economizer PID output increases from 0-100%), minimum airflow setpoint at terminal units shall proportionately reset lower to maintain required minimum fresh air ventilation.																	
8	Resetting shall occur based on increments of 10% change of value of economizer PID output.																	
9	Demand Based Ventilation Control (if present): During occupied mode, Demand Ventilation controls shall monitor and satisfy zone ventilation requests. The Demand Ventilation Controls shall first increase zone minimum airflow to satisfy ventilation requirements, and then increase the outdoor air rate at the air handler. Coordinate with the associated section in the most current revision of the VAV terminal unit sequence for multiple zone systems and network the zone ventilation requests to the AHU controller.																	
10	VAV Terminal Minimum Reset for pressure relief: If a majority of VAV terminal units on a fan system have the ability to reset to full shutoff during normal occupied periods (such as in "Standby" mode), then if the actual duct static pressure exceeds the maximum static pressure setpoint with fan at minimum speed, then disable resetting VAV terminal unit airflow minimums to 0 and maintain at normal minimum occupied airflow.																	

### 3.06 THIRD PARTY INTEGRATION MANAGEMENT - OPEN PROTOCOL DEVICES

- A. **PURPOSE:** The purpose of the Integration is to gather and use a larger number of points from specific units that will provide more information and controllability to the BAS system than just by adding a few sensors. HVAC equipment, which can have LonWorks devices are: variable frequency drives, chillers, boiler controllers, packaged energy recovery units, make up air units, computer room air conditioning units, etc. The actual values the equipment it is controlling are to be displayed to aid with future troubleshooting and understanding equipment performance where the offset value shown from a second independent sensor may hide the root problem.
- B. **CONTROLS CONTRACTOR RESPONSIBILITIES:** The successful controls contractor is to research do planning and reading to figure out how to implement the integration. It is recommended that they call the phone number on the installations and operations manual and discuss a plan and details with factory tech support. There will be a point's list and description somewhere that helps define each value.
- C. **COMMUNICATIONS CARD AND PROTOCOL:** The communication card is to be provided on the HVAC or Variable Frequency Drive units, as specified in their respective division 23. Specific protocols; Use BACnet, LonWorks, Modbus, OPC, SMS or what other specific manufacturer has chosen to standardize on. If a standard factory option, provide a self-discovery protocol like BACnet or LonWorks.
- D. **NETWORK MANAGEMENT COMMUNICATIONS TRUNK:** Keep the wiring to integrated pieces of equipment separated from the field controllers. Run a separate comm port and comm wire segment to support the integrated equipment because it expedites the process to rule out many of the first tech support questions like; address conflict, comm bus length and routing, interference from other types of controllers. It also helps to adjust baud rate, parity and other comm settings where if you have to change all the other controllers on a comm bus, this can really take time. Comm wires should get polled as a test to make sure comm drop and this problem is reflected on the Niagara system. However, "if after all the steps above are completed and the integration fails, then the contractor is not responsible for going any further"
- E. **VERIFICATION OF INTEGRATED VALUES:** Integrated values must be verified, double-check against an LCD display or measured values from an instrument. Typically just one point of each type of facet needs to be verified to confirm any conversion factors or zero shifting and the remaining points are all done the same way.

### 3.07 INSTALLATION

#### A. GENERAL

1. Install system and materials in accordance with manufacturer's instructions, and as detailed on the project drawing set.
2. Line and low voltage electrical connections to control equipment shown specified or shown on the control diagrams shall be furnished and installed by the Control System Contractor in accordance with these specifications.
3. Equipment furnished by the Mechanical Contractor that is normally wired before installation shall be furnished completely wired. Control wiring normally performed in the field will be furnished and installed by the Control System Contractor.
4. All control devices mounted on the face of control panels shall be clearly identified as to function and system served with permanently engraved phenolic labels.

#### B. WIRING

1. All electrical control wiring to the control panels shall be the responsibility of the Control System Contractor.
2. All wiring shall be in accordance with the Project Electrical Specifications, the National Electrical Code and any applicable local codes. All control wiring shall be installed in raceways.
3. Existing sensor wiring may be reused if in proper working condition and in compliance with the requirements outlined in the project documents.
4. New power and communications wiring is required. One data drop is required per controller.
5. All control wiring below 8 feet in Mechanical Rooms shall be installed in conduit.

#### C. CONTINUITY OF OPERATION AFTER ELECTRIC POWER INTERRUPTION

1. Equipment and associated factory-installed controls, field installed controls, electrical equipment and power supplies connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without the need for manual interventions by operator when power is restored either through backup power source or through normal power is restored before backup power is brought online.

### 3.08 PROJECT CLOSEOUT

#### A. ACCEPTANCE TESTING

1. Upon completion of the installation, the Control System Contractor shall load all system software and start-up the system. The Control System Contractor shall perform all necessary calibration, testing and de-bugging and perform all required operational checks to insure that the system is functioning in full accordance with these specifications.
2. The Control System Contractor shall perform tests to verify proper performance of components, routines, and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100% of the input and output points and sequences of operation of the DDC system. Upon completion of validation testing, prepare and submit a report showing status of all I/O points and sequences. Identify adjustments or corrections made and indicate instruments that were replaced.
3. System Acceptance: Satisfactory completion is when the Control System Contractor has performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the Owner's Representative. Acceptance shall include:
  - a. Demonstrate accuracy and calibration of 15% of the I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying the performance requirements indicated, additional I/O points may be selected by reviewers.
  - b. Demonstrate operation of randomly selected dampers and valves in normal-on, normal-off and failed positions.

- c. Demonstrate reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.
- d. For up to 15% of HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set points of 20% or more.

### **3.09 OPERATOR TRAINING**

- A. During system commissioning and at such time acceptable performance of the Control System hardware and software has been established, the Control System Contractor shall provide on-site operator instruction to the owner's operating personnel. Operator instruction shall be done during normal working hours and shall be performed by a competent representative familiar with the system hardware, software and accessories.
- B. The Control System Contractor shall provide two (2) hours of comprehensive training for system orientation, product maintenance and troubleshooting, programming and engineering, if not provided under a previous contract at the site using the same brand and type of controllers within the previous 3 years.

### **3.10 WARRANTY SERVICE PERIOD AND SOFTWARE MAINTENANCE EXTENDED SERVICES**

- A. Equipment, materials and workmanship incorporated into the work shall be warranted for a period of one year from the time of system acceptance.
- B. Within this period, upon notice by the Owner, any defects in the BAS due to faulty materials, methods of installation or workmanship shall be promptly repaired or replaced by the Control System Contractor at no expense to the Owner
- C. Maintenance of Computer Software Programs: The Control System Contractor shall maintain all software during the warranty period. In addition, all factory or sub-vendor upgrades to software shall be added to the systems, when they become available, at no additional cost. New products are not considered upgrades in this context.
- D. Maintenance of Control Hardware: The Control System Contractor shall inspect, repair, replace, adjust, and calibrate, as required, the controllers, control devices and associated peripheral units during the warranty period. The Control System Contractor shall then furnish a report describing the status of the equipment, problem areas (if any) noticed during service work, and description of the corrective actions taken. The report shall clearly certify that all software is functioning correctly.
- E. Service Period: Calls for service by the Owner shall be honored within 24 hours and are not to be considered as part of routine maintenance.
- F. Service Documentation: A copy of the service report associated with each owner-initiated service call shall be provided to the owner.
- G. All JACE controllers are to include a five year software maintenance upgrade agreement that allows updates to the latest revision of the controller firmware.

### **3.11 WARRANTY ACCESS**

- A. The Owner shall grant to the Control System Contractor reasonable access to the BAS during the warranty period. Remote access to the BAS (for the purpose of diagnostics and troubleshooting, via the Internet, during the warranty period) will be allowed.

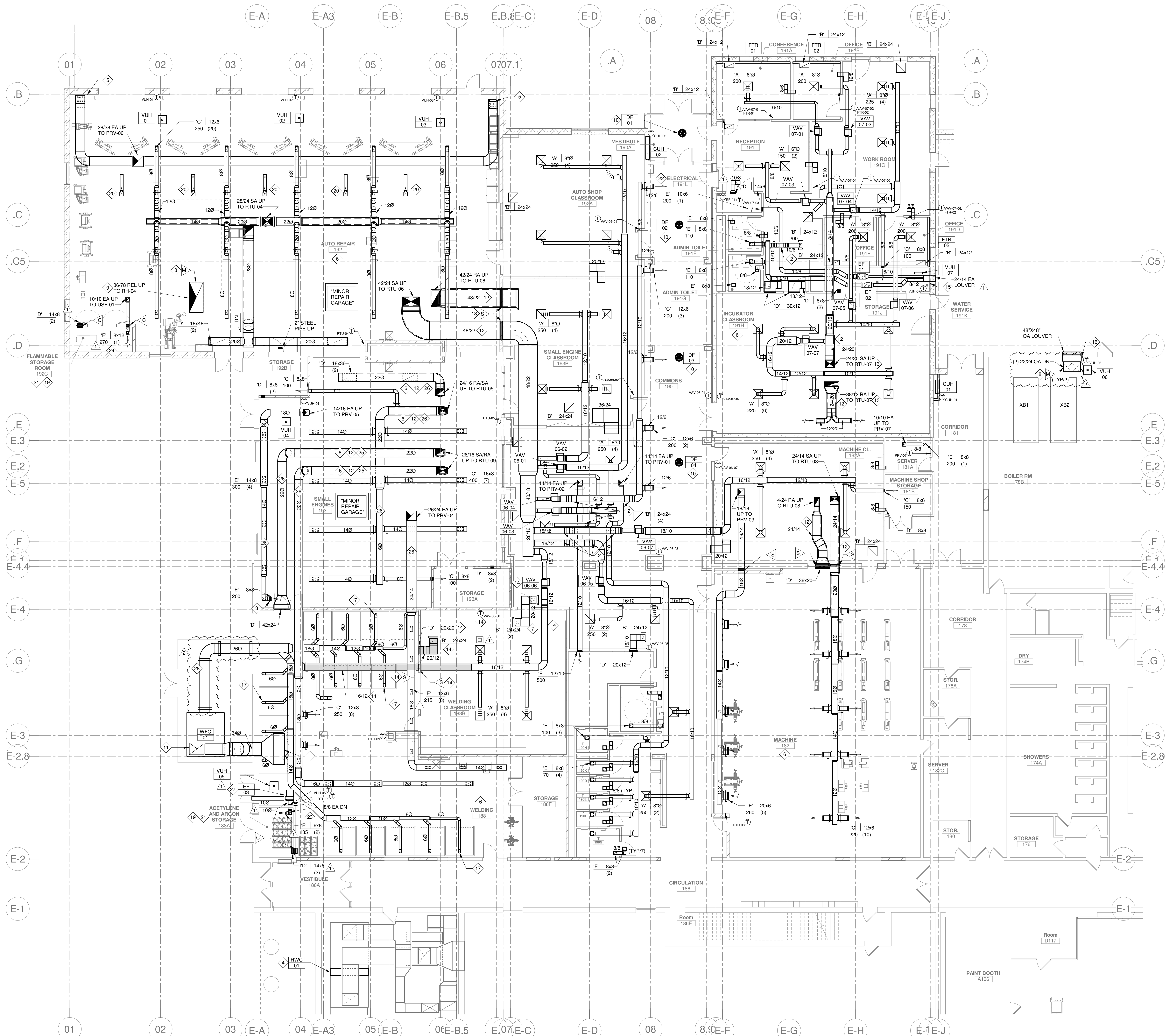
### **3.12 OPERATION & MAINTENANCE MANUALS**

- A. See Division 1 for requirements. O&M manuals shall include the following elements, as a minimum:
  1. As-built control drawings for all equipment.
  2. As-built Network Communications Diagram.
  3. General description and specifications for all components.

4. Completed Performance Verification sheets.
5. Completed Controller Checkout/Calibration Sheets.

**END OF SECTION 230900**

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### GENERAL NOTES - HVAC

- A. IDENTIFY ANY INSULATION, FITTINGS, TILE PLASTER, ETC. WHICH MAY CONTAIN ASBESTOS AND IDENTIFY OWNER. OWNER SHALL REMOVE ASBESTOS BY SEPARATE CONTRACTOR. THIS CONTRACTOR SHALL REINSULATE ALL ABATED PIPING REMAINING.
- B. REMOVE AND REINSTALL ALL EXISTING CEILING SYSTEMS REQUIRED FOR DEMOLITION AND INSTALLATION OF NEW PIPING, DUCTWORK, CONTROLS, ETC. UNLESS NOTED OTHERWISE ON ARCHITECTURAL DRAWING.
- C. PROVIDE VOLUME DAMPER AT EVERY BRANCH DUCT FROM MAINS. LOCATE DAMPERS NEXT TO MAIN WITH HANDLES EASILY ACCESSIBLE.
- D. ALL ELBOWS THROUGHOUT THE BUILDING THAT CANNOT FIT A LONG SWEEP RADIUS ELBOW TO BE A SHORT RADIUS ELBOW WITH TURNING VANES. IF DUCT IS OVER 48" ELBOW SHALL HAVE AN INSIDE RADIUS OF 12". IF DUCT IS UNDER 48" ELBOW SHALL HAVE AN INSIDE RADIUS OF 6". CONSTRUCT SHORT RADIUS ELBOWS AS PER SMACNA DUCT CONSTRUCTION STANDARDS 2020.
- E. LOCATE DUCTWORK AS HIGH AS POSSIBLE. DUCTWORK UNDER BEAMS MUST BE TIGHT TO STRUCTURE.
- F. TRANSFER DUCT TO BE INTERNALLY LINED.
- G. DUCT TO VAV BOXES SAME AS INLET SIZE UNLESS NOTED OTHERWISE.
- H. FIELD VERIFY ALL EXISTING CONDITIONS.
- I. ALL DUCTWORK WITHIN 25'-0" DOWNSTREAM OF SUPPLY FANS AND WITHIN 25'-0" UPSTREAM OF RETURN FANS TO BE DOUBLE WALL PERFORATED DUCT WITH INTERNAL INSULATION AND LINER.
- J. PROVIDE FIRESTOPPING FOR ALL OPENINGS THRU FIRE RATE WALLS.

### KEYNOTES

1. PROVIDE SAFETY FILTER.
2. ROUTE DUCT BRANCH UP INTO JOIST SPACE.
3. ROUTE 10"Ø ROUND EXHAUST ALONG SIDE WALL DN TO 24" A.F.F. PROVIDE EXHAUST GRILLE MOUNTED 45° POINTED AT THE GROUND.
4. INSTALL NEW HW HEATING COIL INTO EXISTING AHU. PROVIDE SHEETMETAL MATERIALS AND LABOR AS REQUIRED TO MOUNT NEW COIL IN EXISTING UNIT. CONTRACTOR TO TRIM COIL FLANGES AS NECESSARY.
5. DROP 24"12" EXH DUCT DN TO 2" A.F.F. ANGLE DUCT AT 45° POINTED AT FLOOR. PROVIDE BIRDSCREEN AT END OF DUCT.
6. ALL EXPOSED DUCTS TO BE PAINT GRIP READY. ALL EXPOSED DUCTWORK TO BE SEALED INTERNALLY.
7. CONSTRUCTION PHASE 2: PROVIDE TRANSFER DUCT AND GRILLES.
8. PROVIDE PARALLEL BLADE MOTORIZED DAMPERS, CONTROLS CONTRACTOR TO PROVIDE THE ACTUATORS AND ASSOCIATED WIRING TO OPERATE THE DAMPERS. MAINTAIN EXISTING INTERLOCKS WITH EXISTING BOILERS. PROVIDE 18"x18" ACCESS PANEL. POWER TO BE 120V.
9. REL DUCTS TO BE MOUNTED HIGH AS POSSIBLE.
10. PROVIDE NEW DESTRAT FAN. MOUNT HIGH AS POSSIBLE IN STRUCTURE.
11. PROVIDE SILENCER.
12. PROVIDE DOUBLE WALL PERFORATED DUCT 25' DOWNSTREAM OF SUPPLY FANS AND UPSTREAM OF RETURN FANS.
13. DUCT PENETRATIONS OF STORM SHELTER ROOF TO BE PROTECTED BY RATED SHROUD. REFER TO SPEC 21.05.29 PROVIDE CYCLONE CWS SHROUD AND INSTALL BELOW ROOF DECK. FOLLOW MANUFACTURERS INSTRUCTIONS.
14. PHASE 1: WELDING CLASSROOM WILL BE RUN OFF OF RTU-09 AS INDICATED WITH SHADED DUCTWORK. PROVIDE TRANSFER AS INDICATED.  
PHASE 2: WELDING CLASSROOM WILL BE SERVED BY RTU-06-VAV-06-06 AS INDICATED ON PLANS. CONTRACTOR TO PROVIDE ALL LABOR AND MATERIALS REQUIRED TO DISCONNECT AND CAP 16"12" SA DUCT AND SMOKE DAMPER FROM RTU-09 MAIN. DISCONNECT AND REMOVE TRANSFER FROM 18B1188 AND PATCH WALL AIRTIGHT. PROVIDE NEW 18"12" SA DUCT. CONNECT TO VAV-06-06 AND ALL ASSOCIATED REBALANCE WORK OF BOTH SYSTEMS.
15. PROVIDE 24" DEEP PLENUM BEHIND LOUVER.
16. PROVIDE 18" DEEP PLENUM BEHIND OA LOUVER.
17. DROP TO WELDING SLOT EXHAUST PLENUM TYP EACH STATION. REFER TO DETAIL 14.M502.
18. PROVIDE SMOKE DAMPER.
19. PROVIDE A GAS DETECTION SYSTEM FOR THIS ROOM AND CONNECT TO BAS TO SIGNAL AN ALARM.
20. CAR EXHAUST FAN SYSTEM. EXHAUST DUCT UP THRU ROOF TO GOOSENECK. FOLLOW MANUFACTURERS INSTRUCTIONS FOR INSTALLATION AND HANGING IN STRUCTURE. PROVIDE AUTOMOTIVE SERIES 35'x4" HOSE WITH 32" HOSE REEL WITH 1 HP MOTOR.
21. PROVIDE A SIGN STATING THE MAXIMUM STORAGE MUST BE POSTED OUTSIDE OF THIS ROOM. REFER TO ARCH PLANS FOR EXACT VERBIAGE.
22. PROVIDE H2 GAS DETECTION FOR INVERTER AND EXHAUST FAN. REFER TO SPEC.
23. DROP EXHAUST DUCT DOWN IN STORAGE RM. LOW GRILLE. MOUNT 12" A.F.F. HIGH GRILLE. BOTTOM OF GRILLE 12" BELOW STRUCTURE.
24. MOUNT TOP OF GRILLE TO BE 12" A.F.F.
25. ROUTE MAIN DUCT IN BETWEEN STRUCTURE AS HIGH AS POSSIBLE.
26. ROUTE MAIN DUCT BELOW AND AS TIGHT TO STRUCTURE AS POSSIBLE.
27. PROVIDE ANGLE IRON SUPPORT PLATFORM SUPPORTED FROM ROOF STRUCTURE. PRIME AND PAINT WITH 2 COATS ENAMEL PAINT (GRAY).
28. PROVIDE DUCT SUPPORT STANDS AS REQUIRED. REFER TO DETAIL 16.M502. MAINTAIN ACCESS TO FUME COLLECTOR DRUMS.

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952.436.1100 Fax: 952.436.3218

**Key Plan**

Legend:  
C ADD PHASE 2  
B RENO - EXIST  
A RENO - EXIST

TRUE NORTH

I hereby certify that this plan, specification or report was prepared by me or under my direct supervision and that I am a duly Licensed PROFESSIONAL ENGINEER under the laws of the STATE OF MINNESOTA

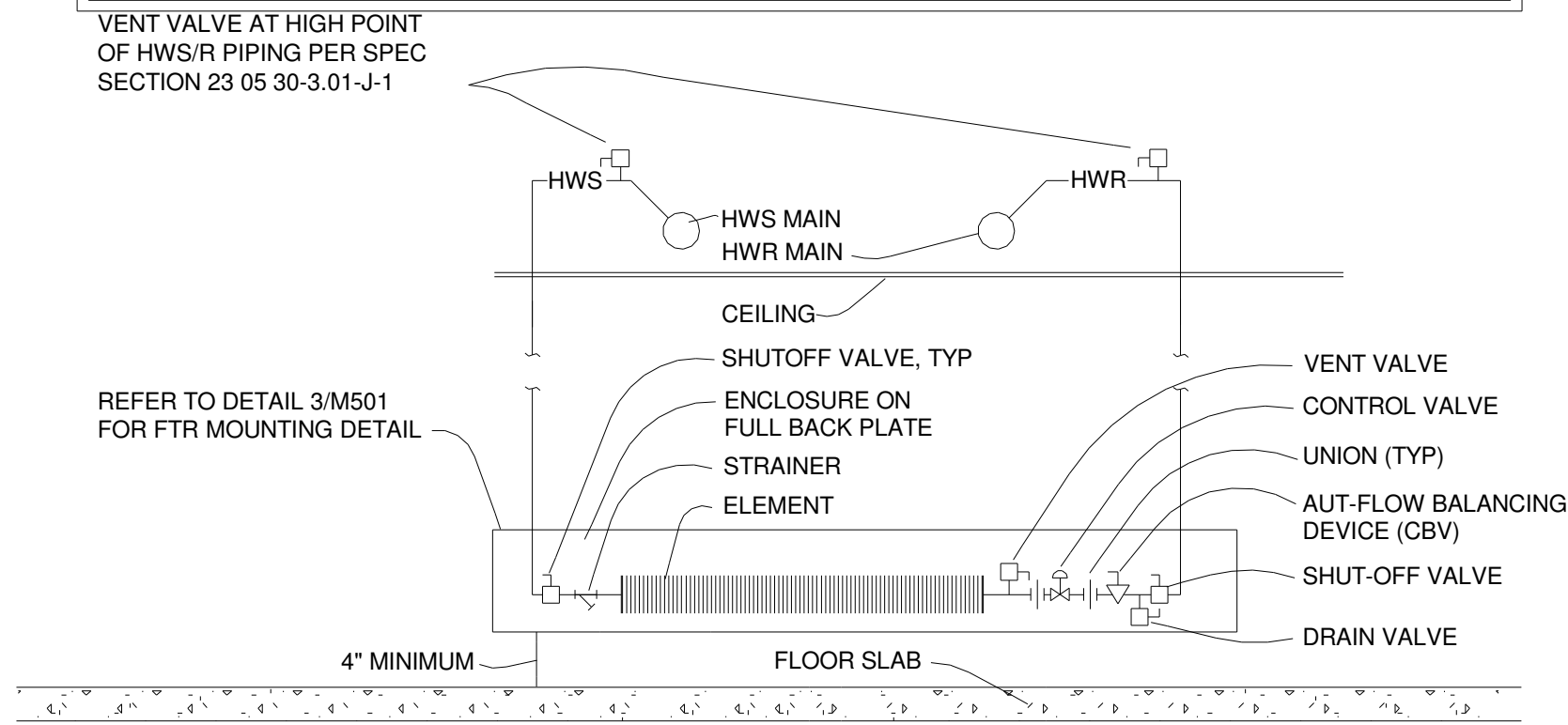
*Trevor Gilbertson*  
TREVOR GILBERTSON  
License Number: 49181 Date: 04/14/2026

No.	Date	Revision Description
1	04/23/2026	ADDENDUM #1
2	05/05/2026	ADDENDUM #3

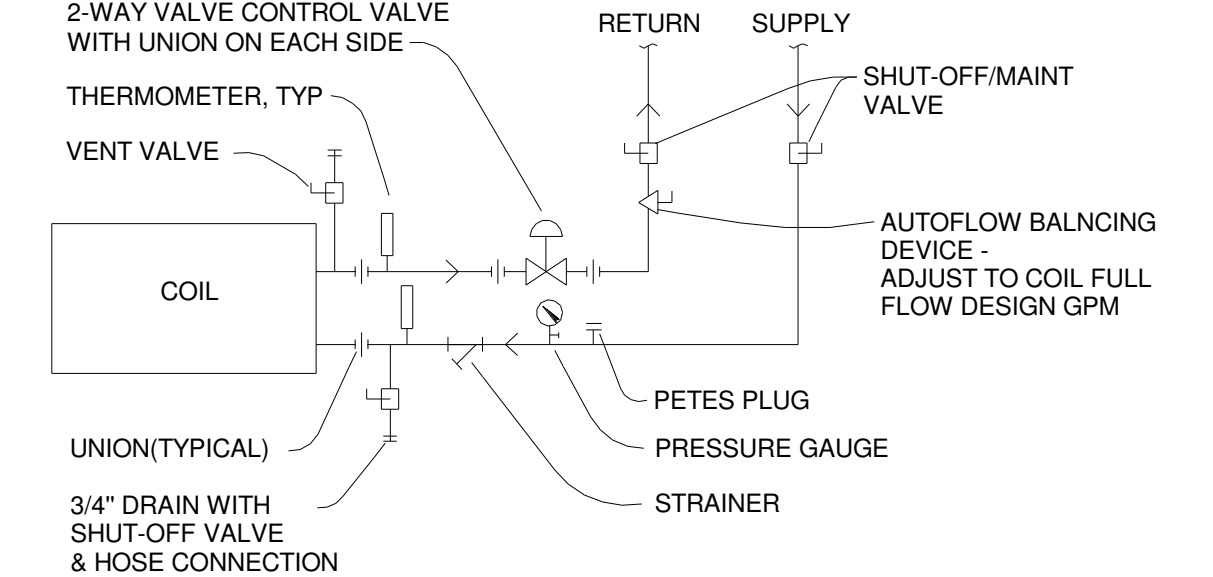
### CONSTRUCTION DOCUMENTS LEVEL 1 VENTILATION PLAN

1 LEVEL 1 VENTILATION PLAN  
1/8" = 1'-0"

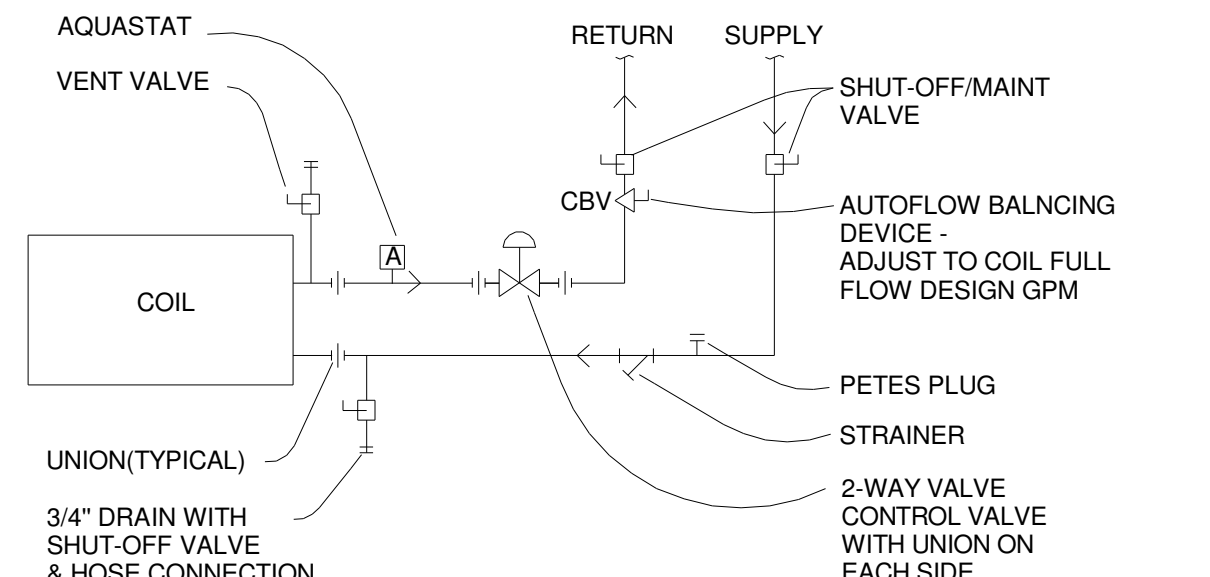
NOTE: IT IS THE INTENT THAT THE FTR SERVING A SINGLE ROOM BE ISOLATED BETWEEN SHUT-OFF VALVES THAT ARE ACCESSIBLE FROM THE SAME ROOM THAT THE FTR IS INSTALLED. THESE VALVES ARE TO BE USED FOR MAINTENANCE OF THE FTR WITHOUT DISRUPTION OF OTHER ROOMS OR SERVICES IN THE BUILDING. SHUT-OFF VALVES, VENTS AND DRAINS SERVING THE MAINS OR BRANCH PIPING ARE IN ADDITION TO THE VALVES SERVING THE FTR.



1 HOT WATER FINNED TUBE RADIATION  
NO SCALE



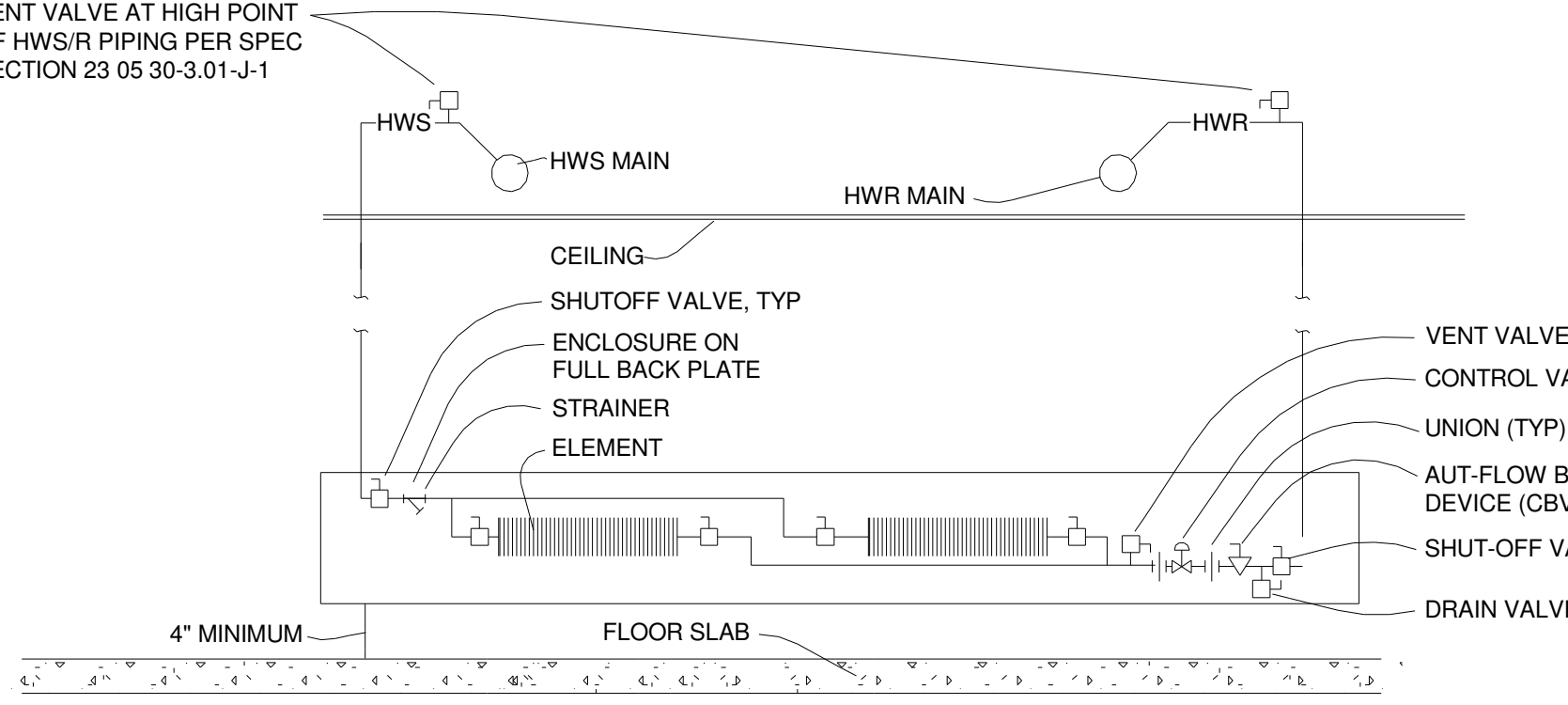
2 AHU COIL PIPING DETAIL (2-WAY)  
NO SCALE



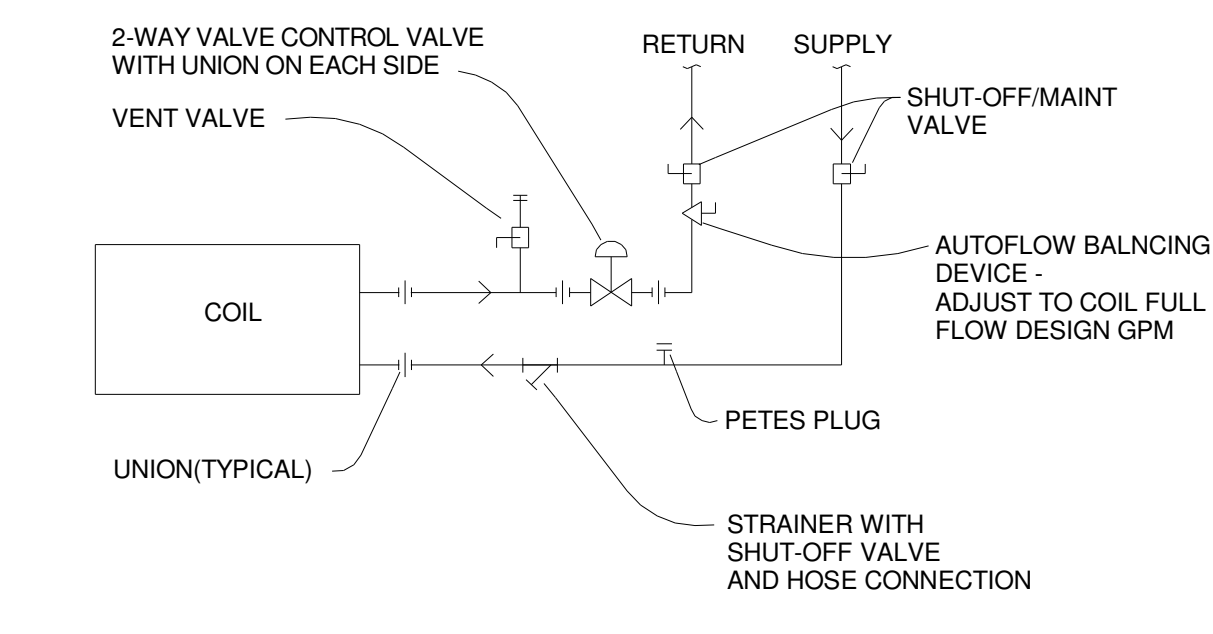
3 UNIT HEATER PIPING  
NO SCALE

NOTE FOR ALL PIPING DETAILS:  
1. ALL DRAIN AND VENT VALVES TO BE APOLLO MODEL 70-100-HC WITH HOSE THREAD, BRONZE CAP AND CHAIN PER SPECIFICATION SECTION 23 05 23 AND SECTION 23 21 13.23.

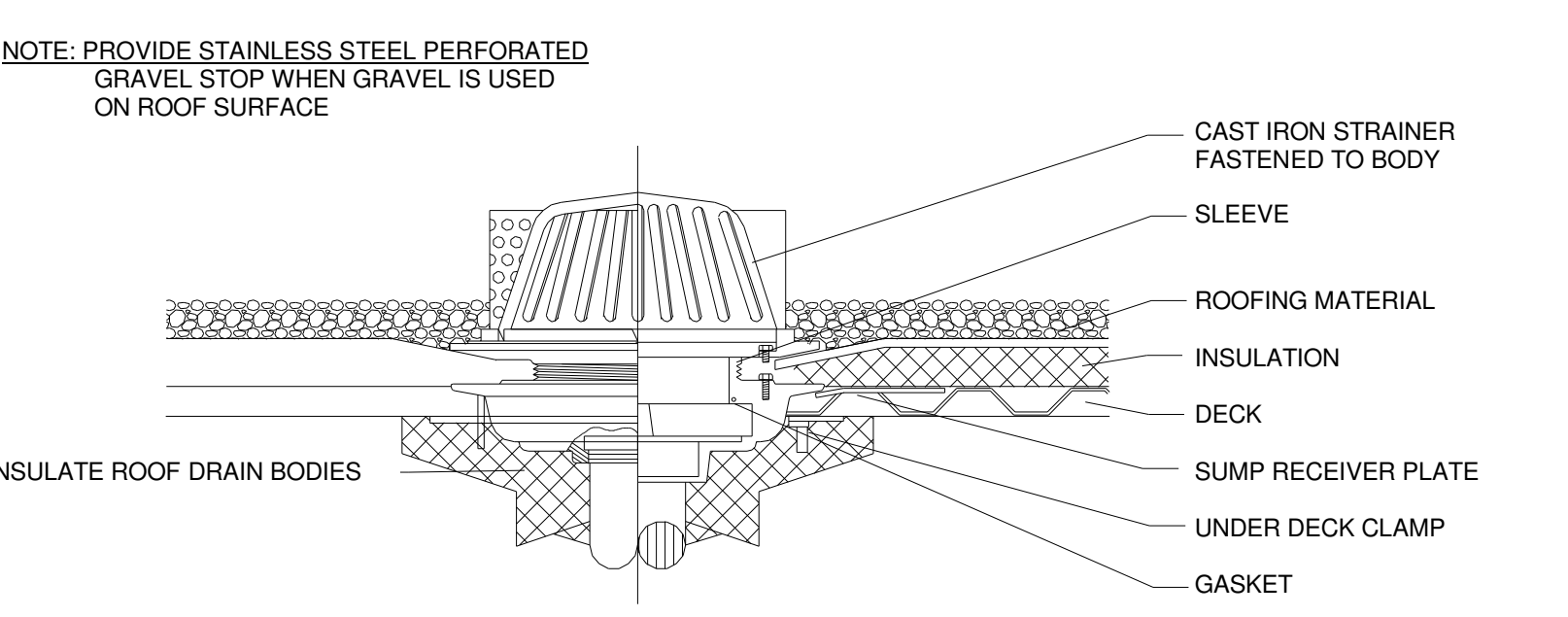
NOTE FOR ALL PIPING DETAILS:  
• GENERAL REQUIREMENTS: PROVIDE A PRESSURE INDEPENDENT AUTO FLOW TYPE BALANCE DEVICE RATED FOR 250 PSI AND 250 DEGREES. THESE BALANCE VALVES SHALL BE USED AT TERMINALS WITH 2" AND SMALLER PIPING. THE GENERAL INTENT IS TO USE PRESSURE INDEPENDENT BALANCE DEVICES AND PRESSURE DEPENDENT CONTROL VALVES.  
• ALL PRESSURE INDEPENDENT BALANCE DEVICES SHALL HAVE A PERMANENTLY AFFIXED TAG LISTING SIZE, RATED GPM, RATED PRESSURE DROP AND HYDRONIC COMPONENT SERVED.  
• ON PIPE SIZES ABOVE 2", AN AUTOMATIC FLOW CONTROL VALVE (AFCV) SHALL BE USED. IN A THREE WAY VALVE APPLICATION A MANUAL BALANCE VALVE (B&G CIRCUIT SETTER OR EQUAL) WILL BE REQUIRED ON THE BYPASS PIPING.  
• ALL DEVICES SHALL HAVE PORTS AND QUICK CONNECTION FOR TAB READINGS.  
• COIL PACKS ARE NOT ALLOWED.



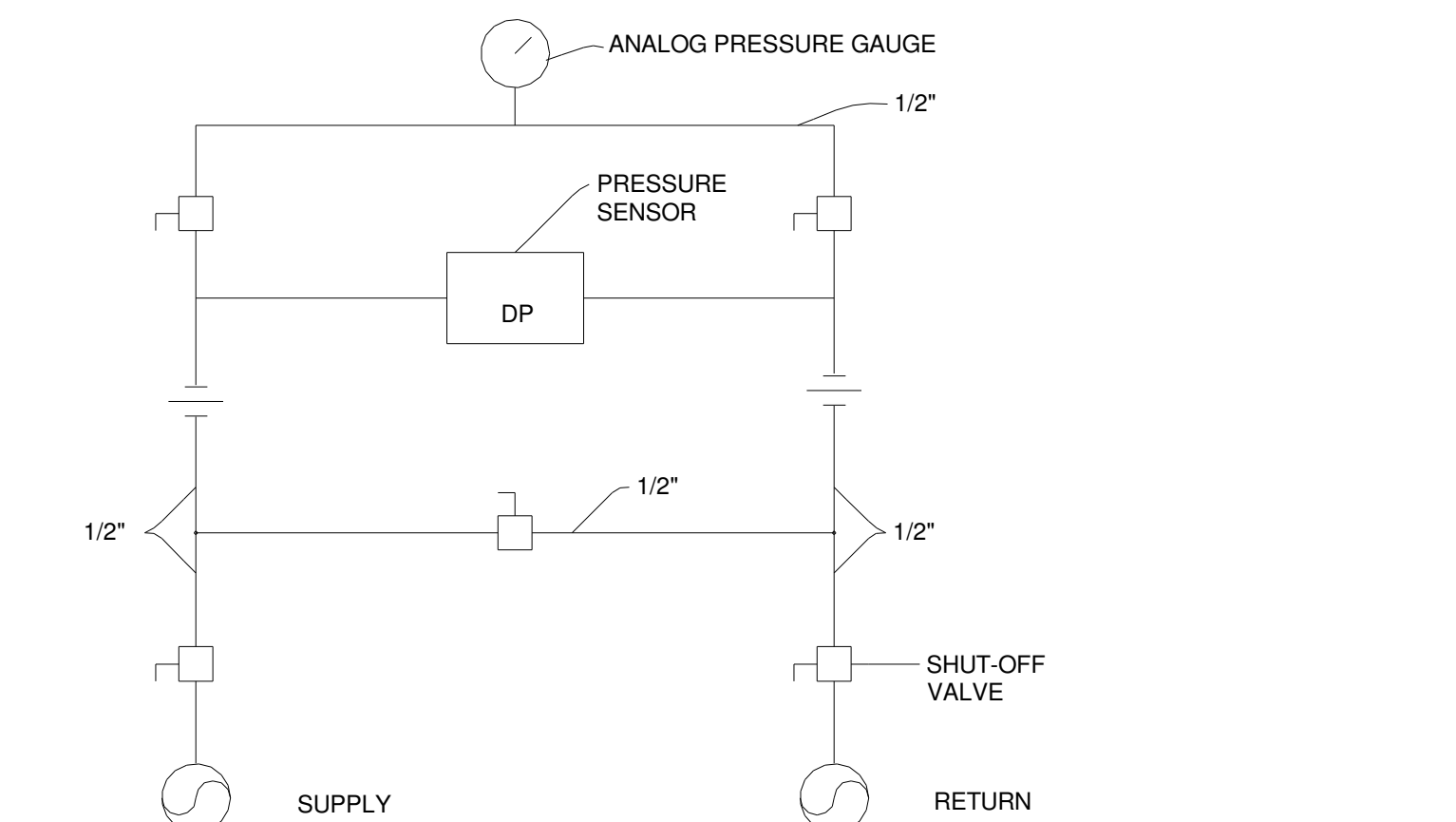
4 HOT WATER FINNED TUBE RADIATION  
NO SCALE



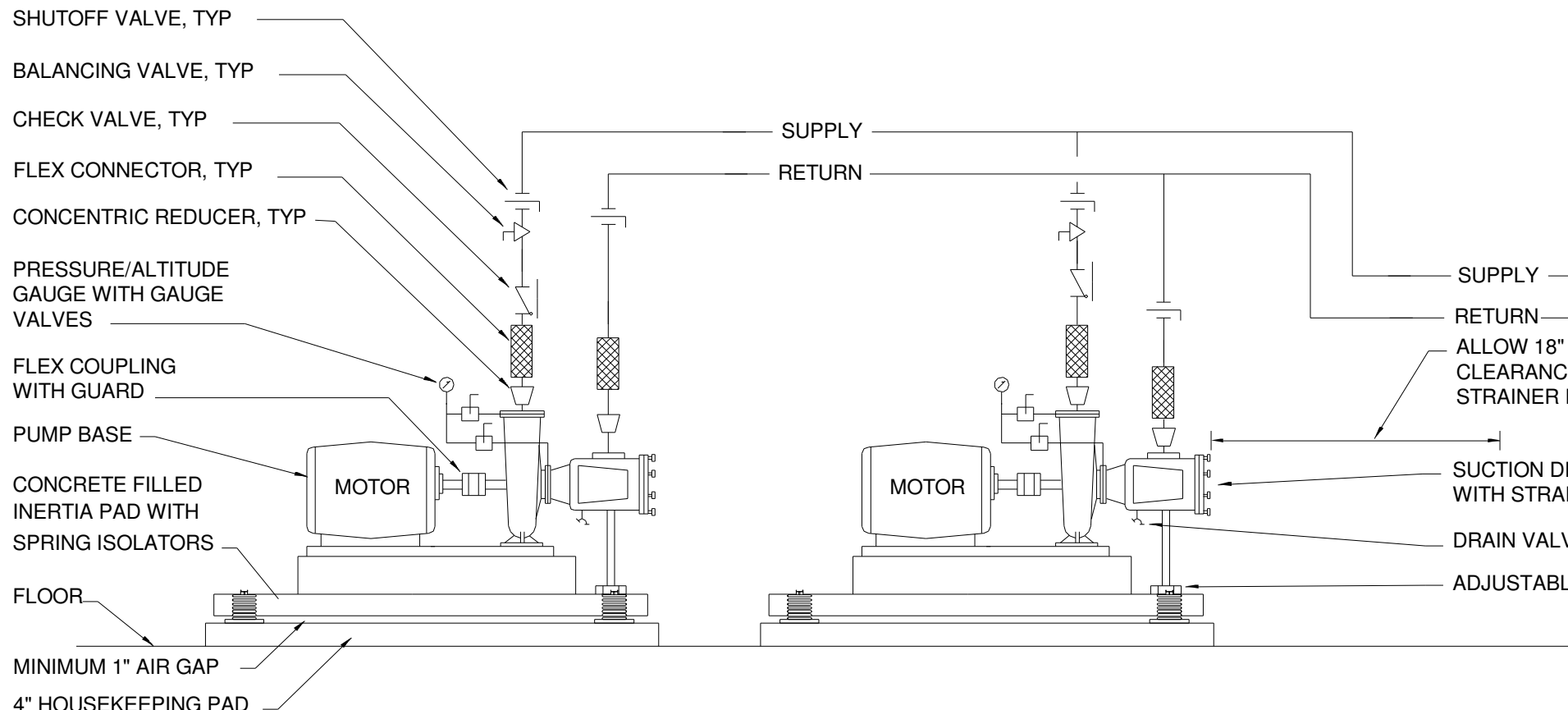
5 VAV COIL PIPING DETAIL (2-WAY)  
NO SCALE



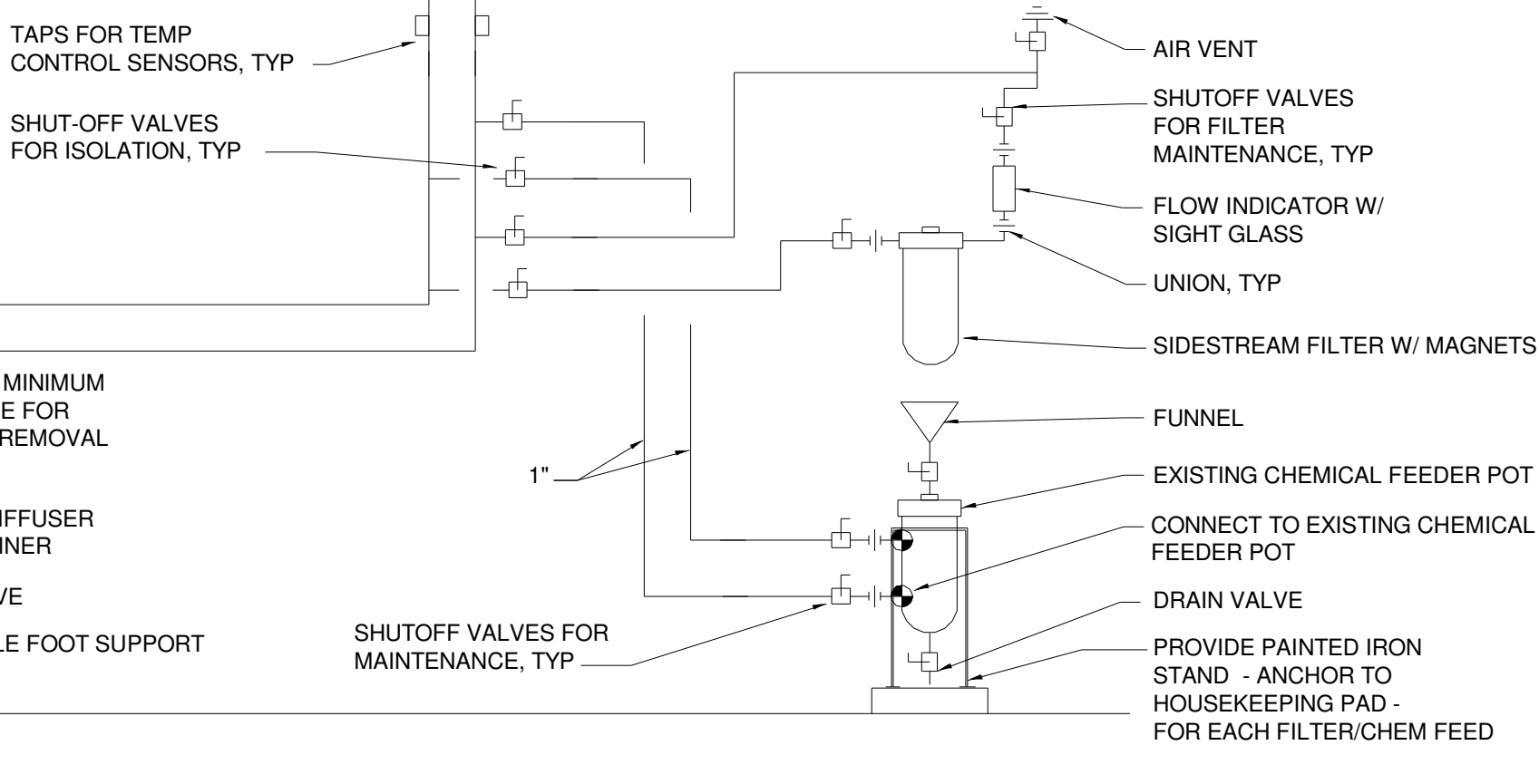
6 ROOF DRAIN DETAIL  
NO SCALE



7 PRESSURE SENSOR DETAIL  
NO SCALE

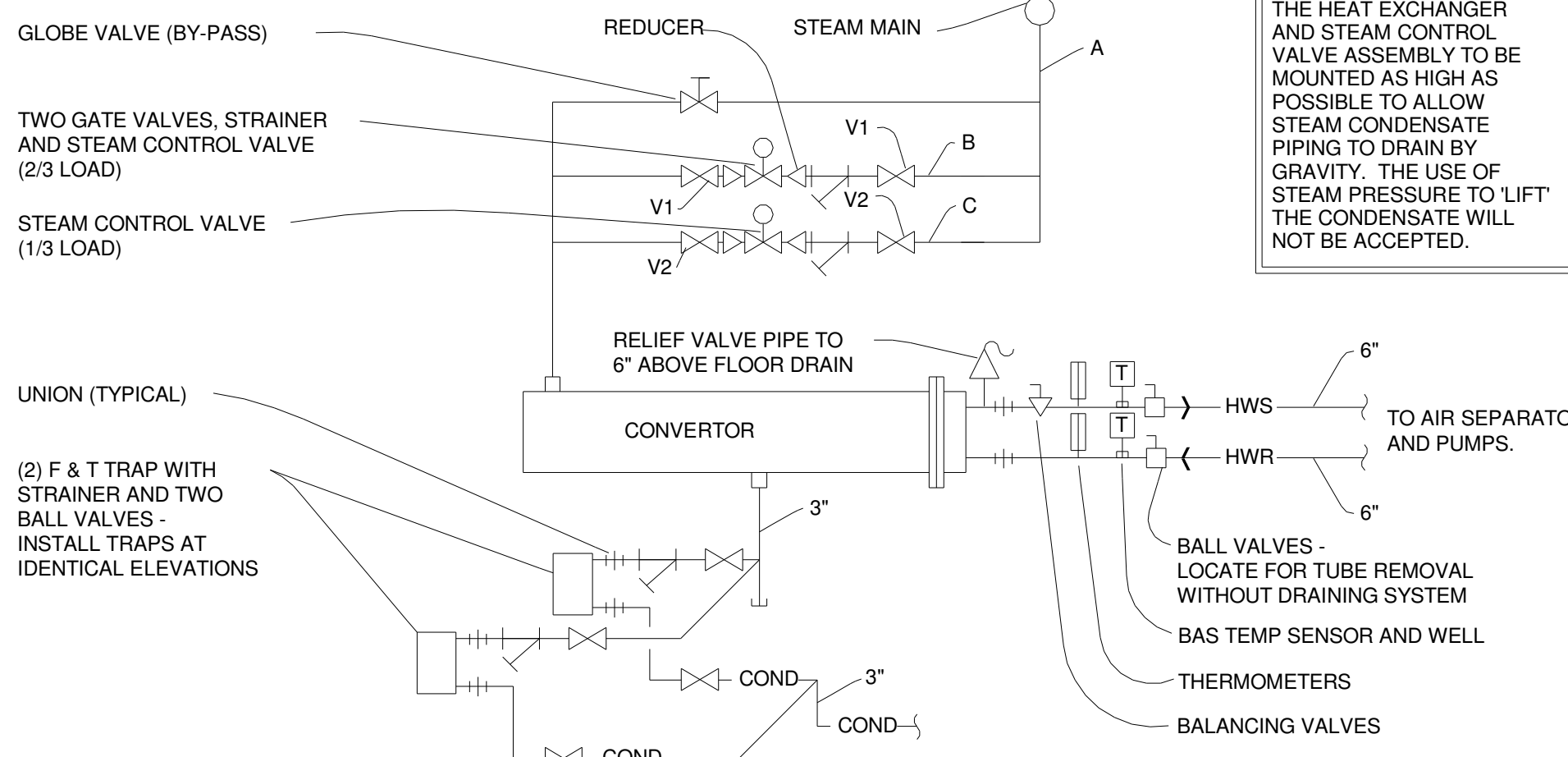


8 BASE MOUNTED PUMP PIPING DETAIL  
NO SCALE



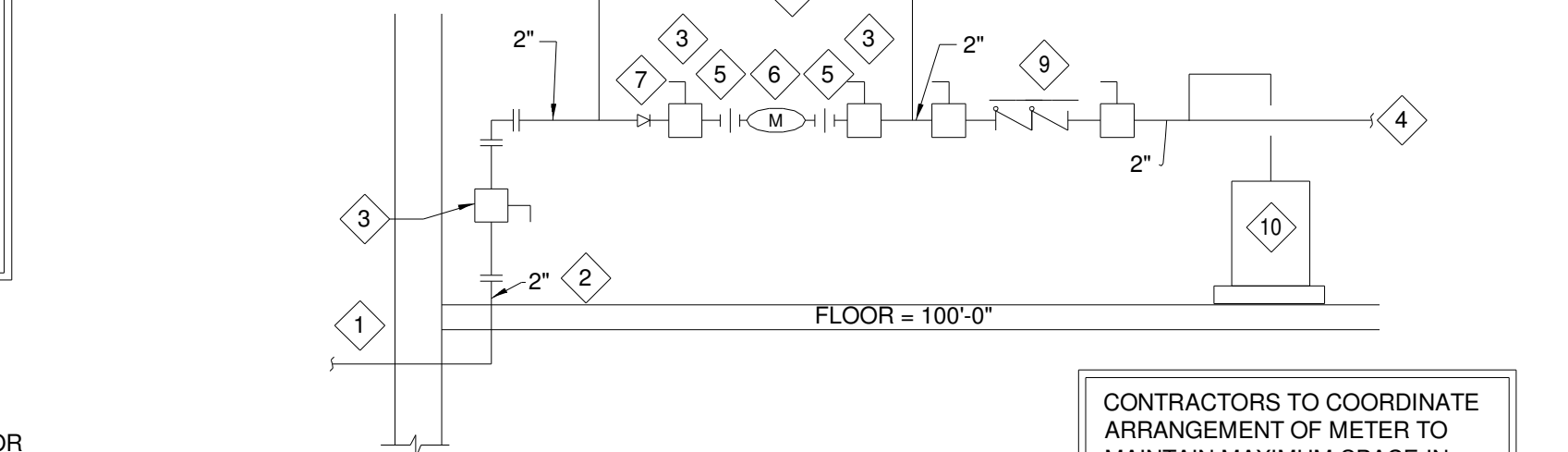
9 F AND T TRAP DETAIL AT DRIP  
NO SCALE

HEAT EXCHANGER VALVE SCHEDULE									
HEAT EXCHANGER	STEAM SUPPLY			STEAM CAPACITY (PPH)			BYPASS SIZE	VALVE SIZE	
	A	B	C	A	B	C		V1	V2
HX-1	6"	4"	2"	6,670	4,447	2,223	12"	10"	8"

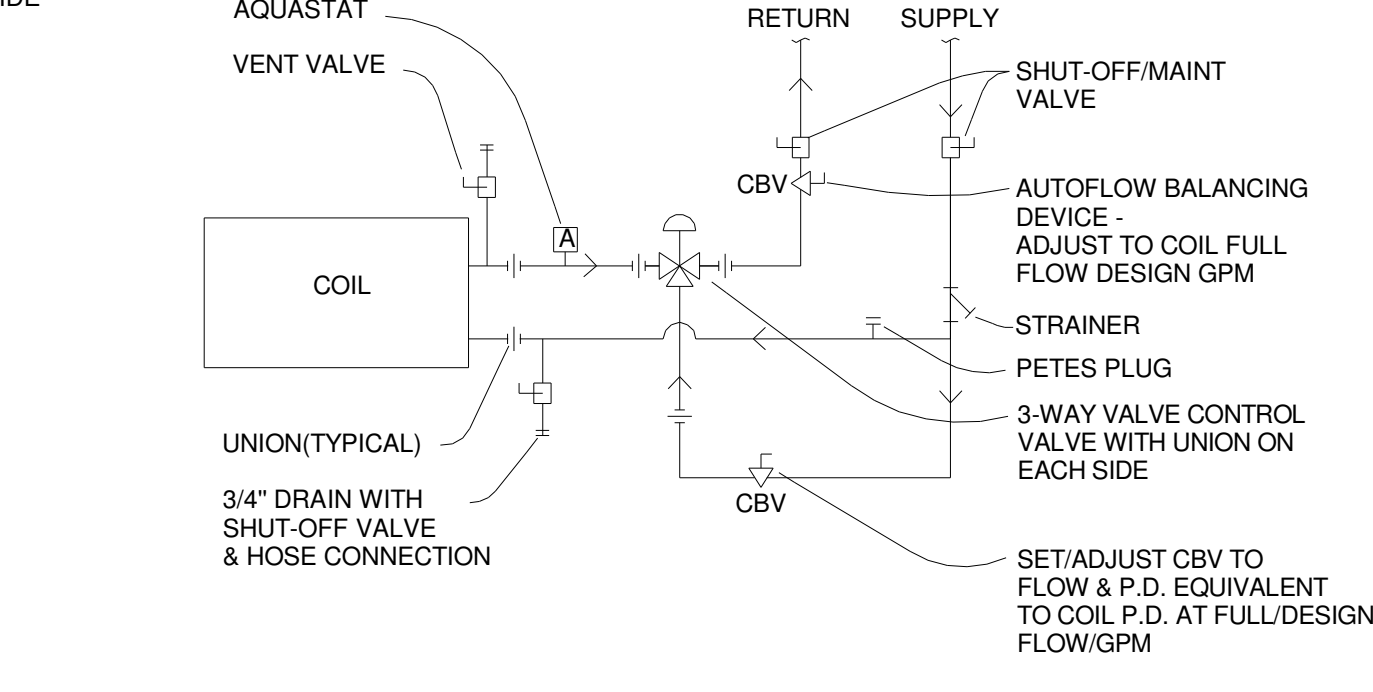


10 STEAM TO WATER CONVERTOR DETAIL  
NO SCALE

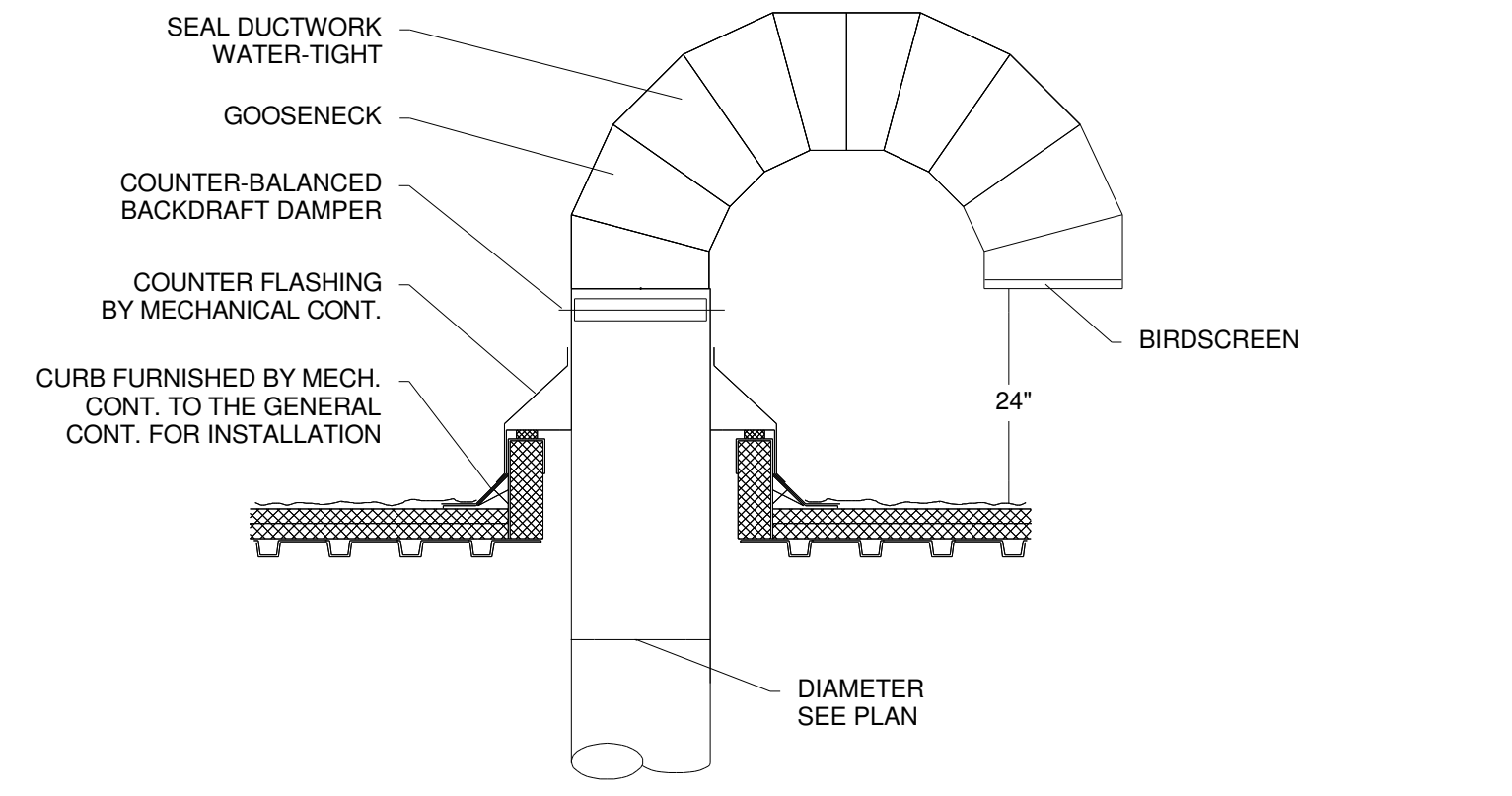
- NOTES:  
1. TRIPLE DUTY/COMBINATION VALVE IS NOT TO BE USED.  
2. PUMP TO BE SECURED TO CONCRETE PAD WITH FLUSH TYPE ANCHORS AND CAP BOLTS.
- WATER SERVICE DETAIL KEY NOTES:  
1. 2" DOMESTIC WATER SERVICE INTO BUILDING BY SITE UTILITY CONTRACTOR TERMINATED IN ROOM AND CAPPED.  
2. COORDINATE WATER SERVICE TESTS WITH SITE UTILITIES CONTRACTOR AND AHU.  
3. BALL VALVE VALVE, TYP.  
4. PROVIDE 2" COLD WATER PIPING TO SHELTER.  
5. PROVIDE UNION.  
6. PLUMBING CONTRACTOR IS TO OBTAIN THE WATER METER FROM CITY.  
7. PROVIDE PIPE REDUCER.  
8. PROVIDE BYPASS OF METER PER THE REQUIREMENTS OF THE AHU.  
9. PROVIDE 2" DOUBLE CHECK VALVE BACKFLOW PREVENTOR. PROVIDE APOLLO MODEL DCLF-4A (LEAD FREE) OR WATTS EQUAL.  
10. PROVIDE A B&G PT-5 EXPANSION TANK AND HOUSEKEEPING PAD.



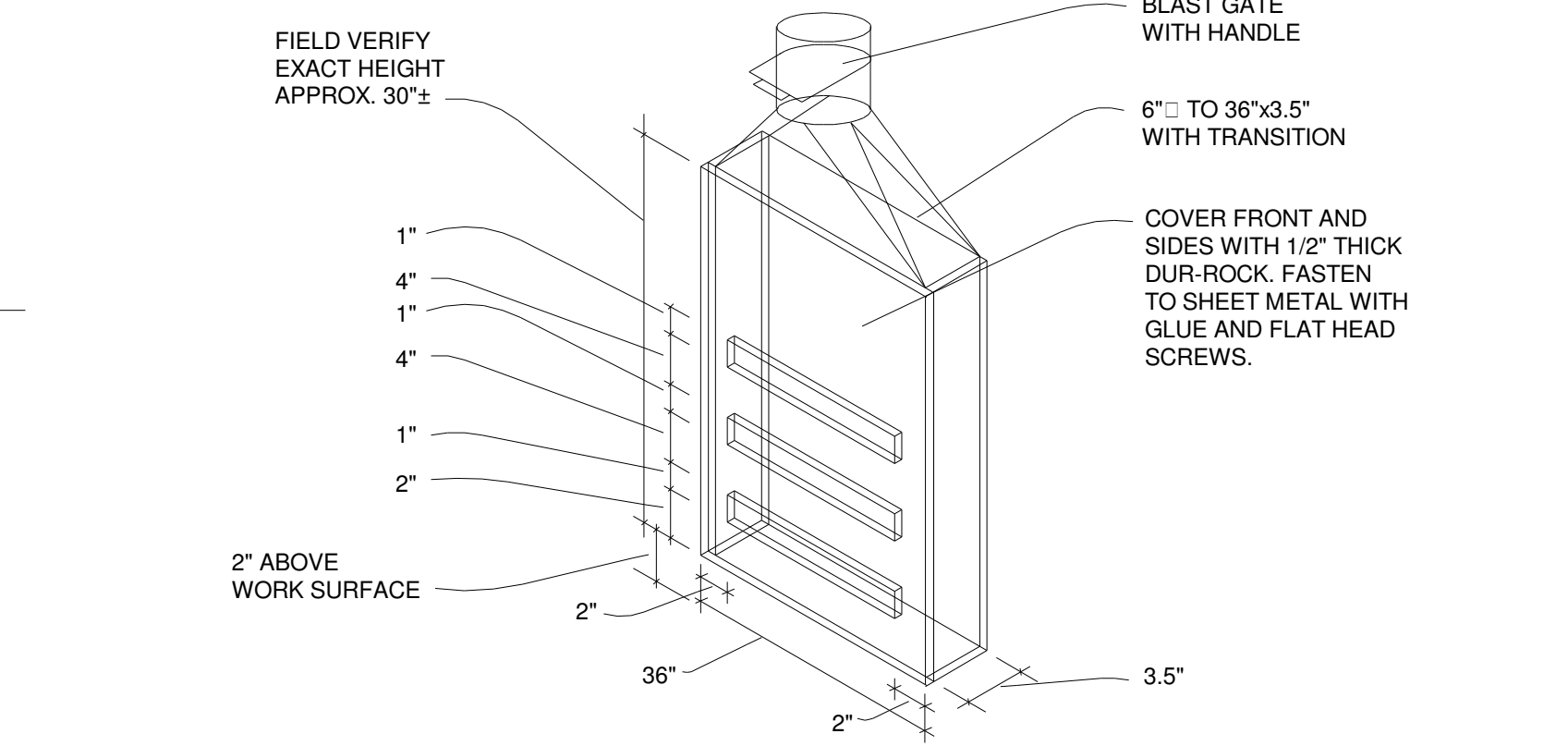
11 WATER SERVICE DETAIL  
NO SCALE



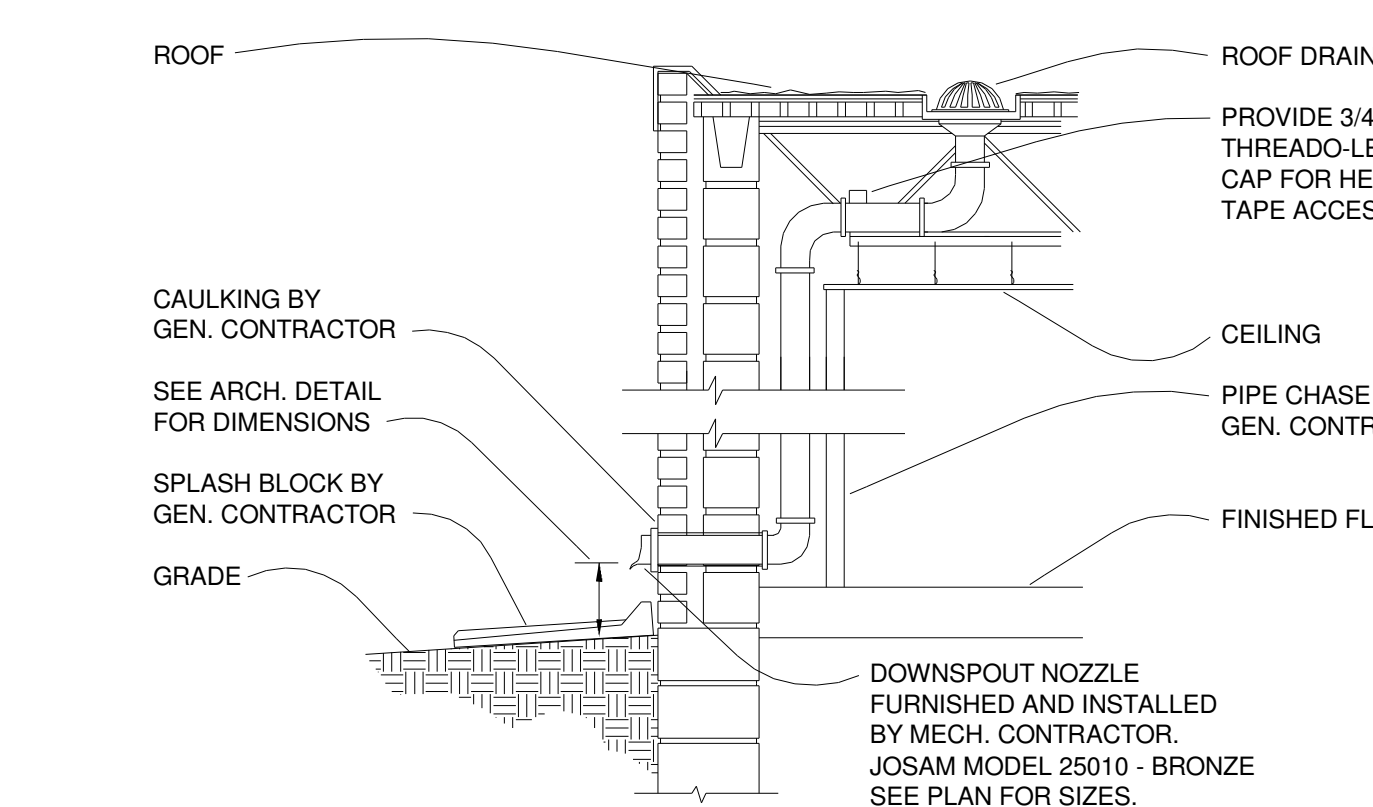
12 UNIT HEATER PIPING DETAIL (3-WAY)  
NO SCALE



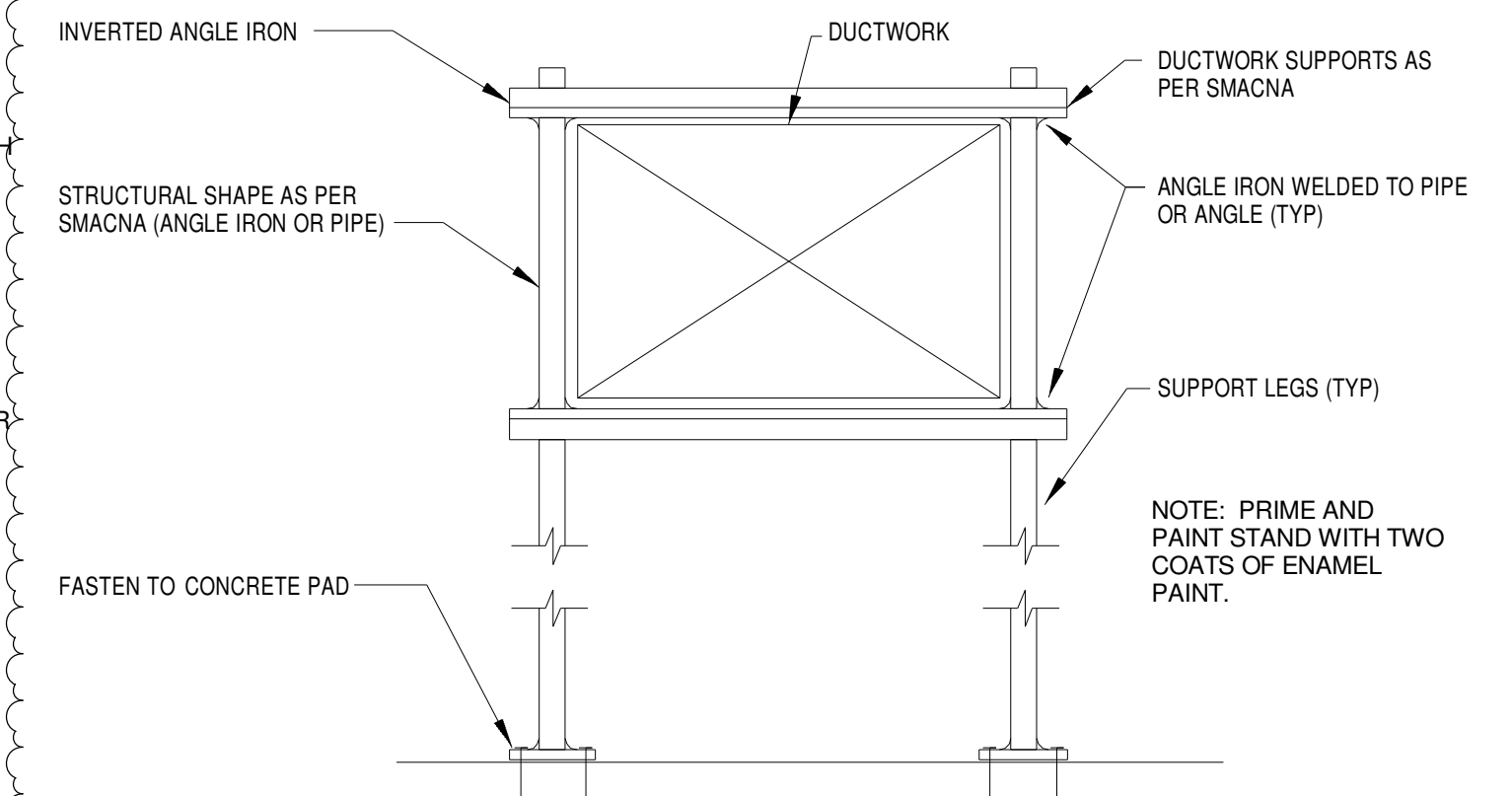
13 GOOSENECK VENT THRU ROOF DETAIL  
NO SCALE



14 WELDING SLOT EXHAUST PLENUM DETAIL  
NO SCALE



15 DOWNSPOUT WITH NOZZLE DETAIL  
NO SCALE



16 DUCT SUPPORT  
NO SCALE

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Key Plan showing existing and proposed building footprints (A, B, C) and a north arrow.

I hereby certify that this plan, specification or report was prepared by me or under my direct supervision and that I am a duly Licensed PROFESSIONAL ENGINEER under the laws of the STATE OF MINNESOTA.  
TREVOR GILBERTSON  
License Number: 493161 Date: 04/14/2026

No.	Date	Revision	Description
1	05/05/2026	ADDENDUM #3	

**CONSTRUCTION DOCUMENTS**  
**MECHANICAL DETAILS**

Project: R23-4815.001  
Date: 04/14/2026  
Drawn by: KO  
Checked by: AT  
**M502**

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