ADDENDUM NO. 02

December 4, 2025

Kalamazoo Public Schools Loy Norrix High School Mechanical Improvements
606 East Kilgore Road
Kalamazoo, MI 49001

TO: ALL BIDDERS OF RECORD

This Addendum forms a part of and modifies the Bidding Requirements, Contract Forms, Contract Conditions, the Specifications and the Drawings dated October 31, 2025, by TowerPinkster. Acknowledge receipt of the Addendum in the space provided on the Bid Form. Failure to do so may subject the Bidder to disqualification.

This Addendum consists of Pages ADD 2-1 through ADD 2-1 and TowerPinkster Addendum No. 02, dated November 25, 2025, consisting of 81 pages.

A. SPECIFICATION SECTION 01 32 00 – SCHEDULES AND REPORTS

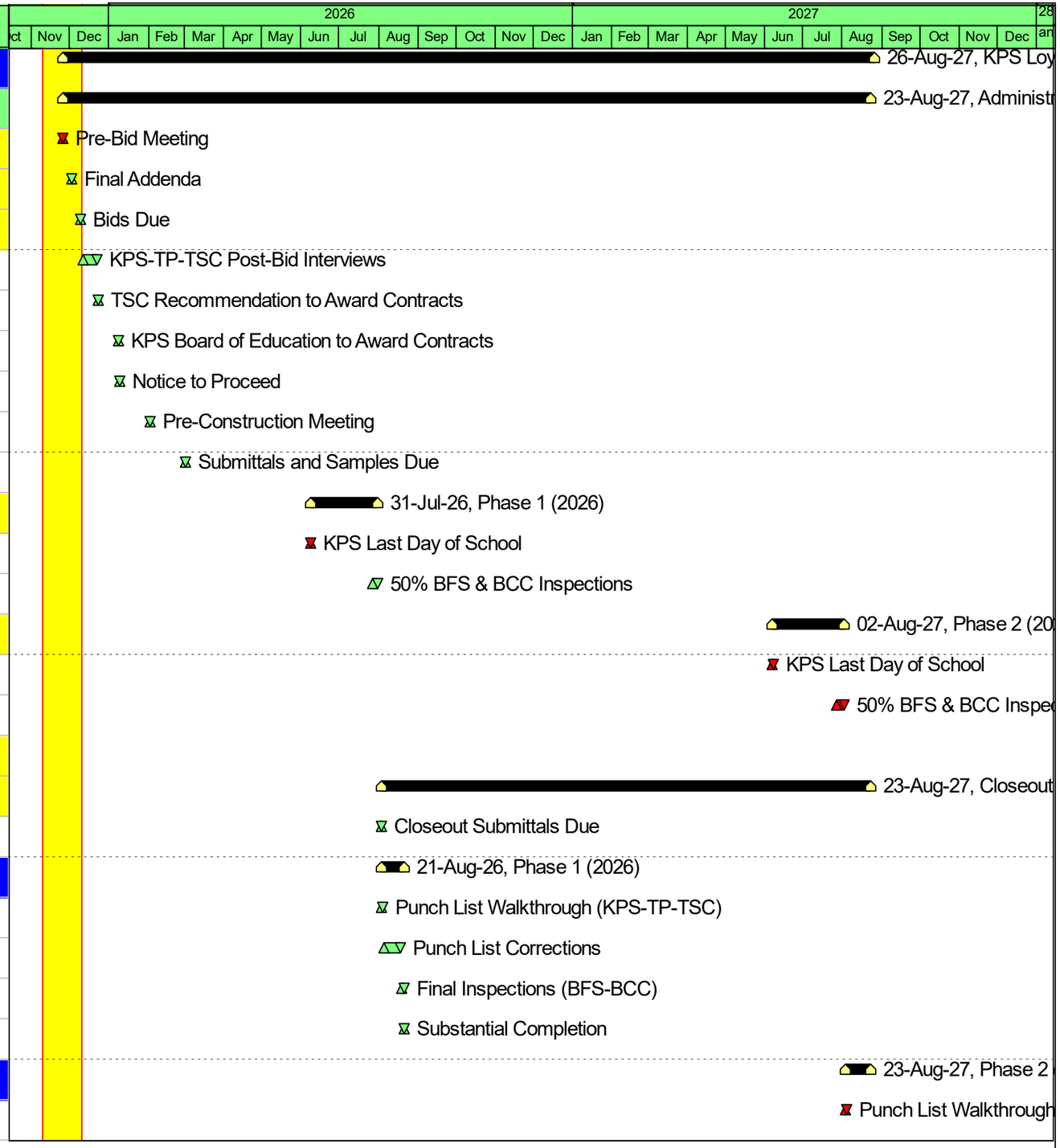
a. 1.03 GUIDELINE SCHEDULE

Add:

1. See Guideline Schedule attached.

B. Refer to the attached Request For Information summary, Pre-Bid RFI No. 01 though 21 are included

Activity Name	Original Duration	Start	Finish
KPS Loy Norrix High Unit D Mechanical & Renova	455	25-Nov-25	26-Aug-27
Administration	452	25-Nov-25	23-Aug-27
Pre-Bid Meeting	1	25-Nov-25*	25-Nov-25
Final Addenda	1	02-Dec-25	02-Dec-25
Bids Due	1	09-Dec-25	09-Dec-25
KPS-TP-TSC Post-Bid Interviews	8	11-Dec-25	22-Dec-25
TSC Recommendation to Award Contracts	1	23-Dec-25	23-Dec-25
KPS Board of Education to Award Contracts	1	08-Jan-26	08-Jan-26
Notice to Proceed	1	09-Jan-26	09-Jan-26
Pre-Construction Meeting	1	02-Feb-26	02-Feb-26
Submittals and Samples Due	1	02-Mar-26	02-Mar-26
Phase 1 (2026)	40	08-Jun-26	31-Jul-26
KPS Last Day of School	1	08-Jun-26*	08-Jun-26
50% BFS & BCC Inspections	5	27-Jul-26	31-Jul-26
Phase 2 (2027)	41	07-Jun-27	02-Aug-27
KPS Last Day of School	1	07-Jun-27*	07-Jun-27
50% BFS & BCC Inspections	5	27-Jul-27	02-Aug-27
Pre-Installation Meetings	0		
Closeout	276	03-Aug-26	23-Aug-27
Closeout Submittals Due	1	03-Aug-26	03-Aug-26
Phase 1 (2026)	15	03-Aug-26	21-Aug-26
Punch List Walkthrough (KPS-TP-TSC)	2	03-Aug-26	04-Aug-26
Punch List Corrections	10	05-Aug-26	18-Aug-26
Final Inspections (BFS-BCC)	3	19-Aug-26	21-Aug-26
Substantial Completion	1	21-Aug-26	21-Aug-26
Phase 2 (2027)	15	03-Aug-27	23-Aug-27
Punch List Walkthrough (KPS-TP-TSC)	2	03-Aug-27	04-Aug-27



Actual Work
Remaining Work
Critical Remaining Work
Milestone
Summary

224010.13 - KPS Loy Norrix High Unit D Mechanical & Renovations
Guideline Schedule - 10-Nov-25

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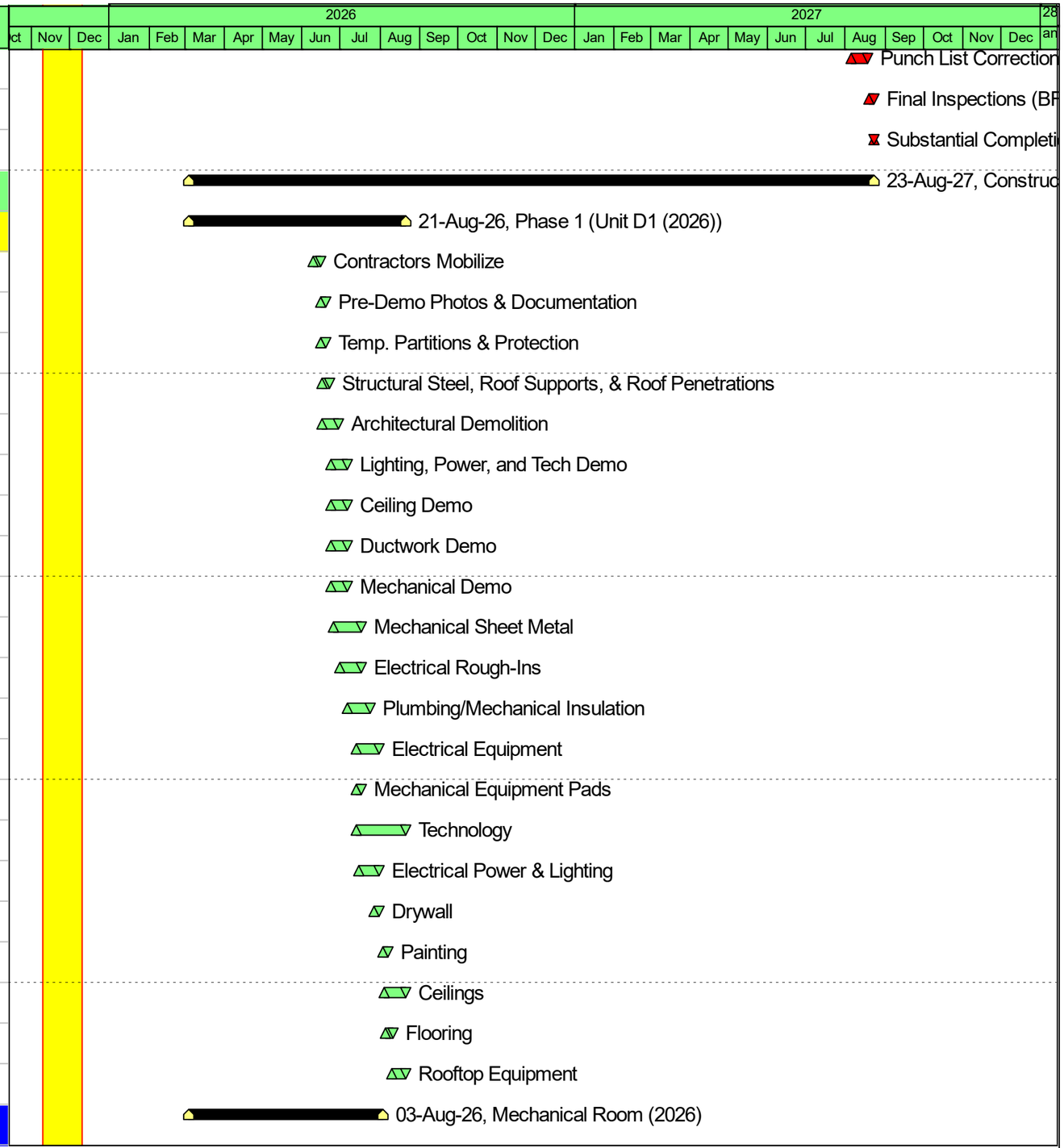
Activity Name	Original Duration	Start	Finish
Punch List Corrections	10	05-Aug-27	18-Aug-27
Final Inspections (BFS-BCC)	3	19-Aug-27	23-Aug-27
Substantial Completion	1	23-Aug-27	23-Aug-27
Construction	384	04-Mar-26	23-Aug-27
Phase 1 (Unit D1 (2026))	123	04-Mar-26	21-Aug-26
Contractors Mobilize	5	09-Jun-26	15-Jun-26
Pre-Demo Photos & Documentation	5	15-Jun-26	19-Jun-26
Temp. Partitions & Protection	5	15-Jun-26	19-Jun-26
Structural Steel, Roof Supports, & Roof Penetrations	5	16-Jun-26	22-Jun-26
Architectural Demolition	10	16-Jun-26	29-Jun-26
Lighting, Power, and Tech Demo	10	23-Jun-26	06-Jul-26
Ceiling Demo	10	23-Jun-26	06-Jul-26
Ductwork Demo	10	23-Jun-26	06-Jul-26
Mechanical Demo	10	23-Jun-26	06-Jul-26
Mechanical Sheet Metal	17	25-Jun-26	17-Jul-26
Electrical Rough-Ins	14	30-Jun-26	17-Jul-26
Plumbing/Mechanical Insulation	15	06-Jul-26	24-Jul-26
Electrical Equipment	15	13-Jul-26	31-Jul-26
Mechanical Equipment Pads	5	13-Jul-26	17-Jul-26
Technology	30	13-Jul-26	21-Aug-26
Electrical Power & Lighting	13	15-Jul-26	31-Jul-26
Drywall	5	27-Jul-26	31-Jul-26
Painting	5	03-Aug-26	07-Aug-26
Ceilings	14	04-Aug-26	21-Aug-26
Flooring	5	05-Aug-26	11-Aug-26
Rooftop Equipment	10	10-Aug-26	21-Aug-26
Mechanical Room (2026)	109	04-Mar-26	03-Aug-26



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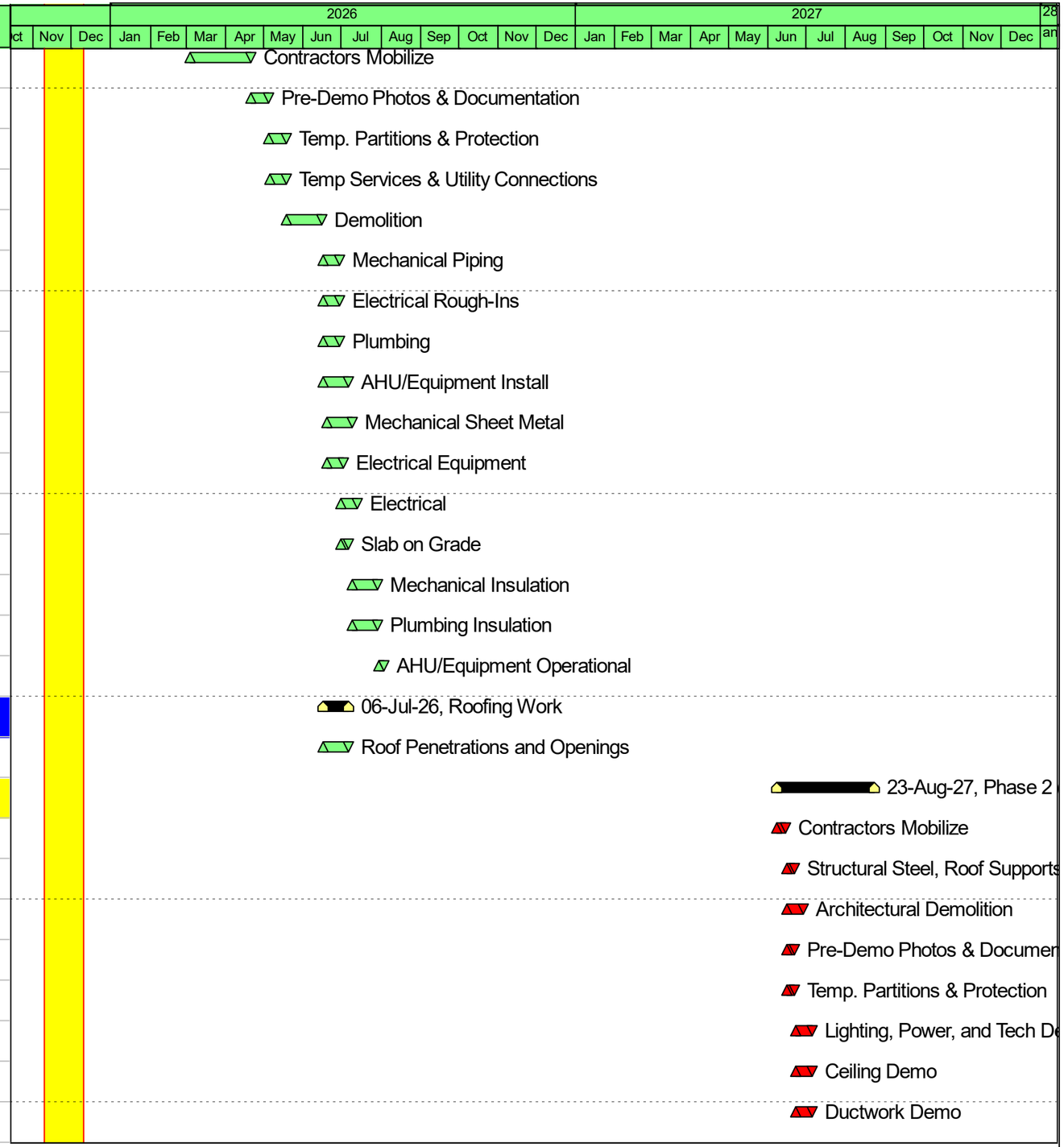
Activity Name	Original Duration	Start	Finish
Contractors Mobilize	34	04-Mar-26	20-Apr-26
Pre-Demo Photos & Documentation	10	21-Apr-26	04-May-26
Temp. Partitions & Protection	10	05-May-26	18-May-26
Temp Services & Utility Connections	9	06-May-26	18-May-26
Demolition	20	19-May-26	15-Jun-26
Mechanical Piping	10	16-Jun-26	29-Jun-26
Electrical Rough-Ins	10	16-Jun-26	29-Jun-26
Plumbing	10	16-Jun-26	29-Jun-26
AHU/Equipment Install	15	16-Jun-26	06-Jul-26
Mechanical Sheet Metal	15	19-Jun-26	09-Jul-26
Electrical Equipment	10	19-Jun-26	02-Jul-26
Electrical	10	30-Jun-26	13-Jul-26
Slab on Grade	5	30-Jun-26	06-Jul-26
Mechanical Insulation	15	09-Jul-26	29-Jul-26
Plumbing Insulation	15	09-Jul-26	29-Jul-26
AHU/Equipment Operational	3	30-Jul-26	03-Aug-26
Roofing Work	15	16-Jun-26	06-Jul-26
Roof Penetrations and Openings	15	16-Jun-26	06-Jul-26
Phase 2 (Unit D2 (2027))	55	08-Jun-27	23-Aug-27
Contractors Mobilize	5	08-Jun-27	14-Jun-27
Structural Steel, Roof Supports, & Roof Penetrations	5	15-Jun-27	21-Jun-27
Architectural Demolition	10	15-Jun-27	28-Jun-27
Pre-Demo Photos & Documentation	5	15-Jun-27	21-Jun-27
Temp. Partitions & Protection	5	15-Jun-27	21-Jun-27
Lighting, Power, and Tech Demo	10	22-Jun-27	05-Jul-27
Ceiling Demo	10	22-Jun-27	05-Jul-27
Ductwork Demo	10	22-Jun-27	05-Jul-27



Actual Work
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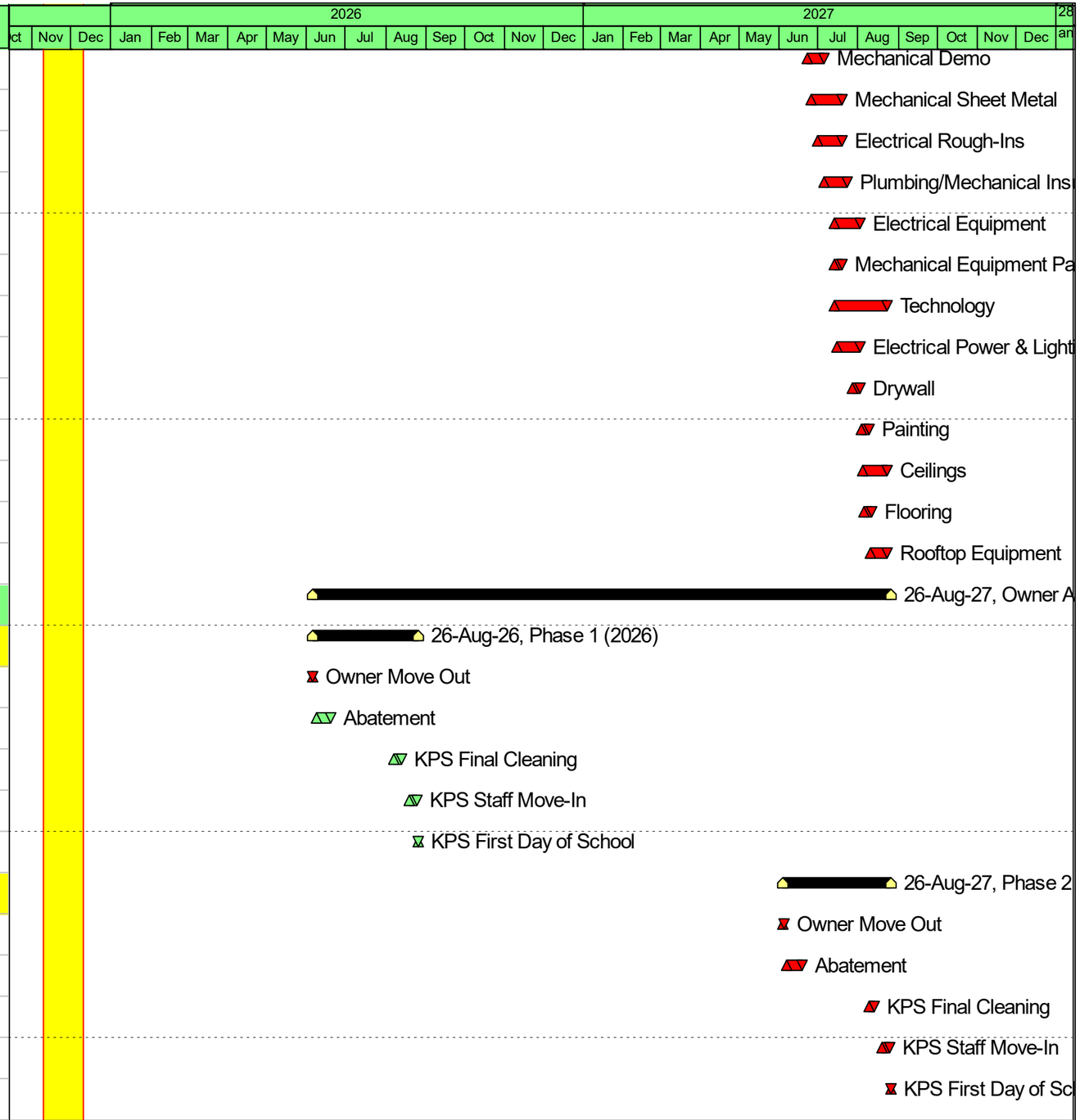
Activity Name	Original Duration	Start	Finish
Mechanical Demo	10	22-Jun-27	05-Jul-27
Mechanical Sheet Metal	17	25-Jun-27	19-Jul-27
Electrical Rough-Ins	14	30-Jun-27	19-Jul-27
Plumbing/Mechanical Insulation	15	05-Jul-27	23-Jul-27
Electrical Equipment	15	13-Jul-27	02-Aug-27
Mechanical Equipment Pads	5	13-Jul-27	19-Jul-27
Technology	30	13-Jul-27	23-Aug-27
Electrical Power & Lighting	13	15-Jul-27	02-Aug-27
Drywall	5	27-Jul-27	02-Aug-27
Painting	5	03-Aug-27	09-Aug-27
Ceilings	14	04-Aug-27	23-Aug-27
Flooring	5	05-Aug-27	11-Aug-27
Rooftop Equipment	10	10-Aug-27	23-Aug-27
Owner Activities	320	05-Jun-26	26-Aug-27
Phase 1 (2026)	59	05-Jun-26	26-Aug-26
Owner Move Out	1	05-Jun-26*	05-Jun-26
Abatement	10	08-Jun-26	19-Jun-26
KPS Final Cleaning	5	07-Aug-26	13-Aug-26
KPS Staff Move-In	5	19-Aug-26	25-Aug-26
KPS First Day of School	1	26-Aug-26	26-Aug-26
Phase 2 (2027)	60	04-Jun-27	26-Aug-27
Owner Move Out	1	04-Jun-27*	04-Jun-27
Abatement	10	07-Jun-27	18-Jun-27
KPS Final Cleaning	5	09-Aug-27	13-Aug-27
KPS Staff Move-In	5	19-Aug-27	25-Aug-27
KPS First Day of School	1	26-Aug-27	26-Aug-27



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Pre-Bid RFI Log

12/4/2025

RFI #	Company Submitting RFI	Date Received	RFI Description	RFI Response
1	Kalamazoo Mechanical Inc.	11/25/2025	What is the RFI cut off date?	[TSC}: RFI's are to be submitted by EOD 12.05.2025. We will do our best to answer questions after that date as possible.
2	Kalamazoo Mechanical Inc.	11/25/2025	Do you have a line item schedule?	[TSC]: Yes, we will include it in the next Addendum.
3	Kalamazoo Mechanical Inc.	11/25/2025	Who is responsible for providing and installing the louvers?	[TSC]: Louvers are currently listed in General Trades. This will be changed to Mechanical bid category in the next Addendum.
4	Kalamazoo Mechanical Inc.	11/25/2025	Who is the CxA and what system are they using?	[TSC]: CxA is contracted through TP. System is Tridium.
5	Kalamazoo Mechanical Inc.	11/25/2025	Will meetings be virtual or in person? Weekly?	[TSC]: Progress Meetings will be on-site in field office trailer.
6	Kalamazoo Mechanical Inc.	11/25/2025	Is the mechanical contractor responsible for temporary heating?	[TSC]: Yes.
7	Kalamazoo Mechanical Inc.	11/25/2025	Are we responsible for any floor protection? Yes.	[TSC]: Each trade is responsible for protecting the floor against damage from their work.
8	Kalamazoo Mechanical Inc.	11/25/2025	A100D1, note 10 says general trades is picking up the insulated panels, please confirm.	[TSC]: Yes. General Trades is to include insulated panels.
9	Kalamazoo Mechanical Inc.	11/25/2025	M201, note 13 has us running piping inside of some casework that does not appear to be demolished. Will accommodations be made for this?	[TSC]: There is no chase existing here. TP to address. [TP}:
10	Miller-Davis Company	12/3/2025	Is the mechanical bid category responsible for demo of mechanical Items?	[TSC]: Yes, Mecahnical Bid is to demo Mechanical items.
11	Miller-Davis Company	12/3/2025	Is the mechanical bid category responsible for louvers?	[TSC]: Yes. This will be addressed in Addendum No. 3
12	Miller-Davis Company	12/3/2025	Are the concrete mechanical pads on sheet A 100D1 existing, or new? Can specs/drawings for new mechanical pads be provided?	[TSC]: To be addressed in Addendum No. 3. Any new pads would be by General Trades.
13	Miller-Davis Company	12/3/2025	Who is responsible for roof penetrations/demo?	[TSC]: Roofing Bid Category.
14	Miller-Davis Company	12/3/2025	Who is responsible for metal panel installation, A 100D1/2, and can specs for the metal panels be provided?	[TSC]: Metal panels are by General Trades. [TP]:
15	Miller-Davis Company	12/3/2025	On sheet AD301 it calls for the removal of glass at four locations, but on sheet A301 it calls for the infill at 5 locations. Please Advise.	[TP]:

16	Miller-Davis Company	12/3/2025	Who is responsible for the break metal closure pieces, A 100D1/1, at the new uv units?	[TSC]: Mechanical Bid responsible for these break metal pieces. [TP]:
17	Miller-Davis Company	12/3/2025	There are notes in the architectural plans for the reinstallation of wood trim, A321/4, but there are no removal notes of wood trim. Please advise.	[TP]:
18	Miller-Davis Company	12/3/2025	Who is responsible for caulking what? Sealants are required at bulkheads, ceilings transition, windows and the roof, but the sealant spec is located in the roofing bid category.	[TSC}: All trades are responsible for caulking and sealing work installed by them or penetrations for their work. To be further clarified in Addendum 3.
19	Miller-Davis Company	12/3/2025	Can a schedule be provided?	[TSC]: A 'Guideline Schedule' (not final project schedule) is included in this Addendum 2.
20	Miller-Davis Company	12/3/2025	Can a site plan be provided to show where tree & plant protection and trash chutes need to go?	[TSC]: A Site Logistics Plan will be included in this Addendum 3. Use of trash chutes is not anticipated.
21	Miller-Davis Company	12/3/2025	Who is responsible for the clear anodized aluminum chase?	[TSC}: Mechanical contractor is responsible for chases
22				
23				
24				

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ADDENDUM NO. 2

DATE OF ISSUANCE:	**November 25, 2025**
PROJECT:	**Loy Norrix High School Mechanical Improvement D Wing** **606 East Kilgore Road** **Kalamazoo, MI 49001**
OWNER:	**Kalamazoo Public Schools**
ARCHITECT'S PROJECT NO.:	**23-637.00**
ORIGINAL BID ISSUE DATE:	**October 31, 2025**

SCOPE OF WORK

This Addendum includes changes to, or clarifications of, the original Bidding Documents and any previously issued addenda, and shall be included in the Bid. All of these Addendum items form a part of the Contract Documents. The Bidder shall acknowledge receipt of this Addendum in the appropriate space provided on the Bid Form. Failure to do so may result in disqualification of the Bid.

DOCUMENTS INCLUDED IN THIS ADDENDUM

This Addendum includes **4** pages of text and the following documents:

- Bidding Documents: **n/a**
- Contract Conditions: **n/a**
- Specification Sections: **23 0516 23 0900, 23 5700, 23 8233**
- Drawings: **S 202D1, S 402, AD 100D1, AD 101D1, A 100D1, A 101D1, A 200D1, A 201D1, M 200D1, M 502, M 504, M 506, E403, E405, E406, AND E407**

CHANGES TO PREVIOUSLY ISSUED ADDENDA

None.

CHANGES TO SPECIFICATIONS

ADD-1 Item No. S-1 - Expansion Compensators Manufacturers

Refer to Specification Section: 23 0516 Expansion Fittings and Loops for HVAC Piping

Included Victaulic as an approved manufacturer for expansion compensators.

ADD-1 Item No. S-2 - Heat Exchangers Manufacturers

Refer to Specification Section: 23 5700 Heat Exchangers For HVAC

Included Armstrong as an approved manufacturer for shell and tube heat exchangers.

ADD-1 Item No. S-3 - Instrumentation and Control Approved Installers

Refer to Specification Section: 23 0900 Instrumentation and Control For HVAC

Included SBS Smart Building Services as an approved installer.

ADD-1 Item No. S-4 - Flat-Pipe Steel Radiators

Refer to Specification Section: 23 8233 Convectors

Added Flat-pipe steel radiators to the specification.

CHANGES TO DRAWINGS

ADD-2 Item No. D-1 - Beam Size Coordination

Refer to Sheet(s): S 202D1

Update beam size in note to match size of new beam called out on plan at south end of new RTU as shown clouded on S 202D1.

ADD-2 Item No. D-2 - Galvanization Clarification

Refer to Sheet(s): S 402

Add notes referring to galvanization of all new exterior steel and repair of damaged galvanization of existing exterior steel due to new beam installation as shown clouded in details 2/S 402 and 3/S 402.

ADD-2 Item No. D-3 - Clarify Bulkhead Demo Location

Refer to Sheet(s): AD 101D1

Bulkhead in Computer Lab D-10 previously not called out to be demoed is updated in the corresponding demo plan to reflect correct demo work.

ADD-2 Item No. D-4 - Demolition Keynote #10 Update

Refer to Sheet(s): AD 100D1

Updated demolition keynote No.10 to include “to return to owner”.

ADD-2 Item No. D-5 - Demolition Keynote Update

Refer to Sheet(s): AD 101D1

Updated keynote No.11 to include remove and salvage. Added keynote No.20.

ADD-2 Item No. D-6 - Countertop Demolition Verbiage Updated

Refer to Sheet(s): AD 101D1

Updated demolition keynote No.7 verbiage to clarify countertop demolition scope.

ADD-2 Item No. D-7 - Solid Surface Floor Trim Keynote

Refer to Sheet(s): AD 101D1, A 101D1

Added demo keynote No.18 and new construction keynote No.23 to update work regarding existing solid surface floor trim alongside storefront in Computer Lab D-10.

ADD-2 Item No. D-8 - Vertical Unit Ventilator Break Metal Enclosure Update

Refer to Sheet(s): A 100D1

Updated plan detail 1/A100D1 verbiage to clarify break metal height to extend to above ceiling.

ADD-2 Item No. D-9 - Remove Patching Scope in Classroom D-9 and Computer Lab D-10.

Refer to Sheet(s): A 101D1

Removed keynote #1 scope from rooms D-9 and D-10 due to patch, prime, and paint not needed on a storefront system.

ADD-2 Item No. D-10 - Shaft Wall System

Refer to Sheet(s): A 200D1

Added a 1 hour rated shaft wall system to be installed directly below the structural concrete beams running alongside the exterior storefront. Refer to reflected ceiling plan sheet listed above for locations and corresponding 1 hour rated shaft wall detail.

ADD-2 Item No. D-11 - Ceiling Detail Call Out in Classroom D-5

Refer to Sheet(s): A 200D1

Added a ceiling detail call out to indicate the correct type of bulkhead construction.

ADD-2 Item No. D-12 - Updated scope For Doors in Classroom D-11, D-12, and D-13

Refer to Sheet(s): AD 101D1, A 101D1, A 201D1

Removed keynote #16 from demo plans, louvers above doors will not be demolished.

Updated door transom detail to reflect new break metal enclosure on both sides of the existing louvers. One hour shaft wall to run continuous across.

ADD-2 Item No. D-13 - Reheat Coil Piping Details

Refer to Sheet(s): M 502 and M 504

Removed “AHU Heating Coil Piping Detail-3-Way Valve (AHU-C1)” and replaced with “Reheat Coil Piping Detail (2-Way)” and “Reheat Coil Piping Detail (3-Way)”.

Updated Heating Coil Schedule to provide a 3-Way Control Valve on RCH-245.

ADD-2 Item No. D-14 - AHU Heating Coil Piping Details

Refer to Sheet(s): M 504

Revised AHU Heating Coil Piping Details to reflect Pre-Heat and Re-Heat coils. Removed circulating pump from Re-Heat coil detail.

ADD-2 Item No. D-15 - Unit D2 Valves

Refer to Sheet(s): M 200D1

Added shut-off valves on 4” heating supply and return lines to isolate Unit D2.

ADD-2 Item No. D-16 - Added Metering and Demand Information to E403

Refer to Sheet(s): E403

Added metering requirement to panel PPDPA prior to construction. Added demand information to both panels PPDPA and PPD3.

ADD-2 Item No. D-17 - Clarified Demand Information on E405

Refer to Sheet(s): E405

Clarified demand Information on panels MDPD2 and MDPD.

ADD-2 Item No. D-18 - Revisions to Electrical Feeder Schedule

Refer to Sheet(s): E406

Added disconnect information where it was previously missing.

Revised (3) 120V feeds for voltage drop: EF-D2, FCU245, FCU246

Removed graphics and shading from schedule.

Revised feeder voltage drop information to be a cumulative voltage drop in lieu of the individual voltage drop that was shown previously.

ADD-2 Item No. D-19 - Revisions to Electrical Light Fixture Schedule

Refer to Sheet(s): E407

Added fixtures that were previously missing.

Added light fixture and lighting control equals.

END OF ADDENDUM.

SECTION 23 0516 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Expansion compensators.
2. Flexible-hose expansion joints.
3. Pipe bends and loops.
4. Alignment guides and anchors.

1.2 DEFINITIONS

A. BR: Butyl rubber.

B. Buna-N: Nitrile rubber.

C. CR: Chlorosulfonated polyethylene synthetic rubber.

D. CSM: Chlorosulfonyl-polyethylene rubber.

E. EPDM: Ethylene-propylene-diene terpolymer rubber.

F. NR: Natural rubber.

G. PTFE: Polytetrafluoroethylene plastic.

1.3 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping system fluids, materials, working pressures, and temperatures.

B. Capability: Products shall absorb 200 percent of maximum axial movement between anchors.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Delegated-Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and bends.

2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.
4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Product Certificates: For each type of pipe expansion joint, signed by product manufacturer.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For pipe expansion joints to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. Steel Shapes and Plates: AWS D1.1, "Structural Welding Code - Steel."
2. Welding to Piping: ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 EXPANSION JOINTS

A. Expansion Compensators: Double-ply corrugated steel, stainless-steel, or copper-alloy bellows in a housing with internal guides, antitorque device, and removable end clip for positioning.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Adsco Manufacturing, LLC.
   b. Flexicraft Industries.
   c. Flex-Pression, Ltd.
   d. Flex-Weld, Inc.
   e. Hyspan Precision Products, Inc.
   f. Metraflex, Inc.
   g. Senior Flexonics, Inc.; Pathway Division.
   h. Unaflex Inc.
   i. Victaulic.

2. Minimum Pressure Rating: 150 psig(1035 kPa), unless otherwise indicated.
3. Configuration for Copper Piping: Two-ply phosphor-bronze or stainless-steel bellows and bronze or stainless-steel shroud.
4. Configuration for Steel Piping: Two-ply stainless-steel bellows and carbon-steel shroud.
5. End Connections for Steel Pipe NPS 2(DN 50) and Smaller: Threaded or flanged.

B. Flexible-Hose Expansion Joints: Manufactured assembly with two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose; with inlet and outlet elbow fittings, corrugated-metal inner hoses, and braided outer sheaths.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Flex-Hose Co., Inc.
   b. Flexicraft Industries.
   c. Flex-Pression, Ltd.
   d. Metraflex, Inc.

2. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with solder- joint end connections.
   a. NPS 2(DN 50) and Smaller: Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F(3100 kPa at 21 deg C) and 340 psig at 450 deg F(2340 kPa at 232 deg C) ratings.
   b. NPS 2-1/2 to NPS 4(DN 65 to DN 100): Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F(2070 kPa at 21 deg C) and 225 psig at 450 deg F(1550 kPa at 232 deg C) ratings.

3. Flexible-Hose Expansion Joints for Steel Piping: Carbon-steel fittings with threaded end connections for NPS 2(DN 50) and smaller and flanged, grooved, or weld end connections for NPS 2-1/2(DN 65) and larger.
   a. NPS 2(DN 50) and Smaller: Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F(3100 kPa at 21 deg C) and 325 psig at 600 deg F(2250 kPa at 315 deg C) ratings.
   b. NPS 2-1/2 to NPS 6(DN 65 to DN 150): Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F(1380 kPa at 21 deg C) and 145 psig at 600 deg F(1000 kPa at 315 deg C) ratings.

2.2 ALIGNMENT GUIDES

A. Description: Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Adsco Manufacturing, LLC.
   b. Advanced Thermal Systems, Inc.
   c. Flex-Hose Co., Inc.
   d. Flexicraft Industries.
   e. Flex-Weld, Inc.
   f. Hyspan Precision Products, Inc.
   g. Metraflex, Inc.
   h. Piping Technology & Products, Inc.
   i. Senior Flexonics, Inc.; Pathway Division.

2.3 MATERIALS FOR ANCHORS

A. Steel Shapes and Plates: ASTM A 36/A 36M.

B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex head.

C. Washers: ASTM F 844, steel, plain, flat washers.

D. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, and tension and shear capacities appropriate for application.

1. Stud: Threaded, zinc-coated carbon steel.
2. Expansion Plug: Zinc-coated steel.
3. Washer and Nut: Zinc-coated steel.

E. Chemical Fasteners: Insert-type-stud bonding system anchor for use with hardened portland cement concrete, and tension and shear capacities appropriate for application.

1. Bonding Material: ASTM C 881, Type IV, Grade 3, 2-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
2. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
3. Washer and Nut: Zinc-coated steel.

F. Concrete: Portland cement mix, 3000 psi(20.7 MPa) minimum. Comply with requirements in Division 03 Section "Cast-in-Place Concrete" for formwork, reinforcement, and concrete.

G. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink, nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi(34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

A. Install manufactured, nonmetallic expansion joints according to FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."

B. Install expansion joints of sizes matching size of piping in which they are installed.

C. Install alignment guides to allow expansion and to avoid end-loading and torsional stress.

3.2 PIPE BEND AND LOOP INSTALLATION

A. Install pipe bends and loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Attach pipe bends and loops to anchors.

1. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.

3.3 SWING CONNECTIONS

A. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

B. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

3.4 ALIGNMENT-GUIDE INSTALLATION

A. Install guides on piping adjoining pipe expansion fittings and loops.

B. Attach guides to pipe and secure to building structure.

3.5 ANCHOR INSTALLATION

A. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.

C. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.

D. Install pipe anchors according to expansion-joint manufacturer's written instructions if expansion joints or compensators are indicated.

E. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

END OF SECTION 23 0516

SECTION 23 0900 – INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Work shall include furnishing all labor, materials, equipment, and service necessary for a complete and operating Building Management System (BMS), utilizing direct digital controls. The BMS shall be capable of total integration of the facility infrastructure systems with user access to all system data either locally over a secure Intranet within the building or by remote access by a standard Web Browser over the Internet. This shall include HVAC control, electrical, gas and water metering, energy management, alarm monitoring, security and personnel access control, fire-life safety system monitoring, and all trending, reporting and maintenance management functions related to normal building operations all as indicated.

1. New Work shall communicate with and be integrated into Owner's existing district wide DDC control system.
2. All labor, material, equipment and software not specifically referred to herein or on the plans, required to meet the functional intent of this specification, shall be provided without additional cost to the Owner.
3. The intent of this specification is to provide a system that is consistent with BMS systems throughout the owner's facilities running the Niagara 4 Framework.
4. 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.
5. 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.
6. Any control vendor that shall provide additional BMS server software shall be unacceptable. Only systems that utilize the Niagara 4 Framework shall satisfy the requirements of this section.
7. The BMS 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 Niagara 4 Framework server.
8. Graphics, banner, functionality, navigation, data points, trends, and, etc. shall match the District's Template.
9. Owner shall receive all Administrator level login and passwords for engineering toolset prior to the final 10% of the project payment. The Owner shall have full licensing and full access rights for all network management, operating system server, engineering and programming software required for the ongoing maintenance and operation of the BMS.
10. OPEN NIC STATEMENTS - All Niagara 4 software licenses shall have the following NiCS set to ALL: "accept.station.in=*"; "accept.station.out=*"; "accept.wb.in=*"; "accept.wb.out=*". All open NIC statements shall follow Niagara Open NIC specifications.
11. All JACE hardware licenses and certificates shall be stored on local MicroSD memory card employing encrypted "safe boot" technology.
12. All JACE (SNC) and Station PASS PHRASES and PASSWORDS will be provided to the Owner or their representative at 90% completion or prior to retention being paid.
13. To ensure quality, only JACE/WEBs 8000 hardware products will be used on this project.

B. All products of the BMS 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 90.1-1999.
18. CE 61326
19. C-Tick
20. cUL

C. Work shall include but not limited to providing controls and instrumentation in accordance with equipment sequence of operations and their point lists. Point lists shall be a guide to the points required for control system. Final points required shall be determined by sequence of operation requirements.

D. Work required in this section shall include the complete Building Management System (BMS) including all controllers Interoperable LonWorks Controllers (ILC), Interoperable BACnet Controllers (IBC), control devices, control panels, controller programming, controller programming software, controller input/output wiring, power wiring, interlock and safety wiring, graphical user interface, Graphical User Interface (GUI), Graphical Development Tool (GDT), Network Area Controller(s) (NAC), server software, controller software and programming of the NAC and server, development of all graphical screens, setup of schedules, logs and alarms, global server software control applications, system integration and coordination of the NAC and server software to the Wide Area Network.

E. Ethernet LAN wiring, and Ethernet routing devices if applicable. The BMS shall provide a single point Ethernet connection utilizing OBIX TCP/IP to the Owner's WAN.

F. Work required in this section shall include providing all electrical work required for this section. The system shall include all interconnecting wiring and conduit as required for a fully operational system as specified. Wiring shall be installed as per local codes or Division 26 whichever is more stringent.

1. Power supply wiring and conduit from power source to power connection on DDC controls and DDC control panels.
   a. Line voltage wiring shall utilize methods and materials complying with the requirements of the Electrical Specifications, local building code, and NEC.

2. Control wiring and conduit between field-installed controls, indicating devices, and control panels.
   a. Low voltage wiring shall use methods and materials complying with the requirements of the Electrical Specifications, local building code and NEC. Plenum rated cable is acceptable where concealed and accessible.

1.2 RELATED SECTIONS

A. The following Sections contain requirements that relate to this Section:

1. Division 01 Section "Alternates" for requirements of alternates that relate to this Section.
2.
   a. Alternate No. 1 pertains to training the owner on the use of building controls.

1.3 WORK BY OTHERS

A. Setting in place of control valves, flow meters, water pressure and differential taps, flow switches, thermal wells, control dampers, airflow stations, and access doors.

B. Duct smoke detectors provide under Division 28.

1.4 SPECIFICATION NOMENCLATURE

A. Acronyms used in this specification are as follows:

1. Actuator: Control device that opens or closes valve or damper in response to control signal.
2. AI: Analog Input.
3. AO: Analog Output.
4. Analog: Continuously variable state over stated range of values.
5. BMS: Building Management System.
6. DDC: Direct Digital Control.
7. Discrete: Binary or digital state.
8. DI: Discrete Input.
9. DO: Discrete Output.
10. FC: Fail Closed position of control device or actuator. Device moves to closed position on loss of control signal or energy source.
11. FO: Fail open (position of control device or actuator). Device moves to open position on loss of control signal or energy source.
12. GUI: Graphical User Interface.
13. HVAC: Heating, Ventilating and Air Conditioning.
14. IDC: Interoperable Digital Controller.

15. ILC: Interoperable Lon Controller.
16. LAN: Local Area Network.
17. Modulating: Movement of a control device through an entire range of values, proportional to an infinitely variable input value.
18. Motorized: Control device with actuator.
19. NAC: Network Area Controller.
20. NC: Normally closed position of switch after control signal is removed or normally closed position of manually operated valves or dampers.
21. 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.
22. OSS: Operating System Server, host for system graphics, alarms, trends, etc.
23. Operator: Same as actuator.
24. PC: Personal Computer.
25. 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.
26. P: Proportional control; control mode with continuous linear relationship between observed input signal and final controlled output element.
27. 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).
28. PICS: BACnet Product Interoperability Compliance Statement.
29. 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).
30. Point: Analog or discrete instrument with addressable database value.
31. WAN: Wide Area Network.

1.5 ACTION SUBMITTALS

A. Refer to Division 1 for submittal administrative requirements and procedures.

B. Submittal shall consist of:

1. System architecture showing all digital devices, computers and network configuration.
2. Equipment lists of all proposed devices and equipment including data sheets of all products. Provide a PIC statement for each BACnet device and interoperability certification for each LonMark field device provided.
3. Valve, damper, and well and tap schedules showing size, configuration, capacity and location of all equipment.
4. Data entry forms for initial parameters. Contractor shall provide English listing of all analog points with columnar blanks for high and low warning limits and high and low alarm limits, and a listing of all systems with columnar blanks for beginning and end of occupancy periods; and samples of proposed text for points and messages (for at least two systems of at least 15 points total) including sample 480 character alarm message. All text shall be approved prior to data entry.
5. Schematic device wiring and piping interconnection diagrams including panel and device power and sources.
6. Software design data including flowchart of a typical DDC program showing interrelationship between inputs, PID functions, all other functions, outputs, etc.

7. A complete written Sequence of Operation in suppliers own terminology.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance data for control systems equipment to include in the operation and maintenance manual specified in Division 1. Include the following:

1. Maintenance instructions and spare parts lists for each type of control device.
2. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
3. Calibration records and list of set points.

B. Project Record Documents: Upon completion of the work, provide a complete set of 'as-built' drawings and application software on USB drive media or compact disk. Drawings shall be provided as AutoCAD™ or Visio™ compatible files. Three copies of the 'as-built' drawings shall be provided in addition to the documents on USB drive media or compact disk.

1.7 CODES AND APPROVALS

A. The complete BMS installation shall be in strict compliance to the national, state and local mechanical and electrical codes and the electrical section of these specifications. All devices shall be UL or FM listed and labeled for the specific use, application and environment to which they are applied.

B. The system shall comply with NFPA 90A Air Conditioning and 90B Warm Air Heating, Air conditioning.

C. System shall be designed and manufactured to ISO 9001 quality standard, and all electronic equipment shall conform to the requirements of FCC regulation Part 15, Section 15 governing radio frequency electromagnetic interference and be so labeled.

1.8 WARRANTY

A. All components, system software, and parts supplied by the BMS contractor shall be guaranteed against defects in materials and workmanship for one year from acceptance date. The BMS contractor at no charge shall furnish labor to repair, reprogram, or replace components during the warranty period. All corrective software modifications made during warranty periods shall be updated on all user documentation and on user and manufacturer archived software disks. The Contractor shall respond to the Owners request for warranty service within 48 hours during normal business hours.

B. Warranty Access

1. The Owner shall grant to the controls installer reasonable access to the BMS during the warranty period.

1.9 BMS CONTRACTOR QUALIFICATIONS

A. The BMS contractor shall have a local office within a 75 mile(120 Km) radius of the job site, staffed with and NiagaraN4 Certified factory trained engineers fully capable of providing instruction, routine maintenance and 24-hour emergency service on all system components. The BMS contractor shall have a three year experience record in the design and installation of computerized building systems similar in

scope and performance to that specified herein, and shall be prepared to provide evidence of this history as condition of acceptance and approval during Submittal.

1. This office will employ at least four NiagaraN4 programmers.
2. This office will be established as a Honeywell Authorized Controls Integrator - ACI

B. 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.

C. 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.

1.10 SOFTWARE LICENSE AGREEMENT

A. Software licensing for the Network Area Controller (NAC) and server software shall give the Owner the capability to control their system and determine which contractors can bid and engineer their system.

B. It shall be possible to insure the Owner can prevent unauthorized partners from accessing the system for engineering changes.

C. Software licensing shall have the freedom to individually manage authorized parties and independent parties.

D. The Owner shall accept the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software.

1.11 ADDED POINT AND MEMORY CAPACITY

A. The BMS software/firmware provided shall have the capacity for an unlimited number of NACs. Systems requiring future upgrades to accomplish this are not acceptable; capacity shall be provided at the time of bid.

B. Total system point capacity shall have the capacity for an unlimited number of future points. Systems requiring future upgrades to accomplish this are not acceptable; capacity shall be provided at the time of bid.

C. Supervising software shall allow unlimited expansion. Supervising software that is limited to the number of network area controllers is not acceptable

1.12 BMS TESTING AND ADJUSTING

A. Control Contractor shall be responsible for adjusting and readjusting the control systems as required to obtain the desired control sequencing and intent of the specifications. Refer to Section 23 0593 and requirement that system balance be accomplished twice.

B. If proper sequencing or system functions cannot be achieved with the factory provided controls, as specified and installed by the equipment manufacturer, and additional controls are required, the required additional controls shall be added at the expense of the factory controls provider.

1.13 DELIVERY, STORAGE, AND PROTECTION

A. Store equipment and materials inside and protected from weather.

1.14 COORDINATION

A. Coordinate location of exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 28 Section "Fire Detection and Alarm" to achieve compatibility with equipment that interfaces with that system.

C. Coordinate equipment with Division 26 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

D. Pre-Installation Conference: Attend a temperature controls conference with the project engineer to develop a mutual understanding of the sequencing, components, and details required for the project.

1. Engineer may invite other controls related stakeholders to this conference.
2. Provide a minimum of 7 days' advance notice of scheduled meeting time and location.

1.15 PROJECT COMMISSIONING

A. Project has an independent commissioning authority (CxA). Contractors for this project shall meet CxA requirements and shall coordinate with and participate in commissioning activities.

PART 2 - PRODUCTS

2.1 INSTALLERS

A. Subject to compliance with requirements, provide installation, products and services by one of the following:

1. ControlNet LLC.
2. Havel Brothers.
3. **SBS Smart Building Services.**

2.2 GENERAL

A. The Building Management System (BMS) shall be comprised of a network of interoperable, stand-alone digital controllers, Network Area Controllers, server software server, graphical user interface software, Web Browser Clients, portable operator terminals, printers, network devices and other devices as specified herein.

B. Provide the capability to open all control valves in each individual system at one time (I.E. zone, riser) to facilitate water balancing.

2.3 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURES

A. The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate SNMP, LonWorks, BACnet IP, BACnet MSTP, Modbus TCP/IP or Modbus RTU communication protocols 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. In addition, adherence to industry standards including ANSI / ASHRAE™ Standard 135, BACnet and LonMark to assure interoperability between all system components is required. For each LonWorks device that does not have LonMark certification, the device supplier must provide an XIF file for the device. For each BACnet device, the device supplier must provide a PICS document showing the installed device's compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet. For each Modbus device supplier must provide a Registry of data points available on the system.

C. All components and controllers supplied under this contract shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data shall not be acceptable.

D. The supplied system must incorporate the ability to access all data using standard web browsers without requiring 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 a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs shall not be acceptable.

E. The installed system shall provide secure password access to all features, functions and data contained in the overall BMS. Secure Socket Layer (SSL) encryption shall be an available option for remote access.

F. The installed system must be totally scalable to allow for future expansion with the addition of controllers and/or input/output devices. It shall not be necessary to remove equipment supplied under this contract to expand the system.

G. The failure of any single component or network shall not interrupt the control functions of non-affected devices. A single network failure shall only affect shared communications or shared data; individual application controllers and network controllers shall continue normal operation minus only the data from a remote device from the affected network. Automatic default values for all network transported data shall be provided to allow continued operation until the network is restored.

H. 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.

2.4 SYSTEM NETWORK CONTROLLER (SNC)

A. 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 shall be fully programmable to meet the unique requirements of the facility it shall control.

C. The controllers shall 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 cellular modem or connected via the Internet.

D. The communication protocols utilized for peer-to-peer communications between SNC's will be Niagara 4 Fox, BACnet TCP/IP and SNMP. Use of a proprietary communication protocol for peer-to-peer communications between SNC's is not allowed.

E. The SNC shall employ a device count capacity license model that supports expansion capabilities.

F. The SNC shall be enabled to support and shall be licensed with the following Open protocol drivers (client and server) by default:

1. BACnet
2. Lon
3. MODBUS
4. SNMP
5. KNX

G. 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.

H. The SNC shall provide the following hardware features as a minimum:

1. Two 10/100 Mbps Ethernet ports.
2. Two Isolated RS-485 ports with biasing switches.
3. 1 GB RAM
4. 4 GB Flash Total Storage / 2 GB User Storage
5. Wi-Fi (Client or WAP)
6. USB Flash Drive
7. High Speed Field Bus Expansion
8. -20-60°C Ambient Operating Temperature
9. Integrated 24 VAC/DC Global Power Supply
10. MicroSD Memory Card Employing Encrypted Safe Boot Technology

I. The SNC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 16 simultaneous users.

J. The SNC shall provide alarm recognition, storage, routing, management and analysis to supplement distributed capabilities of equipment or application specific controllers.

K. The SNC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via cellular modem, 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 #, access way, etc.).
   c. Acknowledge time, date, and user who issued acknowledgement.

L. Programming software and all controller "Setup Wizards" shall be embedded into the SNC.

1. The SNC shall support the following security functions.
2. Module code signing to verify the author of programming tool and confirm that the code has not been altered or corrupted.
3. Role-Based Access Control (RBAC) for managing user roles and permissions.
4. Require users to use strong credentials.
5. Data in Motion and Sensitive Data at Rest be encrypted.
6. LDAP and Kerberos integration of access management.

M. The SNC shall support the following data modeling structures to utilize Search; Hierarchy; Template; and Permission functionality:

1. Metadata: Descriptive tags to define the structure of properties.

2. Tagging: Process to apply metadata to components
3. Tag Dictionary

N. The SNC shall employ template functionality. Templates are a containerized set of configured data tags, graphics, histories, alarms... that are set to be deployed as a unit based upon manufacturer's controller and relationships. All lower level communicating controllers (PEC, AUC, AVAV, VFD…) shall have an associated template file for reuse on future project additions.

O. The SNC shall be provided with a 5 Year Software Maintenance license. Labor to implement is to be included.

P. In order to ensure future serviceability it is the intent of this specification that the local control contractor provide all programmable microprocessor based controls for all HVAC equipment with the exception of controls that are internal to the operation of equipment, i.e. Chiller control and Boiler combustion control. It is acceptable if the equipment supplier has a DDC ready package available to include dampers, valves, actuators, sensors, relays and safeties, transformer etc. Any equipment provided devices from the factory must match those specified herein and be coordinated with the control contractor to ensure power and signal compatibility are met.

2.5 PROGRAMMABLE EQUIPMENT CONTROLLER (PEC)

A. HVAC control shall be accomplished using LonMark or BACnet based devices where the application has a LonMark profile or BTL Listed PICS 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 shall provide an XIF file for the device. The controller platform shall provide options and advanced system functions, programmable and configurable using Niagara 4 Framework, that allow standard and customizable control solutions required in executing the "Sequence of Operation".

B. All PECs shall be application programmable and shall at all times maintain their certification. All control sequences within or programmed into the PEC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained.

C. 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 and/or 0-10 vdc 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 PEC, provide at each PEC a separate, fully isolated, enclosed, current limited and regulated UL listed auxiliary power supply for power to auxiliary devices.

D. Each PEC shall have expansion ability to support additional I/O requirements through the use of remote input/output modules.

E. PEC Controllers shall support at minimum the following control techniques:

1. General-purpose control loops that can incorporate Demand Limit Control strategies, Set point reset, adaptive intelligent recovery, and time of day bypass.
2. General-purpose, non-linear control loops.
3. Start/stop Loops.
4. If/Then/Else logic loops.
5. Math Function loops (MIN, MAX, AVG, SUM, SUB, SQRT, MUL, DIV, ENTHALPY).

2.6 ADVANCED UNITARY CONTROLLER (AUC)

A. 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 control shall use LonMark or BACnet based devices where the application has a LonMark profile or BTL Listed PICS 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 shall provide an XIF file for the device. The controller platform shall provide options and advanced system functions, programmable and configurable using Niagara 4 Framework, that allow standard and customizable control solutions required in executing the "Sequence of Operation".

B. Minimum Requirements:

1. The controller shall be fully programmable with full functionality on any Niagara 4 brand platform.
   a. Support downloads to the controller from any brand of Niagara 4 platform.
   b. Support uploads from the controller to any brand of Niagara 4 platform.
   c. Support simulation/debug mode of the controller.
   d. Maintain native GUI.

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: 116 Kilobytes with 8 Kilobytes for application program.
   b. FLASH Memory settings retained for ten years.
   c. RAM: 8 Kilobytes.

4. 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 degrees F (25 degrees C).
   c. Power Failure Backup: 24 hours at 32 degrees to 122 degrees F (0 degrees to 50 degrees C).

5. 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.
6. The controller shall have an internal DC power supply to power external sensors.

a. Power Output: 20 VDC ±10% at 75 mA.

7. The controller shall have a visual indication (LED) of the status of the devise:
   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.

8. The minimum controller Environmental ratings.
   a. Operating Temperature Ambient Rating: -40 degrees to 150 degrees F (-40 degrees to 65.5 degrees C).
   b. Storage Temperature Ambient Rating: -40 degrees to 150 degrees F (-40 degrees to 65.5 degrees C).
   c. Relative Humidity: 5% to 95% non-condensing.

9. 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).

10. The controller housing shall be UL plenum rated mounting to either a panel or DIN rail (standard EN50022; 7.5mm x 35mm).
11. 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).

12. The controller shall provide "continuous" automated loop tuning with an Adaptive Integral Algorithm Control Loop.
13. The controller platform shall have standard HVAC application programs that are modifiable to support both the traditional and specialized "sequence of operations" as outlined on the Drawings.

2.7 ADVANCED VARIABLE AIR VOLUME CONTROLLER (AVAV)

A. 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 CO2, 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. Control shall be accomplished using LonMark or BACnet based devices where the application has a LonMark profile or BTL Listed PICS 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 shall provide an XIF file for the device. The controller platform shall provide options and advanced system functions, programmable and configurable using Niagara 4 Framework, that allow standard and customizable control solutions required in executing the "Sequence of Operation".

B. Minimum Requirements:

1. The controller shall be fully programmable with full functionality on any Niagara 4 brand platform.
   a. Support downloads to the controller from any brand of Niagara 4 platform.
   b. Support uploads from the controller to any brand of Niagara 4 platform.
   c. Support simulation/debug mode of the controller.
   d. Maintain native GUI.

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 inch H2O (0 to 374 Pa).
   c. Accuracy: ±2% of full scale at 32 degrees to 122 degrees F (0 degrees to 50 degrees 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 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 degrees F (25 degrees C).
   c. Power Failure Backup: 24 hours at 32 degrees to 122 degrees F (0 degrees to 50 degrees 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 devise:
   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: 32 degrees to 122 degrees F (0 degrees to 50 degrees C).
   b. Storage Temperature Ambient Rating: 32 degrees to 122 degrees F (0 degrees to 50 degrees 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 provide an integrated actuator option.
   a. Actuator type: Series Floating.
   b. Rotation stroke: 95 degrees ±3 degrees for CW or CCW opening dampers.
   c. Torque rating: 44 lb-inch (5 Nm).
   d. Run time for 90 degrees rotation: 90 seconds at 60 Hz.

13. The controller shall have digital inputs (DI), digital Triac outputs (DO), three 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.

14. The controller shall provide "continuous" automated loop tuning with an Adaptive Integral Algorithm Control Loop.
15. The controller shall have a loop execution response time of 1 second.
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 on the Drawings.
   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 set points.

2.8 NETWORKS

A. The Local Area Network (LAN) shall be a 100 Megabits/sec Ethernet network supporting TCP/IP, BACnet IP, Modbus, Java, XML, and HTTP for maximum flexibility for integration of building data with enterprise information systems

B. Local area network minimum physical and media access requirements:

1. Ethernet; IEEE standard 802.3
2. Cable; 10 Base-T, UTP-8 wire, category 5E or 6
3. Minimum throughput; 10 Mbps, with ability to increase to 100 Mbps

2.9 NETWORK ACCESS

A. Owners WAN / LAN Access: Controls Installer must adhere to Owner's policy and requirements to obtain Owner's WAN access.

2.10 BAS SERVER & WEB BROWSER GUI - 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 HTML5 enabled browsers without requiring proprietary operator interface and configuration programs or browser plug-ins. Microsoft, Firefox, and Chrome browsers (current released versions), and Windows as well as non-Window operating systems.

C. The BAS server software shall support at least the following server platforms (Windows 7, 8.1, 10, Server 12). 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 shall provide a HTML5 experience that supports 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. Set point 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. 5 Year Software Maintenance license. Labor to implement is to be included.
3. Embedded System Configuration Utilities for future modifications to the system and controllers.
4. Embedded Graphical Programming Tools.
5. Embedded Direct Digital Control software.

F. BAS Server Database: The BAS server software shall utilize a Java Database Connectivity (JDBC) compatible database such as: MS SQL 8.0, Oracle 8i or IBM DB2. BAS systems written to Non -Standard and/or Proprietary databases are NOT acceptable.

G. Thin Client - Web Browser Based: The GUI shall be thin client or browser based and shall meet the following criteria:

H. Web Browser's for PC's: Only the current released browser (Explorer/Firefox/Chrome) will be required as the GUI and a valid connection to the server network. No installation of any custom software shall be required on the operator's GUI workstation/client. Connection shall be over an intranet or the Internet.

I. Secure Socket Layers: Communication between the Web Browser GUI and BAS server shall offer encryption using 128-bit encryption technology within Secure Socket Layers (SSL). Communication protocol shall be Hyper-Text Transfer Protocol Secure (HTTPS).

2.11 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 set point controls, configuration menus for operator access, reports and reporting actions for events.

B. Mobile Web Browser Navigation through Smart Phones and Tablets: In order to assure comprehensive mobile navigation with all major browsers, navigation shall be done through the use of a touch-friendly dynamic navigation bar. Right-click commands are not compatible with most mobile/touch devices, so all equipment commands shall utilize touch-compatible buttons. The contents of the dynamic navigation bar shall be customized to match the specific requirements of each building, while retaining the same general categories for consistency and ease of use.

C. Critical Data Display: The dynamic navigation bar may also display a critical data summary

D. 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 strong password. Navigation in the system shall be dependent on the operator's role-based application control privileges.

E. Navigation:

1. The buttons of the dynamic navigation bar shall be adaptive, changing hyperlink connections relevant to each system type, allowing hyperlinks, specific to the selected system to be added as requested by the consulting engineer.
2. The dynamic navigation bar at the top of each BMS page will be provided and have the following links/functions:
3. Home: A link that takes the user to a main entry point of navigation at a building or district level.
4. Main Systems Icons/Buttons: Links to general systems like HVAC, Lights, and Card Access are indicated by icon buttons. Links to major systems and equipment such Hydronic Systems or Air Handlers are listed in descriptive buttons.
5. Floor Plans: Links to floor plan sections are shown as graphic outline keys with descriptive buttons. Visual indicators highlight the part of the building that is relevant to the user's navigation (i.e. the section in which the currently viewed VAV box resides). Equipment occupancy status, when applicable, shall be indicated on the floor plan by a color-coded avatar.
6. Alarm Console: A table that shows all points that are in an alarm state and allowing users to silence or acknowledge alarms from the alarm console. The dynamic navigation bar will show the total number of unacknowledged alarms without having to go to the Alarm Console page.
7. Schedules: An at-a-glance schedule page that shows equipment schedule periods. The at-a-glance page allows users to change occupancy times with a weekly or calendar scheduler with a single click.
8. Information: A page with links to pertinent documents, including a BMS User's Guide. This page will provide legends/keys that define status colors and icons. This page will also serve as the landing page for links to the following feature pages, if they are not directly linkable from the dynamic navigation bar:
    a. Weather: A page that shows current local weather conditions in a seven-day forecast.
    b. Alarm History: A log of previous alarms that features sorting and time range filters.
    c. Audit Log: A log of users who have accessed the BMS. It records changes made by users and features sorting and time range filters.
    d. Chart Builder: A tool that allows charts to be made comparing historical data. It allows custom-built chart data to be exported as an Excel or .PDF file.
    e. Override Summary: A table of all equipment with a manual override status.
    f. User Configuration: A page that allows users to change log-in and profile information. Users with administrative rights may add or delete users to the BMS.
    g. Custom Dashboard: A page with customizable charts and gauges which can be saved independently for each operator.
    h. Email Configuration: A page that will allow administrators to set up email notification specifics for operators regarding alarms.
    i. User Configuration: A page that will allow administrators to add, delete, and edit the properties of users for the BAS.
9. Log-Out: Pressing this button will log the current user out of the BMS and return the browser to the log-in screen.
10. Navigational Info Fields: This feature provides information to the user by displaying the building name, current page name, current page description, outside air temperature, current date, and current time. The current page description is editable by the user from the graphic.

F. Graphics Pane: The Graphics Pane shall provide several functional views for each 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 set point

controls, web content and other valid HTML elements. The data on each graphic page shall automatically refresh.

2. Dashboards: User customizable data using drag and drop HTML5 elements. Shall include Web Charts, Gauges, and other custom developed widgets for web browser. User shall have ability to save custom dashboards. See Section 2.13 below.
3. Schedules: Shall be used to create, modify/edit and view schedules based on the systems hierarchy (using the dynamic navigation bar).
4. Alarms: Shall be used to view alarm information geographically (using the dynamic navigation bar), acknowledge alarms, sort alarms by category, actions and verify reporting actions.
5. Charting: Shall be used to display associated trend and historical data, modify colors, date range, axis and scaling. User shall have ability to create HTML charts through web browser without utilizing chart builder. User shall be able to drag and drop single or multiple data points, including schedules, and apply status colors for analysis.
6. Global Set Points page: This page is used to monitor and set global commands that affect multiple systems/equipment. (For example, all finned tube valves in the building would have a global minimum valve position set point and corresponding outside air temperature set point).
7. Preventative Maintenance Schedules page: This page is used to set and track runtimes for mechanical equipment. Alerts shall be sent to the Alarm Console when the runtime reaches the allocated time to notify operators that preventative maintenance is required. These runtime limits should be operator adjustable.
8. 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.

G. Color Graphics: The Web Browser GUI shall make extensive use of color in the graphic pane to communicate information related to set points and comfort. Animated .gifs or .jpg, vector scalable, active set point 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. General Graphic: General area maps shall show locations of controlled buildings in relation to local landmarks.
2. Color Floor Plans: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, as selected by Owner. The room temperature label colors shall be updated dynamically as a zone's actual comfort condition changes to give an at-a-glance realization of temperatures to the operator.
3. 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.
4. Minimum System Color Graphics: Color graphics shall be selected and displayed via a web browser for the following:
    a. Each piece of equipment monitored or controlled including each terminal unit.
    b. Each building.
    c. Each floor and zone controlled.

H. Hierarchical Schedules: Utilizing the Navigation Tree displayed in the web browser GUI, an operator (with proper access credentials) 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 shall be indicated on the Schedules Page.

1. Schedules: Schedules shall comply with the LonWorks and BACnet standards, (Schedule Object, Calendar Object, Weekly Schedule property and Exception Schedule property) and shall allow events to be scheduled based on:
   a. Types of schedule shall be Normal, Holiday or Override.
   b. A specific date.
   c. A range of dates.
   d. Any combination of Month of Year (1-12, any), Week of Month (1-5, last, any), Day of Week (M-Sun, Any).
   e. Wildcard (example, allow combinations like second Tuesday of every month).

2. 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.
3. 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'.
4. 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.
5. 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).
6. 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.

I. 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:

1. 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.
2. 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.

3. 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.
4. 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.
5. 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.
6. 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.
7. 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.
8. 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.
9. 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:
    a. Print: Alarm information shall be printed to the BAS server's PC or a networked printer.
    b. 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.
    c. 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).
    d. Write Property: The write property reporting action updates a property value in a hardware module.
    e. SNMP: The Simple Network Management Protocol (SNMP) reporting action sends an SNMP trap to a network in response to receiving an alarm.
    f. Run External Program: The Run External Program reporting action launches specified program in response to an event.

J. Trends: As system is engineered, all points shall be enabled to trend. 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.

1. 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.
2. 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.

3. 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.
4. Dynamic Update. Trends shall be able to dynamically update at operator-defined intervals.
5. 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.
6. Numeric Value Display. It shall be possible to pick any sample on a trend and have the numerical value displayed.

K. Security Access: Systems that Security access from the web browser GUI to BAS server shall require a Login Name and Strong Password. Access to different areas of the BAS system shall be defined in terms of Role-Based Access Control privileges as specified:

1. 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.
   a. View Privileges shall comprise: Navigation, Network, and Configuration Trees, Operators, Roles and Privileges, Alarm/Event Template and Reporting Action.
   b. Edit Privileges shall comprise: Set point, Tuning and Logic, Manual Override, and Point Assignment Parameters.
   c. Function Privileges shall comprise: Alarm/Event Acknowledgement, Control Module Memory Download, Upload, Schedules, Schedule Groups, Manual Commands, Print and Alarm/Event Maintenance.

2. 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.

2.12 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 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 shall 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 shall be self-documenting and provide the operator with an understandable and exact representation of each sequence of operation.

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 shall support a ' live' mode, where all input/output data, calculated data and set points shall be displayed in a ' live' real-time mode.

2.13 LONWORKS NETWORK MANAGEMENT

A. Network management shall include the following services: device identification, device installation, device configuration, device diagnostics, device maintenance and network variable binding.

B. 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.

C. 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.

D. 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 and within the control system shall not be accepted.

2.14 CUSTOM GRAPHICS - REQUIRED

A. Home Page

1. The building site overview shall provide a “mouse over” function to highlight the floor plan area to be accessed as a navigational aid. Room numbers and/or names will be included at the owner’s request. Critical data points, i.e. Outdoor Air Temperature, Outdoor Air Relative Humidity, Hot Water Supply Temperature, Chilled Water Supply Temperature or National Weather Service data will be continuously visible, in real time, within the HTML frame on all screens. Additional points may be added or deleted at the owner’s request without cost.

B. Floor Plans

1. Detailed floor plans shall be created with a vector drawing program accurately depicting the actual building layout to include all rooms, walls, and hallways. All space sensors shall be accurately placed in their actual locations and tagged with their real time space temperature and equipment each is associated with, i.e. 72.5°F/RTU-1, 74.2°/AHU-1, 73.4°/TU-1. Floor plans too large to be practically shown with data points will provide a “mouse over” function to highlight the floor plan area to be accessed. Room numbers and/or names will be included at the owner’s request.

C. Mechanical Systems

1. Detailed graphics for each mechanical system will include; AHUs, RTUs, CW Piping and Pumps, HW Piping and Pumps, TUs, and EFs as a minimum. Mechanical systems will include on-screen access to their respective set-points, trend logs and schedule. All time schedules will be setup as directed by the owner prior to final job turnover.
2. Detailed graphics for each mechanical system will include; AHUs, RTUs, HXs, CW Piping and Pumps, HW Piping and Pumps, HPs, TUs, and EFs as a minimum. Mechanical systems will include on-screen access to their respective set-points, trend logs and schedule. All time schedules will be setup as directed by the owner prior to final job turnover.
3. Dynamic trends of <u>all</u> data points shall be set up (specification will be followed as to actual number of trend points possible) prior to final job turnover. Each trend will be available directly on screen for quick trend access.
4. Data points will be shown for all relevant inputs and outputs and be positioned near the actual device. Analog and digital parameters will be able to be modified directly from the equipment screen.

D. Terminal Units

1. Terminal units such as cabinet heaters, unit heaters, VAV boxes will depict the actual configuration of the equipment controlled. Actual equipment configurations from manufacturers web sites and/or photos of installed equipment shall be used to ensure graphic depictions are as “near actual” as possible.
2. Terminal units such as heat pumps, fan coil units, unit ventilators, reheat coils, booster coils and VAV boxes will depict the actual configuration of the equipment controlled. Actual equipment configurations from manufacturers web sites and/or photos of installed equipment shall be used to ensure graphic depictions are as “near actual” as possible.

2.15 WEB BROWSER CLIENTS

A. The system shall be capable of supporting an unlimited number of clients using a standard Web browser . Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacturer-specific browsers shall not be acceptable.

B. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the BMS, shall not be acceptable.

C. The Web browser client shall support at a minimum, the following functions:

1. User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.
2. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
3. Storage of the graphical screens shall be in the NAC or server software, without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
4. Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.
5. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
    a. Modify common application objects, such as schedules, calendars, and set points in a graphical manner.
        1) Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
        2) Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
    b. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
    c. View logs and charts
    d. View and acknowledge alarms
    e. Setup and execute SQL queries on log and archive information
6. The system shall provide the capability to specify a user’s (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
7. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

2.16 SERVER SOFTWARE FUNCTIONS AND HARDWARE

A. The server software shall be provided. The server software shall support all TCP/IP connected to the control system router.

B. The Network server software shall provide the following functions, at a minimum:

1. Global Data Access: The server software shall provide complete access to distributed data defined anywhere in the system.
2. Distributed Control: The server software shall provide the ability to execute global control strategies based on control and data objects in any control system in the network, local or remote.
3. The server software shall include a master clock service for its subsystems and provide time synchronization for all control systems.
4. The server software shall accept time synchronization messages from trusted precision Atomic Clock Internet sites and update its master clock based on this data.
5. The server software shall provide scheduling for all control systems and their underlying field control devices.
6. The server software shall provide demand limiting that operates across all control systems. The server software must be capable of multiple demand programs for sites with multiple meters and or multiple sources of energy. Each demand program shall be capable of supporting separate demand shed lists for effective demand control.
7. The server software shall implement the BACnet Command Prioritization scheme (16 levels) for safe and effective contention resolution of all commands issued to control systems. Systems not employing this prioritization shall not be accepted.
8. Each control system supported by the server software shall have the ability to archive its log data, alarm data and database to the Network server software, automatically. Archiving options shall be user-defined including archive time and archive frequency.
9. The server software shall provide central alarm management for all control systems supported by the server software. Alarm management shall include:
    a. Routing of alarms to display, printer, email and pagers
    b. View and acknowledge alarms
    c. Query alarm logs based on user-defined parameters

10. The server software shall provide central management of log data for all control systems supported by the server software. Log data shall include process logs, runtime and event counter logs, audit logs and error logs. Log data management shall include:
    a. Viewing and printing log data
    b. Exporting log data to other software applications
    c. Query log data based on user-defined parameters

C. Server software Hardware Requirements: supplied by

1. The system integrator will be responsible for loading and testing the software on the PC.
2. The system integrator will coordinate with the owner for testing and authorization.

2.17 OBJECT LIBRARIES

A. A standard library of objects shall be included for development and setup of application logic, user interface displays, system services, and communication networks.

B. The objects in this library shall be capable of being copied and pasted into the user's database and shall be organized according to their function. In addition, the user shall have the capability to group objects created in their application and store the new instances of these objects in a user-defined library.

C. In addition to the standard libraries specified here, the supplier of the system shall maintain an on-line accessible (over the Internet) library, available to all registered users to provide new or updated objects and applications as they are developed.

D. All control objects shall conform to the control objects specified in the BACnet specification.

E. The library shall include applications or objects for the following functions, at a minimum:

1. Scheduling Object. The schedule must conform to the schedule object as defined in the BACnet specification, providing 7-day plus holiday & temporary scheduling features and a minimum of 10 on/off events per day. Data entry to be by graphical sliders to speed creation and selection of on-off events.
2. Calendar Object. . The calendar must conform to the calendar object as defined in the BACnet specification, providing 12-month calendar features to allow for holiday or special event data entry. Data entry to be by graphical “point-and-click” selection. This object must be “linkable” to any or all scheduling objects for effective event control.
3. Duty Cycling Object. Provide a universal duty cycle object to allow repetitive on/off time control of equipment as an energy conserving measure. Any number of these objects may be created to control equipment at varying intervals
4. Temperature Override Object. Provide a temperature override object that is capable of overriding equipment turned off by other energy saving programs (scheduling, duty cycling etc.) to maintain occupant comfort or for equipment freeze protection.
5. Start-Stop Time Optimization Object. Provide a start-stop time optimization object to provide the capability of starting equipment just early enough to bring space conditions to desired conditions by the scheduled occupancy time. Also, allow equipment to be stopped before the scheduled un-occupancy time just far enough ahead to take advantage of the building’s “flywheel” effect for energy savings. Provide automatic tuning of all start / stop time object properties based on the previous day’s performance.
6. Demand Limiting Object. Provide a comprehensive demand-limiting object that is capable of controlling demand for any selected energy utility (electric, oil, and gas). The object shall provide the capability of monitoring a demand value and predicting (by use of a sliding window prediction algorithm) the demand at the end of the user defined interval period (1-60 minutes). This object shall also accommodate a utility meter time sync pulse for fixed interval demand control. Upon a prediction that will exceed the user defined demand limit (supply a minimum of 6 per day), the demand limiting object shall issue shed commands to either turn off user specified loads or modify equipment set points to effect the desired energy reduction. If the list of sheddable equipment is not enough to reduce the demand to below the set point, a message shall be displayed on the users screen (as an alarm) instructing the user to take manual actions to maintain the desired demand. The shed lists are specified by the user and shall be selectable to be shed in either a fixed or rotating order to control which equipment is shed the most often. Upon suitable reductions in demand, the demand-limiting object shall restore the equipment that was shed in the reverse order in which it was shed. Each sheddable object shall have a minimum and maximum shed time property to effect both equipment protection and occupant comfort.

F. The library shall include control objects for the following functions. All control objects shall conform to the objects as specified in the BACnet specification.

1. Analog Input Object - Minimum requirement is to comply with the BACnet standard for data sharing. Allow high, low and failure limits to be assigned for alarming. Also, provide a time delay filter property to prevent nuisance alarms caused by temporary excursions above or below the user defined alarm limits.
2. Analog Output Object - Minimum requirement is to comply with the BACnet standard for data sharing.
3. Binary Input Object - Minimum requirement is to comply with the BACnet standard for data sharing. The user must be able to specify either input condition for alarming. This object must also include

the capability to record equipment run-time by counting the amount of time the hardware input is in an "on" condition. The user must be able to specify either input condition as the "on" condition.

4. Binary Output Object - Minimum requirement is to comply with the BACnet standard for data sharing. Properties to enable minimum on and off times for equipment protection as well as interstart delay must be provided. The BACnet Command Prioritization priority scheme shall be incorporated to allow multiple control applications to execute commands on this object with the highest priority command being invoked. Provide sixteen levels of priority as a minimum. Systems not employing the BACnet method of contention resolution shall not be acceptable.
5. PID Control Loop Object - Minimum requirement is to comply with the BACnet standard for data sharing. Each individual property must be adjustable as well as to be disabled to allow proportional control only, or proportional with integral control, as well as proportional, integral and derivative control.
6. Comparison Object - Allow a minimum of two analog objects to be compared to select either the highest, lowest, or equality between the two linked inputs. Also, allow limits to be applied to the output value for alarm generation.
7. Math Object - Allow a minimum of four analog objects to be tested for the minimum or maximum, or the sum, difference, or average of linked objects. Also, allow limits to be applied to the output value for alarm generation.
8. Custom Programming Objects - Provide a blank object template for the creation of new custom objects to meet specific user application requirements. This object must provide a simple BASIC-like programming language that is used to define object behavior. Provide a library of functions including math and logic functions, string manipulation, and e-mail as a minimum. Also, provide a comprehensive on-line debug tool to allow complete testing of the new object. Allow new objects to be stored in the library for re-use.
9. Interlock Object - Provide an interlock object that provides a means of coordination of objects within a piece of equipment such as an Air Handler or other similar types of equipment. An example is to link the return fan to the supply fan such that when the supply fan is started, the return fan object is also started automatically without the user having to issue separate commands or to link each object to a schedule object. In addition, the control loops, damper objects, and alarm monitoring (such as return air, supply air, and mixed air temperature objects) will be inhibited from alarming during a user-defined period after startup to allow for stabilization. When the air handler is stopped, the interlocked return fan is also stopped, the outside air damper is closed, and other related objects within the air handler unit are inhibited from alarming thereby eliminating nuisance alarms during the off period.
10. Temperature Override Object - Provide an object whose purpose is to provide the capability of overriding a binary output to an "On" state in the event a user specified high or low limit value is exceeded. This object is to be linked to the desired binary output object as well as to an analog object for temperature monitoring, to cause the override to be enabled. This object will execute a Start command at the Temperature Override level of start/stop command priority unless changed by the user.
11. Composite Object - Provide a container object that allows a collection of objects representing an application to be encapsulated to protect the application from tampering, or to more easily represent large applications. This object must have the ability to allow the user to select the appropriate parameters of the "contained" application that are represented on the graphical shell of this container.

G. The object library shall include objects to support the integration of devices connected to the Network Area Controller or server software. At a minimum, provide the following as part of the standard library included with the programming software:

1. LonMark/LonWorks devices. These devices shall include, but not be limited to, devices for control of HVAC, lighting, access, and metering. Provide LonMark manufacturer-specific objects to facilitate simple integration of these devices. All network variables defined in the LonMark profile shall be supported. Information (type and function) regarding network variables not defined in the LonMark profile shall be provided by the device manufacturer.
2. For devices not conforming to the LonMark standard, provide a dynamic object that can be assigned to the device based on network variable information provided by the device manufacturer. Device manufacturer shall provide an XIF file and documentation for the device to facilitate device integration.
3. For BACnet devices, provide the following objects at a minimum:
    a. BACnet AI
    b. BACnet AO
    c. BACnet BI
    d. BACnet BO
    e. BACnet Device
4. For each BACnet object, provide the ability to assign the object a BACnet device and object instance number.

2.18 DDE DEVICE INTEGRATION

1. The Network Area Controller shall support the integration of device data via Dynamic Data Exchange (DDE), over the Ethernet Network. The Network Area Controller shall act as a DDE client to another software application that functions as a DDE server.
2. Provide the required objects in the library, included with the Graphical User Interface programming software, to support the integration of these devices into the BMS. Objects provided shall include at a minimum:
    a. DDE Generic AI Object
    b. DDE Generic AO Object
    c. DDE Generic BO Object
    d. DDE Generic BI Object

2.19 OTHER CONTROL SYSTEM HARDWARE

A. Ethernet Switches

1. 8 Port 10/100 MBPS Switch / Hub
2. Din Rail Mounted
3. LED communication indicators
4. Acceptable Manufacturers
    a. Contemporary Controls
    b. INTEL
    c. Cisco Systems

B. Temperature Sensors and Transmitters

1. General Sensor & Transmitter Requirements

a. Provide sensors and transmitters required as outlined in the input/output summary and sequence of operation, and as required to achieve the specified accuracy as specified herein.
b. Temperature transmitters shall be equipped with individual zero and span adjustments. The zero and span adjustments shall be non-interactive to permit calibration without iterative operations. Provide a loop test signal to aid in sensor calibration.
c. Temperature transmitters shall be sized and constructed to be compatible with the medium to be monitored. Transmitters shall be equipped with a linearization circuit to compensate for non-linearities of the sensor and bridge and provide a true linear output signal.
d. Temperature sensors shall be of the resistance type and shall be 10K or 20K Ohm Thermistor type.
    1) Thermistors are acceptable provided the mathematical relationship of a thermistor with respect to resistance and temperature with the thermistor fitting constraints is contained with the controllers operating software and the listed accuracy's can be obtained. Submit proof of the software mathematical equation and thermistor manufacturer fitting constants used in the thermistor mathematical/expressions. Thermistors shall be of the Thermistor (NTC) Type with a minimum of 50 ohm/°C. resistance change versus temperature to insure good resolution and accuracy. Thermistors shall be certified to be stable ±0.13(C. over 5 years and ±0.2(C. accurate and free from drift for 5 years.
e. The following accuracy's are required and include errors associated with the sensor, lead wire and A to D conversion.
    1)

Point Type	Accuracy
Outside Air	+/-3%
Chilled/Hot Water	+/-1%
Room Temperature	+/-1%
Duct Temperature	+/-3%

    2) Sensors Used in Energy Water (BTU) or Process Calculations +/-1%
    3) Sensors used in energy or process calculations shall be accurate over the process temperature range. Submit a manufacturer's calibration report indicating that the calibration certification is traceable to the National Bureau of Standards (NBS) Calibration Report Nos. 209527/222173.

2. Thermowells
    a. When thermowells are required, the sensor and well shall be supplied as a complete assembly including well head and Greenfield fitting, except where wells are to be installed under separate contract.
    b. Thermowells shall be pressure rated and constructed in accordance with the system working pressure
    c. Thermowells and sensors shall be mounted in a threadolet or 1/2" NPT saddle and allow easy access to the sensor for repair or replacement.
    d. Thermowells shall be constructed of the following materials:
        1) Hot Water; brass.
        2) Chilled Water; brass.
        3) Steam; 316 stainless steel.

3. Outside Air Sensors
    a. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.
    b. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate surrounding the sensor element.

c. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.
d. Solar load sensors shall be provided in locations shown. The use of a thermistor combined with a solar compensator is acceptable. Provide calibration charts as part of the O&M Manual.

4. Duct Type Sensors
   a. Duct mount sensors shall mount in a hand box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement. A neoprene grommet (sealtite fitting and mounting plate) shall be used on the sensor assembly to prevent air leaks.
   b. Duct sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate. Duct sensors probe shall be constructed of 304 stainless steel.
   c. For outdoor air duct applications, use a weatherproof mounting box with weatherproof cover and gasket.

5. Averaging Duct Type Sensors
   a. Where called out on the drawings and points lists, provide averaging type duct sensors. Thermistor sensors are acceptable. The sensor shall be multi-point sensitive through the length of the temperature conducting tubing. The thermistors shall be configured in a series / parallel method which creates an end result of total average resistance equal to the same span as a standard thermistor.
   b. Provide capillary supports at the sides of the duct to support the sensing element.

6. Acceptable Manufacturers
   a. Honeywell
   b. Johnson Controls
   c. ACI
   d. Bapi

C. Relative Humidity Sensors/Transmitters

1. The sensor shall be a solid state, resistance type relative humidity sensor of the Bulk Polymer Design. The sensor element shall be washable and shall resist surface contaminations.
2. Humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2 wire isolated loop powered, 4-20ma, 0-10.0 VDC linear proportional output.
3. The humidity transmitter shall meet the following overall accuracy including lead loss and A to D conversion.
   a. Room Type Sensor ±2% RH
   b. Duct Type Sensor ±2% RH

4. Outside air relative humidity sensors shall be installed in a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with sealtite fittings and stainless steel bushings.
5. Provide a single point humidity calibrator, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.
6. Duct type sensing probes shall be constructed of 304 stainless steel and be equipped with a neoprene grommet, bushings and a mounting bracket.
7. Acceptable Manufacturers:
   a. Vailsala
   b. ACI
   c. Veris

d. Honeywell
e. Johnson Controls

D. Differential Pressure Transmitters and Accessories

1. General Air and Water Pressure Transmitter Requirements:
   a. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage and to hold calibrated accuracy when subject to a momentary 40% over-range input.
   b. Pressure transmitters shall provide the option to transmit a 0 to 5V dc, 0 to 10V dc, or 4 to 20 mA output signal.
   c. Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device and shall be supplied with shutoff and bleed valves in the high and low sensing pick-up lines (3 valve manifolds).
   d. Provide a minimum of a NEMA 1 housing for the transmitter. Locate transmitters in accessible local control panels wherever possible.
   e. Low air pressure, differential pressure transmitters used for room pressurization control (i.e. laboratories, OR's clean rooms, etc.) shall be equipped with a LED display indicating the transmitter output signal.
   f. Duct sensing pressure applications where the velocity exceeds 1500 fpm shall utilize a static pressure traverse probes.

2. Low Air Pressure Applications (0 to 125 Pa)
   a. The pressure transmitter shall be capable of transmitting a linear electronic signal proportional to the differential of the room and reference static pressure input signals with the following minimum performance specifications.
      1) Span: Not greater than two times the design space DP.
      2) Accuracy: Plus or minus 0.5% of F.S.
      3) Dead Band: Less than 0.3% of output.
      4) Repeatability: Within 0.2% of output.
      5) Linearity: Plus or minus 0.2% of span.
      6) Response: Less than one second for full span input.
      7) Temperature Stability: Less than 0.05% output shift per degree change.
   b. The transmitter shall utilize variable capacitance sensor technology and be immune to shock and vibration.
   c. Acceptable Manufacturers
      1) Auto Tran
      2) Veris
      3) Setra

3. Medium to High Air Pressure Applications (125 Pa to 2500 Pa)
   a. The pressure transmitter shall be similar to the Low Air Pressure Transmitter except the performance specifications are not as severe. Provide differential pressure transmitters which meet the following performance requirements.
      1) Zero & span: (% F.S./Deg. C): .05% including linearity, hysteresis and repeatability
      2) Accuracy: 1% F.S. (best straight line)
      3) Static Pressure Effect: 0.5% F.S.
      4) Static Pressure Effect: 0.5% F.S. (to 700 KPa)
      5) Thermal Effects: <±.05% F.S. /Deg. C.
      6) Thermal Effects: <±.05% F.S. /Deg. C. over 5C. to 40C. (calibrated at 22°C.)
   b. Acceptable manufacturers:

1) Auto Tran
2) Veris
3) Setra

E. Low Differential, Water Pressure Applications (0 KPa to 5 KPa)

1. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20mA output in response to variation of flow meter differential pressure or water pressure sensing points.
2. The differential pressure transmitter shall have non-interactive zero and span adjustments adjustable from the outside cover and meet the following performance specifications.
   a. 0 – 10 KPa input differential pressure range
   b. 4 - 20 mA output
   c. Maintain accuracy up to 20 to 1 ratio turndown
   d. Reference Accuracy: $\pm$ 0.2% of full span

3. Provide a two year warranty for each transmitter. Replace all transmitters found to be defective at no cost to the Owner during the warranty period. Acceptable Manufacturers:
   a. Tobar
   b. Veris
   c. Foxboro
   d. Omega
   e. Bailey
   f. Modus

F. Medium to High Differential Water Pressure Applications (5 KPa to 700 KPa)

1. The differential pressure transmitter shall meet the low pressure transmitter specifications except the following:
   a. Differential pressure range 5 KPa to 700 KPa.
   b. Reference Accuracy: ±l% of full span (includes non-linearity, hysteresis, and repeatability)
   c. Warranty: 1 year.

2. Acceptable Manufacturers:
   a. Auto Tran
   b. Veris
   c. ACI
   d. Setra

3. Bypass Valve Assembly: Mount stand-alone pressure transmitters in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with hi and low connections piped and valved. Air bleed units, bypass valves and compression fittings shall be provided

G. Electronic Valve And Damper Actuators

1. General Requirements
   a. Electronic actuators shall be electric, direct-coupled type capable of being mounted over the shaft of the damper. They shall be UL listed and the manufacturer shall provide a 2 year unconditional warranty from the date of commissioning. Power consumption shall not exceed 8 watts or 15 VA of transformer sizing capacity per high torque actuator nor 2 watts

or 4 VA for VAV actuators. Sound level shall not exceed 45 dB for high torque or 35 dB for VAV actuators.

b. Electronic overload protection shall protect actuator motor from damage. If damper jams actuator shall not burn-out. Internal end switch type actuators are not acceptable. Actuators may be mechanically and electrically paralleled on the same shaft to multiply the available torque. A reversing switch shall be provided to change action from direct to reverse in relation to control signal as operation requires.

c. Warranty must be two years by manufacturer on actuator as a whole and all components.

d. Acceptable manufacturers:
   1) Honeywell
   2) Johnson Controls
   3) Belimo

2. Control Damper Actuators
   a. OA (outside air), RA (return air), and EA (exhaust air) actuators shall be spring return type for safety functions. Individual battery backup, capacitor return is not acceptable.
   b. The control circuit shall be fully modulating using 2 - 10 volt or 4 - 20 mA signals. Accuracy and repeatability shall be within $\pm$ 1/21 of control signal. A 2 - 10 v or 4 - 20 mA signal shall be produced by the actuator which is directly proportional to the shaft clamp position which can be used to control actuators which are paralleled off a master motor or to provide a feedback signal to the automation system indicating damper position. Accuracy shall be within $\pm$ 2.5%.
   c. Face and bypass dampers and other control dampers shall be modulating using the same control circuit detailed above but shall not be spring return.

3. Miscellaneous Damper Actuators
   a. OA combustion and ventilation air intake and EA damper actuators shall be 2 position spring return closed if any water piping, coils or other equipment in the space which the damper serves needs to be protected from freezing. Otherwise drive open, drive closed type 2 position may be used.
   b. OA combustion and ventilation air intake and EA damper actuators shall be 2 position spring return closed if any water piping, coils or other equipment in the space which the damper serves needs to be protected from freezing. Otherwise drive open, drive closed type 2 position may be used. The minimum torque for any actuator shall be 5 N-m.
   c. Provide auxiliary switches on damper shaft or blade switch to prove damper has opened on all air handling equipment handling 100% outside air.
   d. Provide auxiliary switches on damper shaft or blade switch to prove damper has opened on all air handling equipment handling 100% outside air and greater than 6 KPa TSP.

4. Air Terminals
   a. Air terminal actuators shall use fully modulating floating (drive open, drive closed) 3 wire control or use control circuit as detailed in control dampers depending on the controllers' requirements.
   b. Air terminal actuators shall be minimum 5 N-m torque and use fully modulating floating (drive open, drive closed) 3 wire control or use control circuit as detailed in control dampers depending on the controllers' requirements.

5. Inlet Vanes Actuators
   a. Inlet vane actuators shall provide at least 150% of the minimum torque specified by the manufacturer as necessary to operate vanes properly. Either direct coupled or gear train with linkages are acceptable as required. The control loop for static control of the actuator

shall operate slowly enough to avoid hunting and maintain stable control. See automation system specifications for details.

6. Combination Smoke and Fire Damper Actuators
   a. Actuators shall be factory mounted and connected to the damper section and shall conform to UL 555S specifications.

H. Valve Actuators

1. Control Valves Actuators (3 inch and smaller)
   a. Actuators shall have a gear release button on all non-spring return models to allow manual setting. The actuator shall have either an insulating air gap between it and the linkage or a non-conducting thermoplastic linkage. Care shall be taken to maintain the actuator's operating temperatures and humidity within its specifications. Pipes shall be fully insulated and heat shields shall be installed if necessary. Condensation may not form on actuators and shall be prevented by a combination of insulation, air gap, or other thermal break.
   b. The control circuit shall be fully modulating using 2 - 10 volt or 4 - 20 mA signals. Accuracy and repeatability shall be within 1/21 of control signal. A 2 - 10 v or 4 - 20 mA signal shall be produced by the actuator which is directly proportional to the shaft clamp position which can be used to control actuators which are paralleled off a master motor or to provide a feedback signal to the automation system indicating valve position.
   c. Valve body and actuators shall be shipped fully assembled and tested at the valve factory prior to shipment.

2. Control Valve Actuators (4 inch and larger).
   a. The valve actuator shall consist of a permanent split capacitor, reversible type electric motor which drives a compound epicycle gear. The electric actuator shall have visual mechanical position indication, readable from a distance of 8 meters, showing output shaft and valve position. Unit shall be mounting directly to the valves without brackets and adapters, or readily adapted to suit all other types quarter-turn valves.
   b. The actuator shall have an integral terminal strip, which, through conduit entries, will ensure simple wiring to power supplies. Cable entries shall have UL recommended gland stops within the NPT hole to prevent glands from being screwed in too far and damaging cable.
   c. The actuator shall be constructed to withstand high shock and vibrations without operations failure. The actuator cover shall have captive bolts to eliminate loss of bolts when removing the cover from the base. One copy of the wiring diagram shall be provided with the actuator.
   d. The actuator shall have a self-locking gear train which is permanently lubricated at the factory. The gearing shall be run on ball and needle bearings. Actuators with 70 N-m or more output torque shall have two adjustable factory calibrated mechanical torque limit switches of the single-pole, double-throw type. The motor shall be fitted with thermal overload protection. Motor rotor shaft shall run in ball bearings at each end of motor.
   e. The actuator housing shall be hard anodized aluminum for full environmental protection.
   f. The environmental temperature range of the actuator shall be -22 to 140 deg F(-30 t0+60 deg C).
   g. For intermittent on/off service, the actuator shall be rated at a 20% duty cycle (i.e., 12 minutes extended duty in every hour, or alternatively; one complete cycle every 2 minutes). For more frequent cycling and modulating service, an actuator shall be rated for continuous duty. The actuator rated for continuous duty shall be capable of operating 100% of the time at an ambient temperature of 104 deg F(40 deg C).

h. The actuator shall have an integral self-locking gear train. Motor brakes shall not be required to maintain desired valve position. Levers or latches shall not be required to engage or disengage the manual override. Mechanical travel stops, adjustable to 15° in each direction of 90° rotation shall be standard, as well as two adjustable travel limit switches with electrically isolated contacts. Additional adjustable switches shall be available as option.

i. Single Phase Motor: The motor shall have Class B insulation capable of withstanding locked-rotor for 25 seconds without overheating. Wiring shall also be Class B insulation. An auto-reset thermal cut-out protector shall be embedded in the motor windings to limit heat rise to 175 deg F(80 deg C) in a 104 deg F(40 deg C) ambient. All motors shall be capable of being replaced by simply disconnecting the wires and then removing mounting bolts. Disassembly of gears shall not be required to remove the motor.

j. Materials of Construction: The electric actuator shall have a pressure die-cast, hard anodized aluminum base and cover. The compound gear shall be made of die-cast, hard anodized aluminum or steel. An alloy steel worm gear shall be provided for manual override and torque limiting. Bearings for gears shall be of the ball and needle type; bronze bearings shall be used on the shafting parts.

k. Accessories:
   1) Potentiometer for providing continuous feedback of actuator position at the controller (for valves specified position feedback).

l. Acceptable manufacturers:
   1) Honeywell
   2) Johnson Controls
   3) Belimo

I. Control Valves

1. Control valves shall be 2-way or 3-way pattern as shown constructed for tight shutoff and 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 psig(34 kPa) at rated flow (except as may be noted on the drawings). Valves with sizes up to and including NPS 2 (DN 50) shall be "screwed" configuration and NPS 2-1/2 (DN 65) inch and larger valves shall be "flanged" configuration. Electrically controlled valves shall include spring return type actuators sized for tight shut-off against system pressures and furnished with integral switches for indication of valve position (open-closed). Three-way butterfly valves, when utilized, shall include a separate actuator for each butterfly segment.
2. Acceptable manufacturers:
   a. Honeywell
   b. Belimo

J. Pressure Independent Modulating Control Valves (PICV)

1. PICV valves shall have control and flow control performed by the same valve. PICV valves utilizing a separate ball, globe or butterfly valve in association with a dynamic balancing valve or flow measuring station shall not be acceptable.
2. Valve bodies 2" (50mm) and smaller shall be brass. Valve bodies 3" thru 6" shall be ductile iron.
3. Valves shall have (2) factory installed pressure/temperature ports as part of the actual valve body.
4. Piston and Spring Assembly: Stainless steel or corrosion resistant, tamper proof, self cleaning, removable.
   a. Field adjustable flow rate without removing cartridge from the valve body.

1) In lieu of field adjustability, provide up to 10% of the total project PICV quantity of up or down sized flow rate cartridges as requested by Engineer during TAB.

5. Combination Assemblies: Include bonze or brass-alloy ball valve with stainless steel ball.
6. Identification Tag: Marked with zone identification, valve number, and flow rate.
7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
8. Minimum CWP Rating: 175 psig (1207 kPa).
9. Maximum Operating Temperature: 250 deg F (121 deg C).
10. Maximum Pressure Drop: 5 ft of head pressure drop at rated flow.
11. Seals: EDPM and Teflon

K. Switches

1. Differential Pressure Switches
   a. All pressure sensing elements shall be corrosion resistant. Pressure sensing elements shall be bourdon tubes, bellows, or diaphragm type. Units shall have tamper-proof adjustable range and differential pressure settings.
   b. Pressure sensor switch contacts shall be snap action micro-switch type. Sensor assembly shall operate automatically and reset automatically when conditions return to normal. Complete sensor assembly shall be protected against vibration at all critical movement pivots, slides and so forth.
   c. Differential pressure switches shall be vented to withstand a 50% increase in working pressure without loss of calibration.
   d. Acceptable Manufacturers: Mercoid, Dryer, McDonnell Miller.

2. Electric Low Limit Thermostat (Freeze Stat)
   a. Duct type, fixed 4 deg F(3 deg C) differential, range 32 to 60 deg F(0 to 15 deg C). Sensing element shall be a 20 feet(6m) long capillary tube responding to the lowest temperature sensed along any 12 inches(305 mm) of bulb length. Switch shall be SPDT 120/240 volts AC, rated for 10 amps at 120 volts full load. Unit shall be manually reset. Provide one low limit thermostat for each 20 sq. ft.(1.86 sq. m) or fraction thereof of coil surface area.
   b. Provide DPST switches, 1 NO, 1 NC contact.
   c. Provide manual type low limit thermostat set at 36 deg F(2 deg C) on each air handling unit.
   d. Provide thermostat override on air handling units for smoke control in area being served.

3. Water Flow Switches
   a. UL listed, suitable for all service application conditions. Body minimum working pressure rating shall equal or exceed service pressure. Switch electrical rating shall be 230 volts AC 3.7 ampere, 115 volts AC 7.4 ampere, and 125 VAC 115-230 VAC AC Pilot duty. Unit shall have two SPDT switches. Actuating flow rated shall be field adjustable for the specified and indicated service. Switch location shall preclude exposure to turbulent or pulsating flow conditions. Flow switch shall not cause pressure drop exceeding 2 psi at maximum system flow rate.
   b. Acceptable Manufacturer: McDonnel-Miller.

4. Strap-On Aquastat
   a. UL listed, provided with a suitable removable spring clip for attaching aquastat to pipe and a snap-action SPDT switch. Switch set-point shall be as indicated. Electrical rating shall be 5 amperes, 120 VAC.

5. 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.

L. Flow, Pressure And Electrical Measuring Apparatus

1. Traverse Probe Air Flow Measuring Stations
   a. Traverse probes shall be a dual manifolded, cylindrical, type constructed of 3003 extruded aluminum with an anodized finish to eliminate surface pitting and unnecessary air friction. The multiple total pressure manifold shall have sensors located along the stagnation plane of the approaching air flow and without the physical presence of forward projecting sensors into the airstream. The static pressure manifold shall incorporate dual offset static tips on opposing sides of the averaging manifold so as to be insensitive to flow-angle variations of as much as ±20° in the approaching airstream.
   b. The air flow traverse probe shall not induce a measurable pressure drop, nor shall the sound level within the duct be amplified by its singular or multiple presence in the airstream. Each airflow measuring probe shall contain multiple total and static pressure sensors placed at equal distances along the probe length. The number of sensors on each probe and the quantity of probes utilized at each installation shall comply with the ASHRAE Standards for duct traversing.
   c. Traverse probes shall be accurate to ±25% of the measured airflow range.
   d. Traverse probes shall be accurate to ±25% of the measured airflow range down to 60 Pa static pressure.
   e. Each flow measuring station shall be complete with its own dedicated microprocessor with a 4-line, 80 character, Alpha Numeric display and full function key pad. The panel shall be fully programmable and display calculated liters per minute directly on a LED monitor on the panel face.
   f. Provide 24 volt 1 phase power to each flow measuring station.
   g. Acceptable Manufacturers:
      1) Air Monitor
      2) Ultratech
      3) Air Sentinel.

2. Shielded Static Pressure Sensor
   a. Provide for each zone where required a shielded static pressure sensor suitable for ceiling surface mounting, complete with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, and 3/8" compression takeoff fittings, all contained in a welded stainless steel casing, with polish finish on the exposed surfaces.
   b. Provide for each zone where required a shielded static pressure sensor suitable for ceiling surface mounting, complete with multiple sensing ports, pressure impulse suppression chamber with minimum volume of 800 cubic centimeters, airflow shielding, and 3/8" compression takeoff fittings, all contained in a welded stainless steel casing, with polish finish on the exposed surfaces.
   c. These probes shall be capable of sensing the static pressure in the proximity of the sensor to within 1% of the actual pressure value while being subjected to a maximum airflow of 1000 feet/min.(300 m/min) from a radial source.
   d. The shielded static sensing devices shall be used for both reference and space pressure sensing.
   e. Pressure sensors used for outside air pressure reference purposes shall be equipped with a conduit seal for pneumatic tubing and bushings for a weather tight installation.

3. Static Pressure Traverse Probe
   a. Provide multipoint traverse probes in the duct at each point where static pressure sensing is required.
   b. Each duct static traverse probe shall contain multiple static pressure sensors located along the exterior surface of the cylindrical probe. Pressure sensing points shall not protrude beyond the surface of the probe.
   c. The duct static traverse probe shall be of 304 stainless steel construction and (except for 3/4" dia. probes with lengths of 24 inches(610 mm) or less) be complete with threaded end support rod, sealing washer and nut, and mounting plate with gasket and static pressure signal fitting. The static traverse probe shall be capable of producing a steady, non-pulsating signal of standard static pressure without need for correction factors, with an instrument accuracy of ± 1/2%.
   d. Acceptable Manufacturers:
      1) Auto Tran
      2) Veris
      3) Setra

M. Relays And Contactors

1. Relays other than those associated with digital output cards shall be general purpose, enclosed type and protected by a heat and shock resistant duct cover. Number of contacts and operational function shall be as required.
2. Solid State Relays (SSR): Input/output isolation shall be greater than IOE^{9} ohms with a breakdown voltage of 1500V root mean square or greater at 60 Hz. The contact life shall be 10 x 10 E^{6} operations or greater. The ambient temperature range of SSRs shall be -18 to 140 deg F(-28 To+60 deg C). Input impedance shall not be less than 500 ohms. Relays shall be rated for the application. Operating and release time shall be for 100 milliseconds or less. Transient suppression shall be provided as an integral part of the relay.
3. Contactors: Contactors shall be of the single coil, electrically operated, mechanically held type. Positive locking shall be obtained without the use of hooks, latches, or semipermanent magnets. Contractor shall be double-break-silver-to-silver type protected by arcing contacts. The number of contacts and rating shall be selected for the application. Operating and release times shall be 100 milliseconds or less. Contactors shall be equipped with coil transient suppression devices.

N. Temperature Control Panels

1. Furnish temperature control panels of code gauge steel with locking doors for mounting all devices as shown. Panels shall conform to NEMA 1 standards, unless otherwise indicated.
2. Control panels shall meet all requirements of UL508A and shall be so certified.
3. All external wiring shall be connected to terminal strips mounted within the panel.
4. Provide engraved phenolic nameplates identifying all devices mounted on the face of control panels and the identification number of the panel.
5. A complete set of ‘as-built’ control drawings (relating to the controls within that panel) shall be furnished within each control panel.

O. Variable Frequency Drives

1. Furnish Variable Frequency Drives (VFD) for installation by the electrical contractor (Div. 16). Drives shall be factory equipped with a LonTalk FTT-10A communications interface.
2. The variable frequency drive (VFD) shall generate the required variable frequency through three main input voltage lines connected to an LC filter and diode bridge. This shall produce a DC voltage for

an insulated gate bi-polar transistor (IGBT) bridge. The IGBT bridge shall produce a pulse-width modulated (PWM) AC voltage for the motor. A microprocessor shall control the motor according to measured signals and control commands sent from the VFD control panel.

3. The VFD enclosure shall be INSERT ENCLOSURE TYPE (NEMA 1, NEMA 12, OPEN CHASSIS).
4. VFD shall be suitable for INSERT DESIRED VOLTAGE RANGE (208-240 VAC, 380-500 VAC, or 525-690 VAC). The VFD shall maintain functionality from -15% to +10% of nominal voltage at a frequency of 45-66 Hz. Ambient operating temperature range shall be 14 F to 104 F, and the humidity range: 5 to 95% RH (non-condensing).
5. The VFD shall accommodate inputs of 0-10 VDC, 4-20 mA, up to six digital inputs. VFD outputs shall include current of 0-20 mA, 500 ohm maximum with 10 bit resolution, and two programmable changeover relay outputs with switching capacity of 24 VDC, 8A; 250 VAC, 8A; and 125 VDC, 0.4A.
6. The VFD shall accommodate Modbus, LonTalk, and BACnet communications protocols for field bus control.
7. The variable frequency drive shall have separate pre-loaded user-programmable applications which can be modified using a personal computer-based commissioning tool with an optional software package, or an alpha-numeric LCD user interface. Aforementioned application functionality shall include but not be limited to:
    a. Basic Functionality Application providing the following:
        1) Control I/O signals (two (2) analog inputs, one (1) digital input, and one (1) analog output) are fixed
        2) One (1) programmable digital input and one (1) programmable digital output
        3) All parameters have default values,
        4) No more than nine (9) parameter settings are required for startup and operation.
    b. Expanded Functionality Application providing all capabilities in the previous application as well as the following:
        1) One (1) programmable digital input and all outputs are programmable
        2) Frequency limit and prohibit capability
        3) Programmable start/stop and reversing logic
        4) Automatic restart
        5) Programmable actions for motor thermal and stall protection
        6) DC brake at stop
    c. Application that provides all previously mentioned capability as well as enabling the use of two different control and frequency sources. Each source must be programmable.
    d. Application which provides all functionality from the Expanded Functionality Application as well as accommodates multiple, required fixed speed references.
    e. PID Control Application – Uses internal PID control loop to control motor frequency as well as providing:
    f. Input and output phase supervision
    g. Programmable capability for three (3) digital inputs and all outputs
    h. Sleep function
    i. Multi-purpose Control Application – The frequency reference can be selected from analog inputs, joystick control, motor potentiometer, or a mathematical function of the analog inputs.
    j. Application specifically designed to control one leading variable speed drive and up to 3 auxiliary drives.

8. Variable frequency drives shall be UL listed and sized for the power and loads applied.
9. Drives shall include built-in radio frequency interference (RFI) filters and be constructed to operate in equipment rooms and shall not be susceptible to electromagnetic disturbances typically

encountered in such environments. Similarly, the drives must not excessively disturb the environment within which it is used.

10. All VFDs over 3 horsepower shall be provided with an AC choke before rectifiers. All included chokes and filters shall be integrated in the factory enclosure.
11. VFDs shall be installed in strict conformance to the manufacturer's installation instructions, and shall be rated to operate over a temperature range of 14 to 104 F.
12. VFD automatic operation shall be suitable for 4-20 ma input signal. Each VFD shall be fan cooled and have an integral keypad and alphanumeric "plain-language" display unit for user interface. The display shall indicate VFD status (RUN motor rotation, READY, STOP, ALARM, and FAULT), and shall indicate the VFD current control source (DDC input signal, keypad, or field bus control). In addition to the alphanumeric display, the display unit shall have three pilot lights to annunciate when the power is on (green), when the drive is running (green, blinks when stopping and ramping down), and when the drive was shut down due to a detected fault (red, fault condition presented on the alphanumeric display).
13. Three types of faults shall be monitored, "FAULT" shall shut the motor down, "FAULT Auto-reset" shall shut the motor down and try to restart it for a programmable number of tries, and "FAULT Trip" shall shut the motor down after a FAULT Auto-reset fails to restart the motor. Coded faults shall be automatically displayed for the following faults:
    a. Over current
    b. Over voltage
    c. Earth ground
    d. Emergency stop
    e. System (component failure)
    f. Under voltage
    g. Phase missing
    h. Heat sink under temperature
    i. Heat sink over temperature
    j. Motor stalled
    k. Motor over temperature
    l. Motor underload
    m. Cooling fan failure
    n. Inverter bridge over temperature
    o. Analog input control under current
    p. Keypad failure
    q. Other product unique monitored conditions
14. In addition to annunciating faults, at the time of fault occurrence the VFD shall capture and make available to the user certain system data for subsequent analysis during fault trouble shooting, including duration of operation (days, hours, minutes, seconds),output frequency, motor current, motor voltage, motor power, motor torque, DC voltage, unit temperature, run status, rotation direction, and any warnings. The last 30 fault occurrences shall be retained as well as the fault data listed in the previous sentence of each fault. New faults beyond 30 shall overwrite the oldest faults.
15. The display unit keypad shall allow setting operational parameters including minimum and maximum frequency, and acceleration and deceleration times. The display shall offer user monitoring of faults, frequency, unit temperature, and motor speed, current, torque, power, voltage, and temperature.
16. Acceptable manufacturers:
    a. ABB
    b. Honeywell
    c. Square D

P. Temperature Control Air Compressor (when required): A duplex air compressor system (two compressors mounted on one tank) shall be furnished and installed by the temperature control contractor. Air compressor system shall be sized to fit the pneumatic control system, to insure no more than 33% run time. The tank shall be sized for a maximum of 6 starts per hour. An automatic alternator shall be connected to the motors and pressure switches, in a 'lead-lag' manner, and shall alternate compressor operation after each on-off cycle. Alternator shall be further connected to energize the 'lag' operation after each on-off cycle. Alternator shall be further connected to energize the 'lag' compressor at the setting of the lower pressure switch if the "lead" compressor fails or is disabled for service. Air compressor system shall include a refrigerated air dryer sized for the capacity of the air compressor. Accessories such as filters, pressure regulators, valves, spring isolators, automatic tank drain etc. shall also be furnished for a complete operating system.

Q. Any automatic control dampers not specified to be integral with other equipment. Frames shall not be less than 0.094 inch(2.39 mm) galvanized steel. Blades shall not be over 8 inches(200 mm) wide nor less than 0.063 inch(1.52 mm) galvanized steel roll formed. Bearings shall be oilite, ball-bearing or nylon with steel shafts. Side seals shall be stainless steel of the tight-seal spring type. Dampers and seals shall be suitable for temperature ranges of -40 to 200 deg F(-40 to 93 deg C).

1. Individual damper sections shall have a maximum of 16 sq. ft.(1.49 sq. m) of damper surface and each individual damper section to have its own damper operator.
2. All proportional control dampers shall be opposed blade type and all two-position dampers shall be parallel blade types.
3. Dampers shall be sized to meet ductwork or opening size.
4. Dampers shall be ultra-low leakage dampers and the blade edges shall be fitted with replaceable, snap-on, inflatable seals to limit damper leakage to 6 CFM per square foot for dampers in excess of sixteen inches square at 1-inch wg(250 Pa).

R. Thermally Isolated Dampers: Tampco Series 9000 or equivalent extruded aluminum thermally isolated control dampers with insulated air-foiled shaped blades.

S. Thermally Isolated Dampers: Ruskin Model CDTI50 or equivalent extruded aluminum thermally isolated control dampers with insulated air-foiled shaped blades.

1. Smoke Evacuation System Dampers: UL Listed.

T. Digital Wall Module: Each wall module shall provide temperature indication to the digital controller.

1. Provide software-limited set point adjustment and occupied/unoccupied override capability where indicated.
2. Module mounted adjustments shall use buttons, no slides or wheels.
3. Where indicated, provide plate type security temperature sensors.

U. Digital Wall Module: Each wall module shall provide temperature indication to the digital controller, provide the capability for a software-limited set point adjustment, occupied/unoccupied override capability and fan speed selection/mode. An integral LCD shall annunciate room temperature, set point, fan speed and operating mode. In addition an integral humidity sensor with display shall be available.

V. Wireless Temperature Transmitter: Module shall provide temperature indication to the digital system.

1. Supply Power: Lithium batteries, 8 year battery life at 10 second transmit rate
2. Inputs: Built in thermistor

3. Accuracy: ±0.2 °C
4. Transmitted Range: -40° to 85°C
5. Environmental Operation Range:
   a. Temp: 0° to 60°C
   b. Humidity: 5% to 95% RH non-condensing

6. Material: ABS Plastic
7. Material Rating: UL94 V-0
8. Radio Frequency: 418 MHz
9. Transmitter Interval: ~10 seconds
10. Antenna: Built inside the enclosure
11. Associated Products:
    a. 418 or 900 MHz Receivers: Receives the RF signal from one or more transmitters or repeaters and outputs the values to Analog Output Modules.
    b. Analog Output Modules: Converts the signal from the Receiver into a resistance, voltage or current for sending to the controller.
    c. Repeater: Extends the range of the Transmitter up to 1,000 feet.

W. Power Monitoring Interface: The Power Measurement Interface (PMI) device shall include the appropriate current and potential (voltage) transformers. The PMI shall be certified under UI-3111. The PMI shall perform continuous true RMS measurement based on 32 samples-per-cycle sampling on all voltage and current signals. The PMI shall provide outputs to the BMS based on the measurement and calculation of the following parameters: (a) current for each phase and average of all three phases, (b) kW for each phase and total of all three phases, (c) power factor for each phase and all three phases, (d) percent voltage unbalance and (e) percent current unbalance. These output valves shall be hard-wired inputs to the BMS or shall be communicated to the BMS over the open-protocol LAN.

X. Water Flow Meters: Water flow meters shall be axial turbine style flow meters which translate liquid motion into electronic output signals proportional to the flow sensed. Flow sensing turbine rotors shall be non-metallic and not impaired by magnetic drag. Flow meters shall be 'insertion' type complete with 'hot-tap' isolation valves to enable sensor removal without water supply system shutdown. Accuracy shall be ± 2% of actual reading from 0.4 to 20 feet per second(0.12 to 6.1 meters per second) flow velocities.

Y. Duct smoke detectors shall be furnished and connected to the building fire alarm under Division 28. Contacts shall be provided for the BMS contractor to connect for fan shutdown as specified in the Sequence of Operations.

Z. Carbon Monoxide sensor/transmitter shall be Armstrong Monitoring Corporation AMC-3701 or approved equal. Solid state sensor with 4-20mA linear signal output corresponding to 0-100 PPM CO, Aluminum enclosure, remote calibration feature with non-interactive zero and span, protection against overvoltage and polarity reversal, capable of covering up to 7500 Sq. Ft. (697 Sq. m.). Sensors shall be mounted 3 to 4 feet (0.9 to 1.2 m) above finished floor where indicated on drawings.

AA. Nitrogen Dioxide sensor/transmitter shall be shall be Armstrong Monitoring Corporation AMC-2281 or approved equal. Electrochemical type sensor with 4-20mA linear signal output corresponding to 0-10 PPM NO2, PVC housing, remote calibration feature with non-interactive zero and span, protection against overvoltage and polarity reversal, capable of covering up to 7500 Sq. Ft. (697 Sq. m.). Sensors shall be mounted 12 inches(305 mm) below ceiling where indicated on drawings.

BB. Carbon Dioxide sensors shall be 0-10 Vdc analog output type, with corrosion free gold-plated Non-dispersive Infrared sensing, designed for duct mounting. Sensor shall incorporate internal diagnostics for

power, sensor, analog and output checking, and Automatic Background Calibration algorithm for reduced maintenance. Sensor range shall be 0-3000 PPM with +/- 5% and +/- 50 PPM accuracy.

CC. Outside Air Inlet Airflow Probes:

1. Provide on outside air dampers bead-in-glass thermistor airflow probes capable of continuously measuring the outside air volume.
   a. The airflow probes shall be factory calibrated to NIST traceable standards and use thermal dispersion technology.
   b. The airflow traverse probes shall not significantly impact fan performance or contribute to fan generated noise levels.
   c. The probes shall be capable of producing steady, non-pulsating signals of standard total and static pressure, without need for flow corrections or factors, with an accuracy of 2% of actual reading.

2. Include matching factory transmitter with an accuracy of ±0.5% of Natural Span and be furnished with a built-in 3-way zeroing valve, user selectable square root function, and integral 3-1/2 digit scalable LCD for display of measured process. The Transmitter shall be housed in a NEMA 1 NEMA 4 enclosure with universal 1/8" FPT signal connection ports, and provide 0-5 volt, 0-10 volt, or 4-20ma output signals for use by the building control system.
3. Include matching factory transmitter with an accuracy of ±0.5% of Natural Span and be furnished with a built-in 3-way zeroing valve, user selectable square root function, and integral 3-1/2 digit scalable LCD for display of measured process. The Transmitter shall be housed in a NEMA 1[] NEMA 4 enclosure with universal 1/8" FPT signal connection ports, and provide 0-5 volt, 0-10 volt, or 4-20ma output signals for use by the building control system.
4. The airflow probes shall be the Ebtron “Gold” Series with class “C” density.

DD. Supply Air fan Inlet Airflow Probes:

1. Provide bead-in-glass thermistor airflow probes on AHU supply fan inlets capable of continuously measuring the supply air volume.
   a. The airflow probes shall be factory calibrated to NIST traceable standards and use thermal dispersion technology.
   b. The airflow traverse probes shall not significantly impact fan performance or contribute to fan generated noise levels.
   c. The probes shall be capable of producing steady, non-pulsating signals of standard total and static pressure, without need for flow corrections or factors, with an accuracy of 2% of actual reading.

2. Include matching factory transmitter with an accuracy of ±0.5% of Natural Span and be furnished with a built-in 3-way zeroing valve, user selectable square root function, and integral 3-1/2 digit scalable LCD for display of measured process. The Transmitter shall be housed in a NEMA 1 enclosure with universal 1/8" FPT signal connection ports, and provide 0-5 volt, 0-10 volt, or 4-20ma output signals for use by the building control system.
3. Include matching factory transmitter with an accuracy of ±0.5% of Natural Span and be furnished with a built-in 3-way zeroing valve, user selectable square root function, and integral 3-1/2 digit scalable LCD for display of measured process. The Transmitter shall be housed in a NEMA 4 enclosure with universal 1/8" FPT signal connection ports, and provide 0-5 volt, 0-10 volt, or 4-20ma output signals for use by the building control system.
4. The airflow probes shall be the Ebtron “Gold” Series with class “C” density.

EE. Airflow Measuring System (Duct Mounted Configuration): Provide where indicated, bead-in-glass thermistor airflow measuring stations capable of continuously monitoring the duct airflow they serve. Each airflow measuring station shall consist of an airflow measuring station and a transmitter.

1. Each airflow traverse probe mounted within the station shall contain multiple total and static pressure sensors located along its exterior surface, and internally connected to their respective averaging manifolds.
2. The airflow measuring stations shall have a galvanized steel, 6" deep casing with 90º connecting flanges. Total and static pressure sensors shall be located at the centers of equal areas (for rectangular ducts) or at equal concentric area centers (for circular ducts) across the stations face area.
3. Stations shall be AMCA certified and be capable of measuring the airflow rates within an accuracy of ±2% without the use of correction factors. The maximum allowable unrecovered pressure drop caused by the station shall not exceed .025" w.c. at 2000 FPM, or .085" w.c. at 4000 FPM.
4. The Transmitter shall have an accuracy of ±0.5% of Natural Span and be furnished with a built-in 3-way zeroing valve, user selectable square root function, and integral 3-1/2 digit scalable LCD for display of measured process. The Transmitter shall be housed in a NEMA 1 aluminum enclosure with universal 1/8" FPT signal connection ports, and provide 0-5 volt, 0-10 volt, or 4-20ma output signals for use by the building control system.
5. The airflow probes shall be the Ebtron “Gold” Series with class “C” density.

2.20 NATURAL GAS FLOW METER

A. Provide an ONICON Model F-5100 or equivalent insertion thermal mass flow meter, complete with all installation hardware for insertion and removal of the meter without system shutdown. Materials of construction for metal components in contact with gas shall be 316 stainless steel. The flow meter shall provide SFPM flow readings from a pair of encapsulated platinum sensors and shall not require additional temperature or pressure compensation. In addition, the meter shall continuously display information that can be used to validate the calibration of the meter. Each flow meter shall be individually wet-calibrated against a standard that is directly traceable to NIST. Include certificate of calibration with each flow meter.

B. Accuracy shall be within ± 1% of rate from 500-7000 SFPM and ± 2% of rate from 100-7000 SFPM. Overall turndown shall exceed 1000:1. Output signals shall consist of the following: (1) analog 4-20mA output and (1) scalable pulse output for totalization. The meter shall be equipped with an integrally mounted graphical display.

PART 3 - EXECUTION

3.1 GENERAL

A. The BMS shall be designed, installed, and commissioned in a turnkey operational manner; including all labor not noted in Work by Others paragraph of PART I of this section of these specifications, and not noted in other sections of these specifications.

B. Where control devices are installed on insulated piping or ductwork, provide standoff brackets or thermowells sized to clear insulation thickness. Provide extended sensing elements, actuator linkages, and other accessories as required.

3.2 SEQUENCE OF OPERATION

A. Refer to drawings for sequence of operations.

3.3 INSTALLATION

A. All controls Installer work shall be installed, wired, circuit tested and calibrated by factory certified technicians qualified for this work.

B. Install system and materials in accordance with manufacturer's instructions, and as detailed on the project drawing set.

C. Drawings of BMS are diagrammatic only and any apparatus not shown, such as relays, accessories, etc., but required to make the system operative to the complete satisfaction of the Engineer shall be furnished and installed without additional cost.

D. Line and low voltage electrical connections to control equipment shown, specified, or shown on the control diagrams shall be furnished and installed by the controls Installer in accordance with these specifications.

E. 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.

F. All wiring and tubing shall be properly supported and run in a neat and workmanlike manner. All wiring and tubing exposed and in equipment rooms shall run parallel to or at right angles to the building structure. All tubing and wiring within enclosures shall be neatly bundled and anchored to prevent obstruction to devices and terminals. All wiring shall be in accordance with all local and national codes. All line voltage wiring, all wiring exposed, and all wiring in equipment rooms shall be installed in conduit in accordance to the electrical specifications. All electronic wiring shall be #18 AWG minimum THHN and shielded if required, except standard network (Ethernet, LonWorks, etc.) cabling shall be as tested and recommended in lieu of #18 gauge twisted, #22 or #24 gauge is acceptable if used as a part of an engineered structured cabling system. The control manufacturer must submit technical and application documentation demonstrating that this cabling system has been tested and approved for use by the manufacturer of both the control system and the engineered structured cabling system.

1. Low voltage system cables shall be neatly routed and independently supported with cable rings to the nearest cable tray, technology closet, conduit run or equipment connection.
2. All wiring in ceiling plenums shall be plenum rated.

G. This contractor shall provide all sensing, control, and interlock wiring and tubing for the following unless shown or specified elsewhere by others:

1. Boiler interlocks.
2. Chiller interlocks.
3. Condensing units interlocks.
4. Hydronic piping pressure sensors.
5. CO2 sensors.
6. Connection between occupancy sensors provided by Division 26 and control devices.
7. Air to Air Energy Recovery Unit interlocks.
8. Refrigerant alarm panel interlocks and sensor tubing.
9. Smoke detection devices and HVAC equipment shut-down devices.

H. The controls contractor shall install all software and enter all computer data into the network area controllers, hardware, and related computers including all control programs, initial approved parameters and settings, and graphics.

I. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 40 inches(1016 mm) above the floor.

J. For airflow monitoring devices, perform the following field tests and inspections and prepare test reports:

1. Operational Test: After substantial completion of airflow system, start units to confirm proper operation and readings. Remove and replace malfunctioning units and retest.
2. Test calibration to confirm proper operation and readings.

K. Install natural gas flow meter at gas service entrance to measure whole facility gas usage, include emergency generator.

L. Connect to electrical power monitor at main power service entrance disconnect to measure whole facility electrical usage.

3.4 ACCEPTANCE

A. The BMS contractor shall completely check out, calibrate and test all connected hardware and software to insure that the system performs in accordance with the approved specifications and sequences of operations.

1. Coordinate with other Installers the checkout of each controlled system

B. The controls Installer 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 of the DDC system operation.

C. Upon completion of the performance tests described above, repeat these tests, point by point as described in the validation log above in presence of Owner's Representative, as required. Properly schedule these tests so testing is complete at a time directed by the Owner's Representative. Do not delay tests so as to prevent delay of occupancy permits or building occupancy.

D. System Acceptance: Satisfactory completion is when the controls Installer 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. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

3.5 TRAINING (ALTERNATE 1)

A. All training shall be by the BMS Installer and shall utilize operators’ manuals and as-built documentation.

B. The controls Installer shall provide 40 hours of instruction to the Owner's designated personnel on the operation of the BMS and describe its intended use with respect to the programmed functions specified. Operator orientation of the BMS shall include, but not be limited to; device programming software, graphical development software, graphical user interface, the overall operation program, equipment

functions (both individually and as part of the total integrated system), commands, systems generation, advisories, and appropriate operator intervention required in responding to the System's operation.

C. The training shall be in three sessions as follows:

1. Initial Training: One day session (8 hours) after system is started up and at least one week before first acceptance test. Manual shall have been submitted at least two weeks prior to training so that the Owners' personnel can start to familiarize themselves with the system before training begins.
2. Follow-Up Training: Two one day sessions (8 hours each) after initial training, and before Formal Acceptance. These sessions will deal with more advanced topics and answer questions.
3. Warranty Follow Up: Two one day sessions (8 hours each) to be scheduled at the request of the Owner during the one year warranty period. These sessions shall cover topics as requested by the owner such as; how to add additional points, create and gather data for trends, graphic screen generation or modification of control routines.

D. On-Line Service: Include 40 hours of on-line service assistance to include but not be limited to:

1. Programming changes or modifications, including changes and adjustments to control algorithms
2. Graphic changes or modifications as requested by the Owner or consulting engineer.
3. Operator assistance to include short (1 hour or less) refresh training on system diagnostics and operation, i.e., geothermal optimization, scheduling, trending or operator setup.
4. Consulting engineer assistance to include assistance on control system optimization.

3.6 POINTS LIST

A. Refer to drawings for points list. Provide all additional points as required to accomplish all BMS sequences indicated in the drawings and specifications.

END OF SECTION 23 0900

SECTION 23 5700 - HEAT EXCHANGERS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes shell-and-tube and plate type heat exchangers.

1.2 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, performance, and dimensional requirements of heat exchangers and are based on the specific equipment indicated. Refer to Division 01 Section "Product Requirements."

B. ASME Compliance: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

PART 2 - PRODUCTS

2.1 SHELL-AND-TUBE HEAT EXCHANGERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Bell & Gossett.
2. **Armstrong.**

B. Configuration: U-tube with removable bundle.

C. Shell Materials: Steel.

D. Head:

1. Materials: Cast iron.
2. Flanged and bolted to shell.

E. Tube:

1. Seamless copper tubes.
2. Tube diameter is determined by manufacturer based on service.

F. Tubesheet Materials: Steel tubesheets.

G. Baffles: Steel.

H. Piping Connections:

1. Shell: Flanged or threaded inlet and outlet fluid connections, with threaded drain and vent connections.
2. Head: Threaded or flanged inlet and outlet fluid connections.

I. Support Saddles:

1. Fabricated of material similar to shell.
2. Foot mount with provision for anchoring to support.

PART 3 - EXECUTION

3.1 HEAT-EXCHANGER INSTALLATION

A. Install shell-and-tube heat exchangers on saddle supports.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Maintain manufacturer's recommended clearances for service and maintenance. Install piping connections to allow service and maintenance of heat exchangers.

1. For shell-and-tube heat exchangers, offset piping to allow tube pull.

C. Install shutoff valves at heat-exchanger inlet and outlet connections.

D. Install relief valves on heat-exchanger heated-fluid connection and pipe relief valves, full size of valve connection, to floor drain.

E. Install hose end valve to drain shell.

3.3 FIELD QUALITY CONTROL

A. Test units for leaks. Replace damaged equipment.

3.4 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain heat exchangers. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 23 5700

SECTION 23 8233 - CONVECTORS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Hydronic finned-tube radiators.
2. Hydronic convectors.
3. **Flat-pipe steel radiators.**

1.2 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Color Samples for Initial Selection: For units with factory-applied color finishes.

D. Color Samples for Verification: For each type of exposed finish required.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

PART 2 - PRODUCTS

2.1 HOT-WATER OR STEAM FINNED-TUBE RADIATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Modine.
2. Rittling, a div. of Hydro-Air Components.
3. Sigma.
4. Sterling.
5. Trane.
6. Vulcan.
7. Embassy Industries, Inc.
8. Engineered Air.
9. Rosemex.
10. Slant/Fin.

B. Performance Ratings: Rate finned-tube radiators according to Hydronics Institute's "I=B=R Testing and Rating Standard for Finned-Tube (Commercial) Radiation."

C. Heating Elements: Copper tubing mechanically expanded into flanged collars of evenly spaced aluminum fins resting on element supports. One tube end shall be belled.

D. Element Supports: Ball-bearing cradle type to permit longitudinal movement on enclosure brackets.

E. Front Panel: Minimum 0.0781-inch-(1.98-mm-) thick steel.

F. Wall-Mounting Back Panel: Minimum 0.0329-inch-(0.85-mm-) thick steel, full height, with full-length channel support for front panel without exposed fasteners.

G. Floor-Mounting Pedestals: Conceal insulated piping at maximum 36-inch(914-mm) spacing. Pedestal-mounting back panel shall be solid panel matching front panel. Provide stainless-steel escutcheon for floor openings at pedestals.

H. Support Brackets: Locate at maximum 36-inch(914-mm) spacing to support front panel and element.

I. Finish: Baked finish in manufacturer's standard color as selected by Architect.

J. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches(150 by 175 mm), integral with enclosure.

K. Enclosure Style: Sloped top.

1. Bottom Inlet: Open bottom.
2. Top Outlet Grille: Punched louver; painted to match enclosure.

L. Enclosure Style: Sloped top.

1. Top Outlet Grille: Punched louver; painted to match enclosure.

M. Accessories:

1. Filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.
2. All required expansion controls located within enclosures for long sections of elements.

2.2 HOT-WATER CONVECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Modine.
2. Rittling, a div. of Hydro-Air Components.
3. Sigma.
4. Sterling.
5. Trane.
6. Vulcan.

B. Convector Elements: Seamless copper tubing mechanically expanded into evenly spaced aluminum fins and rolled into cast-iron or brass headers with inlet/outlet and air vent; steel side plates and supports. Factory-pressure-test element at minimum 100 psig(690 kPa).

C. Front and Top Panel: Minimum 0.0677-inch-(1.7-mm-) thick steel with exposed corners rounded; removable front panels with tamper-resistant fasteners braced and reinforced for stiffness.

1. Recessed Cabinets: One-piece front panel, with 4-side gasketed overlap.

D. Wall-Mounting Back and End Panels: Minimum 0.0428-inch-(1.1-mm-) thick steel.

E. Floor-Mounting Pedestals: Conceal conduit for power and control wiring at maximum 36-inch(914-mm) spacing. Pedestal-mounting back panel shall be solid panel matching front panel.

F. Support Brackets: Locate at maximum 36-inch(914-mm) spacing to support front panel and element.

G. Insulation: 1/2-inch-(13-mm-) thick, fibrous glass on inside of the back of the enclosure.

H. Finish: Baked-enamel finish in manufacturer's standard color as selected by Architect.

I. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches(150 by 175 mm), integral with enclosure.

J. Enclosure Style: Sloped top.

1. Top Outlet Grille: Punched louver; painted to match enclosure.

2.3 **FLAT-PIPE STEEL RADIATORS**

A. **Manufacturers: Subject to compliance with requirements, provide products by one of the following:**

1. **Myson Inc.**
2. **Rittling, a div. of Hydro-Air Components.**
3. **Runtal North America, Inc.**
4. **Sterling.**

B. **Heating Elements: Steel, welded and formed into flat, square, steel header with minimum thickness of 0.109 inches(2.76 mm). Include threaded piping and air vent connections.**

1. **Working Pressure 85 psig(585 kPa): 0.058 inch(1.47 mm).**

C. **Mounting: Floor pedestals on maximum spacing of 36 inches(914 mm).**

D. Finish: Baked-enamel finish in manufacturer's standard color as selected by Architect.

E. Accessories:

1. **Steel piping covers finished to match radiator finish.**
2. Flexible Expansion Compensation Hoses: Minimum **400-psig** (2758-kPa) working pressure, and operating temperatures from **33 to 211 deg F** (0.5 to 99.5 deg C).
   a. **Minimum Diameter: Equal to connection size.**

3. **Ribbed pipe cover trims, finished to match the radiators shall be provided.**
4. Radiator shall include an integral heavy gauge (0.09” minimum) all-welded perforated top grille.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive convection heating units for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for hydronic-piping connections to verify actual locations before convection heating unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FINNED-TUBE RADIATOR INSTALLATION

A. Install units level and plumb.

B. Install enclosure continuously around corners, using outside and inside corner fittings.

C. Join sections with splice plates and filler pieces to provide continuous enclosure.

D. Install access doors for access to valves.

E. Install enclosure continuously from wall to wall.

F. Terminate enclosures with manufacturer's end caps, except where enclosures are indicated to extend to adjoining walls.

G. Install valves within reach of access door provided in enclosure.

3.3 CONVECTOR INSTALLATION

A. Install units level and plumb.

B. Install valves within reach of access door provided in enclosure.

C. Install air-seal gasketing between wall and recessing flanges or front cover of fully recessed unit.

3.4 **FLAT-PIPE STEEL RADIATOR INSTALLATION**

A. **Install units level and plumb.**

B. Install expansion compensation hoses.

C. Install piping covers.

D. Install coin or screw driver operated manual air vent on each panel section at factory provided vent connection.

3.5 CONNECTIONS

A. Piping installation requirements are specified in Division 23 Section "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect hot-water units and components to piping according to Division 23 Section "Hydronic Piping."

1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.

C. Install control valves as required by Division 23 Section "Instrumentation and Control for HVAC."

D. Install piping adjacent to convection heating units to allow service and maintenance.

3.6 FIELD QUALITY CONTROL

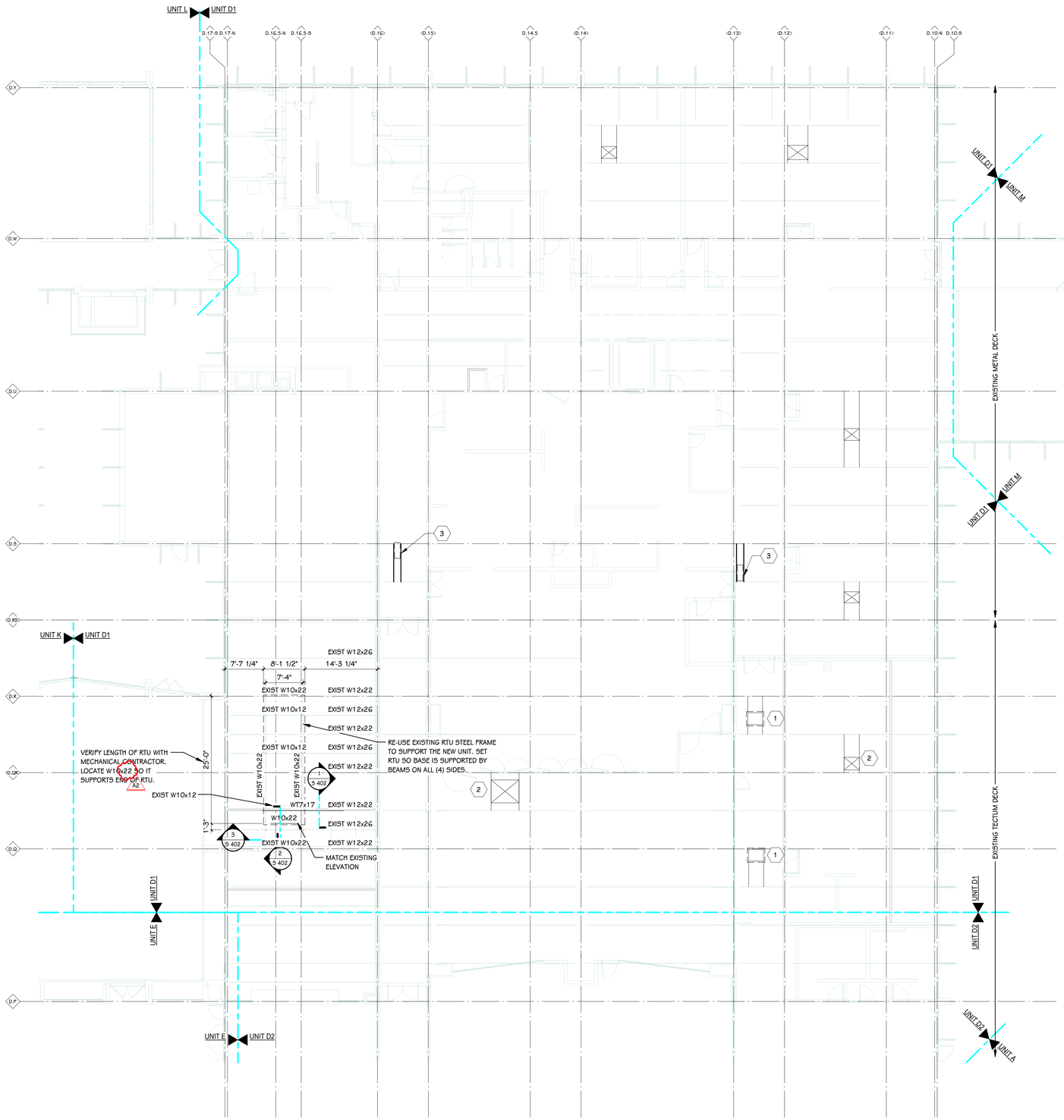
A. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.

B. Perform the following field tests and inspections and prepare test reports:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper convection heating unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace convection heating units that do not pass tests and inspections and retest as specified above.

END OF SECTION 23 8233



ROOF FRAMING PLAN - UNIT D1

3/32" = 1'-0"

NOTES - STRUCTURAL - ROOF AND FLOOR FRAMING

1 REFER TO PLAN FOR TOS ELEVATIONS

2 ALL OPENINGS IN MASONRY WALLS WIDER THAN 8" REQUIRE LINTELS. FOR LINTELS NOT SHOWN ON PLANS REFER TO LINTEL SCHEDULE FOR SIZE, COORDINATE LOCATIONS AND OPENING WIDTHS WITH ARCHITECTURAL AND MECHANICAL DRAWINGS

KEYED NOTES - STRUCTURAL - FRAMING

1 INSTALL ANGLE FRAME TO SUPPORT ACCU. REFER TO TYPICAL ACCU SUPPORT DETAIL. SUPPORT ACCU PAD DIRECTLY OVER ANGLE FRAME.

2 LOCATE ROOF PENETRATIONS BETWEEN BULB TEES. REFER TO S 401 FOR TYPICAL ROOF OPENING FRAME DETAIL FOR ADDITIONAL INFORMATION. COORDINATE SIZE AND LOCATION WITH SUPPLIER.

3 REFER TO TYPICAL FCU ACCU SUPPORT DETAILS.

SYMBOLS LEGEND - STRUCTURAL - FRAMING

INDICATES FRAMED OPENING. REFER TO TYPICAL DETAIL, COORDINATE SIZE AND LOCATION WITH MECHANICAL AND ARCHITECTURAL REQUIREMENTS.

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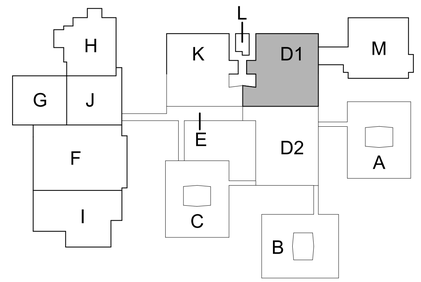

KEY PLAN

SCALE: NO SCALE

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Addendum No. 2	November 25, 2025

PROJECT TITLE
LOY NORRIX HIGH SCHOOL MECHANICAL IMPROVEMENTS PROJECT

OWNER
KALAMAZOO PUBLIC SCHOOLS

Kalamazoo, MI

SHEET TITLE
ROOF FRAMING PLAN - UNIT D1

DATE
OCTOBER 31, 2025

SHEET NUMBER
S 202D1

23-637.00

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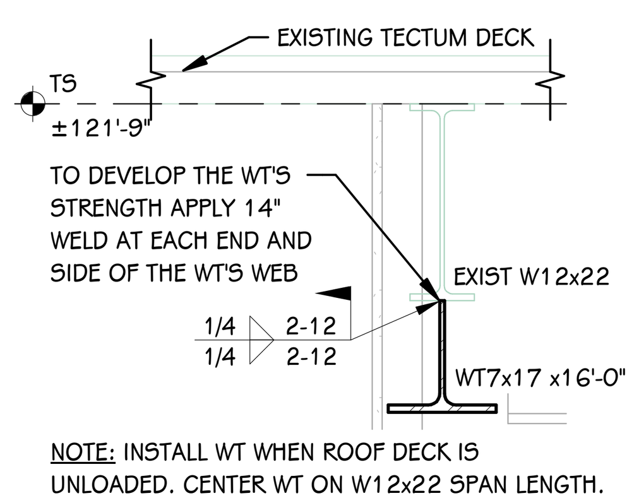
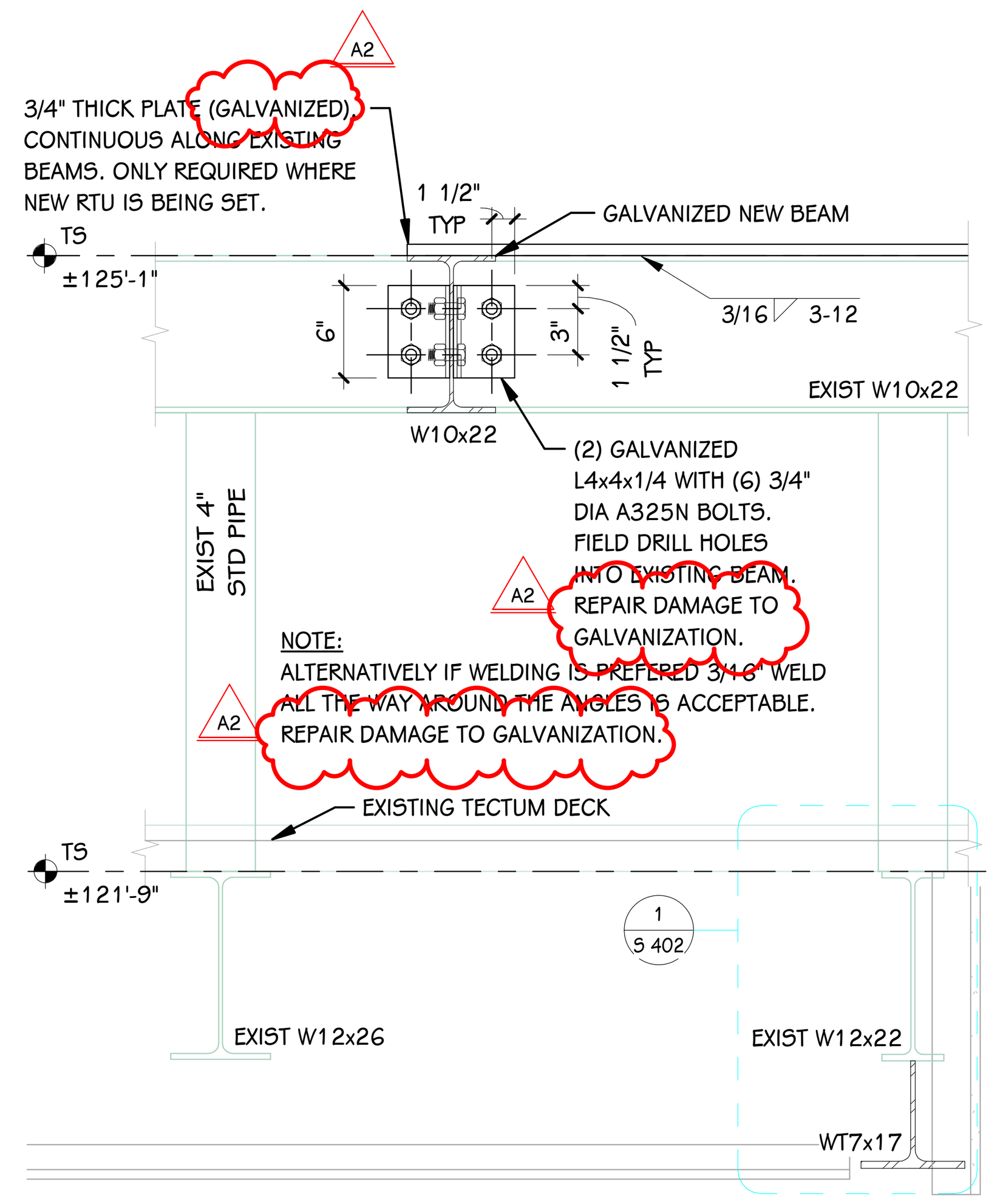
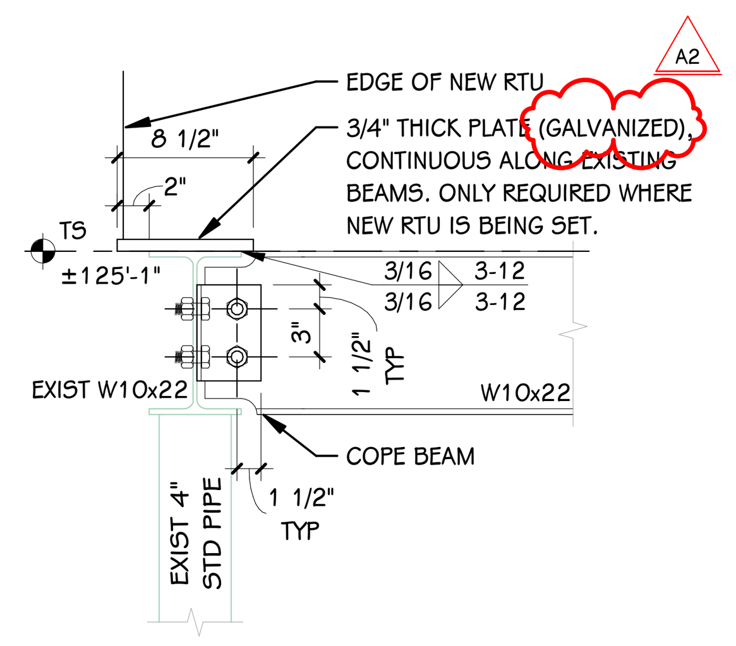


1 S 402 SECTION 1" = 1'-0"



2 S 402 SECTION 1" = 1'-0"



3 S 402 SECTION 1" = 1'-0"

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PROJECT TITLE
LOY NORRIX HIGH SCHOOL MECHANICAL IMPROVEMENTS PROJECT

OWNER
KALAMAZOO PUBLIC SCHOOLS
Kalamazoo, MI

SHEET TITLE
FRAMING DETAILS

DATE
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23-637.00

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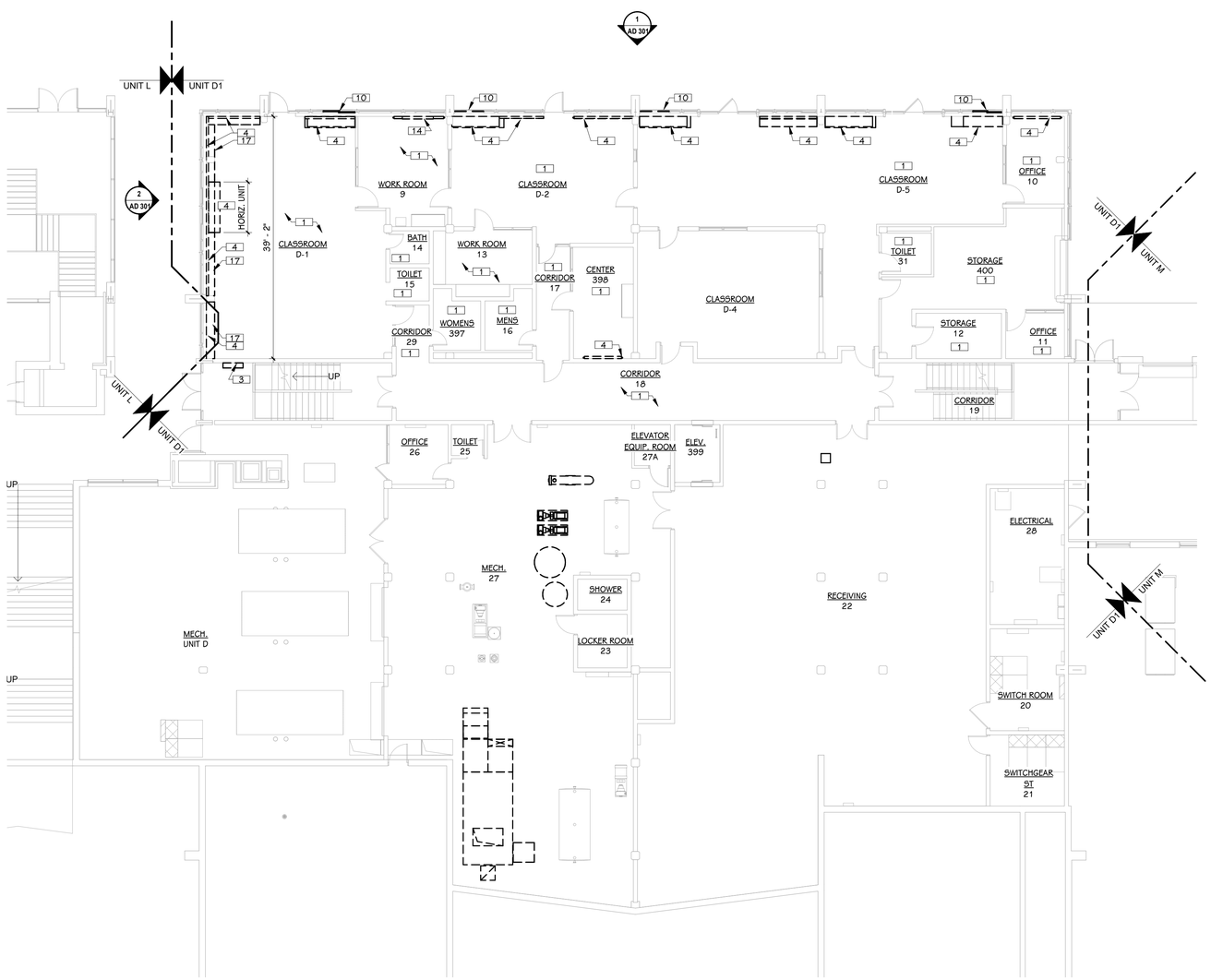


LOWER LEVEL DEMOLITION PLAN - UNIT D1

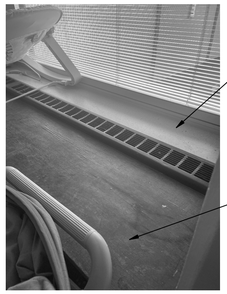
3/32" = 1'-0"

KEYED NOTES - DEMOLITION

1. REMOVE CEILING TILE AND GRID, COORD. WITH NEW CONSTRUCTION.
2. REMOVE HARD LID CEILING AND SUPPORT STRUCTURE AND PREP FOR NEW. COORDINATE EXTEND WITH MECHANICAL DRAWINGS.
3. REMOVE CABINET HEATER - REFER TO MECH. DRAWINGS. PREP WALL FOR NEW FINISH.
4. REMOVE MECH. EQUIPMENT, REFER TO MECH. DRAWINGS
5. REMOVE LOUVER - REFER TO AND COORDINATE WITH MECH. DRAWINGS.
6. REMOVE UNIT VENTILATOR FRONT SCREEN AND COUNTERTOP - SEE MECH. DRAWINGS.
7. REMOVE SECTION OF COUNTERTOP AND FRONT PANEL OVER MECH. UNIT, REFER TO PHOTO 5.
8. REMOVE AND SALVAGE PIPE RAIL SYSTEM FOR REINSTALLATION. STORE AND PROTECT DURING CONSTRUCTION.
9. REMOVE CASEWORK AND PREP FOR NEW.
10. REMOVE GLASS PANEL OUT OF EXISTING STOREFRONT WINDOW FRAME, RETURN TO OWNER, AND COORD. W/ NEW CONSTRUCTION - REFER TO EXTERIOR DEMO. ELEVATIONS.
11. REMOVE AND SALVAGE ALUM. CHASE ALONGSIDE STOREFRONT FOR REINSTALLATION.
12. REMOVE WOOD TRIM PIECE AT CEILING ALONG EXTERIOR WINDOW WALLS AND SALVAGE FOR REUSE. STRIP AND PREP TRIM FOR NEW PRIME AND PAINT.
13. REMOVE WINDOW AC UNIT AND RETURN TO KPS. REMOVE TEMPORARY PANEL AROUND AC UNIT.
14. REMOVE CASEWORK AND COUNTERTOP.
15. REFER TO MECHANICAL DRAWINGS FOR MECHANICAL DEMO SCOPE, PREP OPENING FOR NEW CONSTRUCTION.
16. --NOT IN USE--
17. REMOVE AND SALVAGE CASEWORK FOR REINSTALLATION.
18. REMOVE AND SALVAGE SOLID SURFACE TRIM FOR REINSTALLATION.
19. REMOVE SECTION OF CMU WALL, FULL HEIGHT. COORD. WITH NEW CONSTRUCTION.
20. REMOVE SOLID SURFACE TRIM.

REMOVE AND SALVAGE CASEWORK FOR REINSTALLATION

PHOTO 1: (CLASSROOM D-1)



WINDOW SILL SOLID SURFACE TO REMAIN, TYP.

TEMP. REMOVE CASEWORK AND SALVAGE FOR PIN TUBE REPLACEMENT, REFER TO MECH.

PHOTO 2: (CLASSROOM D-1)

REMOVE AND REPLACE CEILING, REFER TO RCP.

REMOVE GLASS PANEL FOR NEW VERTICAL UNIT VENTILATOR, COORD. WITH MECH, REFER TO FLOOR PLAN FOR LOCATIONS

PATCH, PRIME, AND PAINT WALL AT REMOVED MECH. EQUIPMENT

PHOTO 3

SOLID SURFACE TRIM TO REMAIN, TYP.

PATCH, PRIME, AND PAINT WALL AT REMOVED MECH. EQUIPMENT

PHOTO 4

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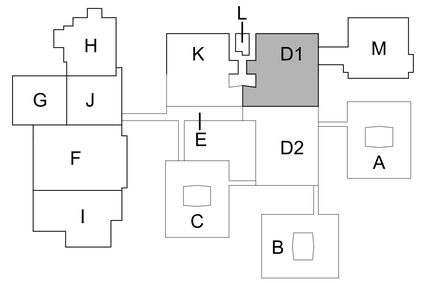

KEY PLAN

SCALE: NO SCALE

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PROJECT TITLE
LOY NORRIX HIGH SCHOOL MECHANICAL IMPROVEMENTS PROJECT

OWNER
KALAMAZOO PUBLIC SCHOOLS

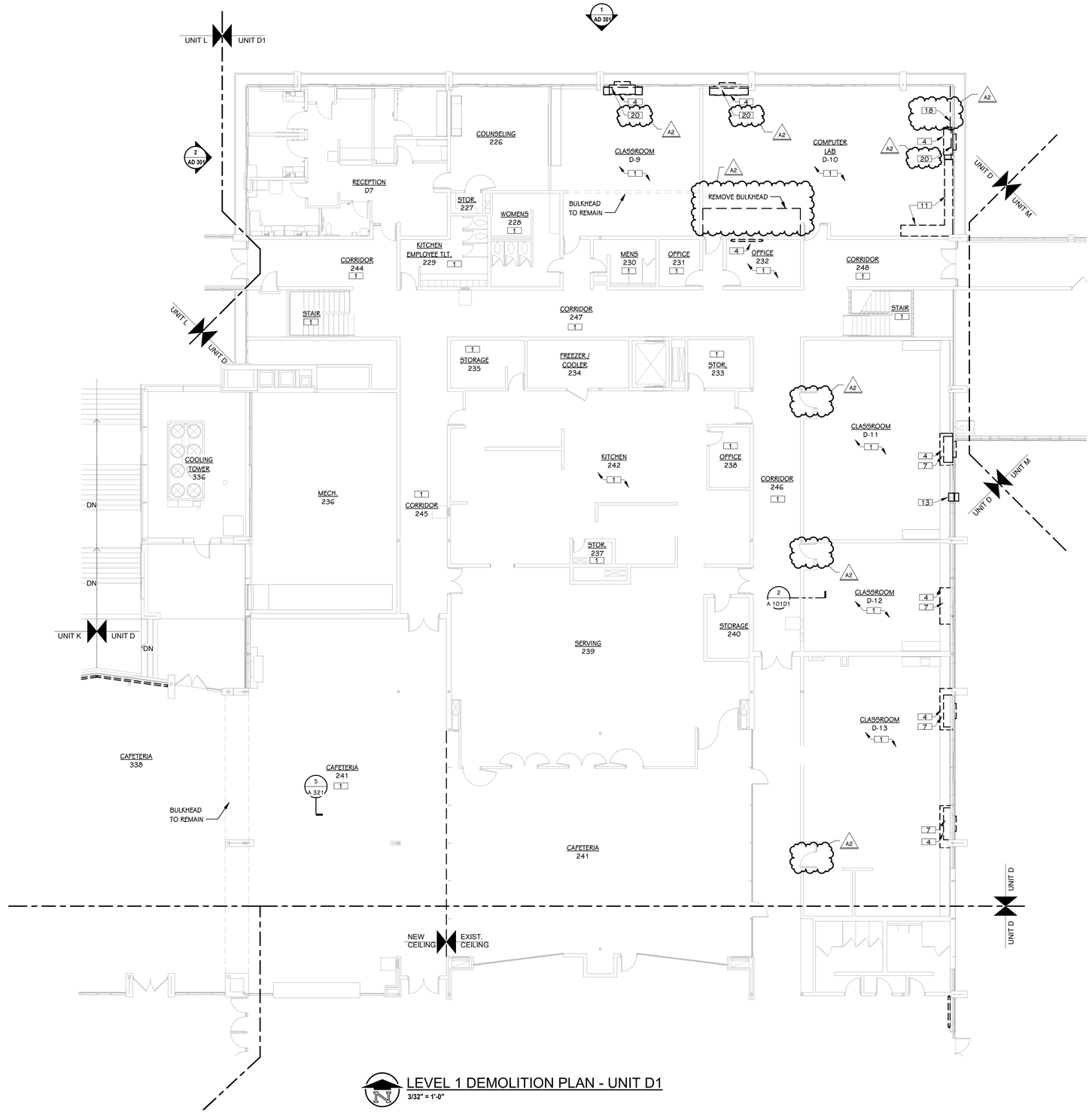
Kalamazoo, Michigan

SHEET TITLE
LOWER LEVEL DEMOLITION PLAN - UNIT D1

DATE
OCTOBER 31, 2025

SHEET NUMBER
AD 100D1

23-637.00



LEVEL 1 DEMOLITION PLAN - UNIT D1

3/32" = 1'-0"

KEYED NOTES - DEMOLITION

1 REMOVE CEILING TILE AND GRID, COORD. WITH NEW CONSTRUCTION.
2 REMOVE HARD LID CEILING AND SUPPORT STRUCTURE AND PREP FOR NEW. COORDINATE EXTEND WITH MECHANICAL DRAWINGS.
3 REMOVE CABINET HEATER - REFER TO MECH. DRAWINGS. PREP WALL FOR NEW FINISH.
4 REMOVE MECH. EQUIPMENT. REFER TO MECH. DRAWINGS.
5 REMOVE LOUVER - REFER TO AND COORDINATE WITH MECH. DRAWINGS.
6 REMOVE UNIT VENTILATOR FRONT SCREEN AND COUNTERTOP - SEE MECH. DRAWINGS.
7 REMOVE SECTION OF COUNTERTOP AND FRONT PANEL OVER MECH. UNIT. REFER TO PHOTO 5.
8 REMOVE AND SALVAGE PIPE RAIL SYSTEM FOR REINSTALLATION. STORE AND PROTECT DURING CONSTRUCTION.
9 REMOVE CASEWORK AND PREP FOR NEW.
10 REMOVE GLASS PANEL OUT OF EXISTING STOREFRONT WINDOW FRAME, RETURN TO OWNER, AND COORD. W/ NEW CONSTRUCTION - REFER TO EXTERIOR DEMO. ELEVATIONS.
11 REMOVE AND SALVAGE ALUM. CHASE ALONGSIDE STOREFRONT FOR REINSTALLATION.
12 REMOVE WOOD TRIM PIECE AT CEILING ALONG EXTERIOR WINDOW WALLS AND SALVAGE FOR REUSE. STRIP AND PREP TRIM FOR NEW PRIME AND PAINT.
13 REMOVE WINDOW AC UNIT AND RETURN TO KPS. REMOVE TEMPORARY PANEL AROUND AC UNIT.
14 REMOVE CASEWORK AND COUNTERTOP.
15 REFER TO MECHANICAL DRAWINGS FOR MECHANICAL DEMO SCOPE, PREP OPENING FOR NEW CONSTRUCTION.
16 --NOT IN USE--
17 REMOVE AND SALVAGE CASEWORK FOR REINSTALLATION.
18 REMOVE AND SALVAGE SOLID SURFACE TRIM FOR REINSTALLATION.
19 REMOVE SECTION OF CMU WALL, FULL HEIGHT. COORD. WITH NEW CONSTRUCTION.
20 REMOVE SOLID SURFACE TRIM.

REMOVE SECTION OF COUNTERTOP ABOVE MECH. UNIT, PROVIDE A CLEAN CUT EDGE TO PREVENT DAMAGE TO ADJACENT COUNTERTOP

REMOVE FRONT PANEL AND ASSOCIATED FRAME AND BASE AROUND MECH. UNIT

SOLID SURFACE TRIM TO REMAIN, TYP.

PHOTO 5 (TYPICAL FOR CLASSROOM D-11, D-12, D-13

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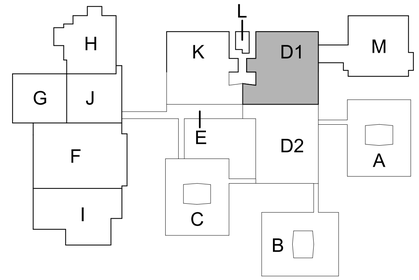

KEY PLAN
SCALE: NO SCALE

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PROJECT TITLE
LOY NORRIX HIGH SCHOOL MECHANICAL IMPROVEMENTS PROJECT

OWNER
KALAMAZOO PUBLIC SCHOOLS
Kalamazoo, Michigan

SHEET TITLE
LEVEL 1 DEMOLITION PLAN - UNIT D1

DATE
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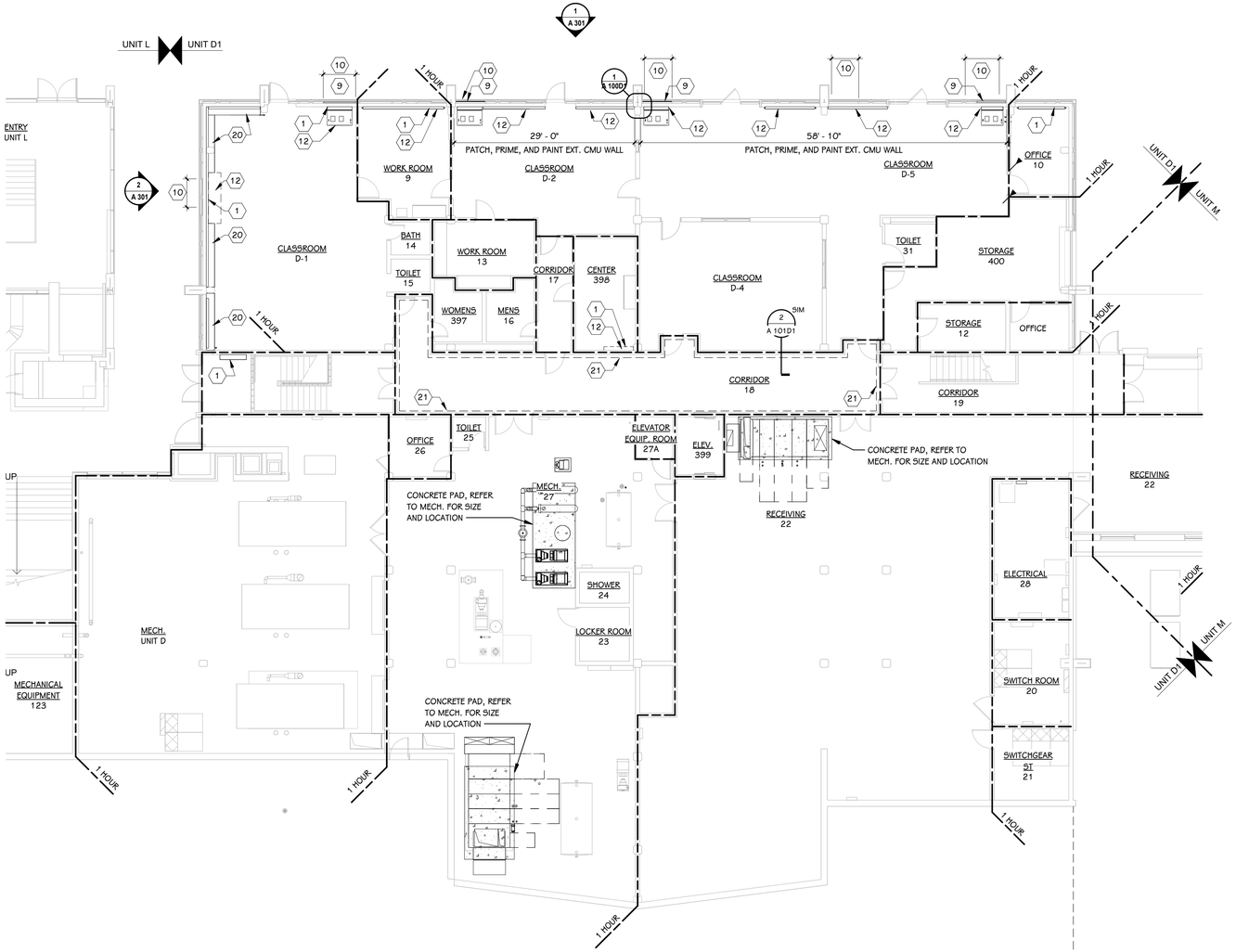
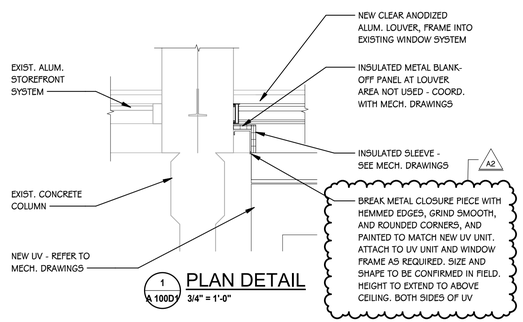
AD 101D1
23-637.00



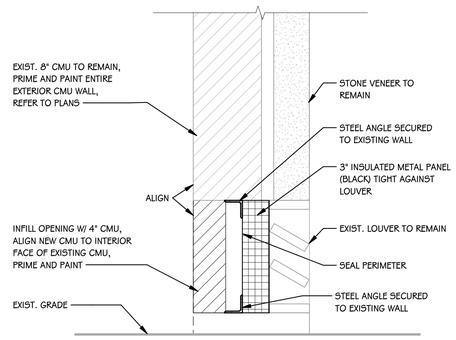
LOWER LEVEL FLOOR PLAN - UNIT D1

3/32" = 1'-0"



1 A 100D1 — PLAN DETAIL

3/4" = 1'-0"



2 A 100D1 — LOUVER INFILL DETAIL

1 1/2" = 1'-0"

KEYED NOTES - NEW CONSTRUCTION

1 PATCH, PRIME AND PAINT WALL AT REMOVED MECH. EQUIPMENT TO MATCH EXISTING COORDINATE WITH NEW EQUIPMENT.
2 NEW 2X2 ACP CEILING SYSTEM, INSTALL AT EXISTING CEILING HEIGHT.
3 PATCH PRIME AND PAINT WALL AT REMOVED MECH. EQUIPMENT AND REMOVED CASEWORK. PAINT TO MATCH EXISTING.
4 PROVIDE A CLEAR ANODIZED ALUM. CHASE UP ALONG THE SIDE WALL FULL HEIGHT ABOVE CEILING. SIZE TO BE MINIMUM REQUIRED FOR MECHANICAL PIPES. COORD. WITH MECH.
5 INSTALL SALVAGED ALUM. CHASE ASSEMBLY UP ALONG THE WALL. INSTALL IN EXISTING LOCATION.
6 NEW EXHAUST THROUGH ROOF (SEE MECH. DRAWINGS). PATCH ROOF AND PROVIDE STEEL FRAMING AROUND NEW ROOF OPENING. SEE MECHANICAL DRAWINGS FOR MORE INFORMATION.
7 AT EACH SIDE OF NEW HORIZ. UV PROVIDE A PRIME AND PAINTED METAL FILLER PANEL (TOP AND FRONT) TO MATCH AND TIE INTO UV. SECURE TO UV AND ADJOINING CASEWORK (BY MECHANICAL). PROVIDE P-LAM. END PANEL AT NEWLY EXPOSED CASEWORK END (MATCH EXISTING)
8 PRIME AND PAINT ALL EXPOSED STEEL ROOF STRUCTURE, TO MATCH EXIST.
9 AT REMOVED GLASS PANEL PROVIDE NEW CLEAR ANODIZED LOUVER INSERT, PROVIDE INSULATED METAL BLANK OFF PANEL AT ANY UNUSED LOUVER AREAS - SEE MECH. DWG'S
10 IN EXISTING LOUVER OPENING INSTALL 3" INSULATED METAL PANEL (BLACK) TIGHT AGAINST LOUVER AND TIGHT IN OPENING. SECURE IN PLACE AND CAULK ALL SIDES. AT INSIDE FLUSH WITH INTERIOR FACE OF EXISTING CMU WALL ADD 4" CMU INFILL TOOTH IN ALL SIDES.
11 INSTALL SALVAGED WOOD TRIM PRIME AND PAINT TO MATCH EXISTING. SEE DETAILS.
12 PATCH FLOORING TO MATCH SURRONDING, REFER TO INTERIORS.
13 BREAK METAL CLOSURE PIECE WITH HEMMED EDGES, GROUND SMOOTH, AND ROUNDED CORNERS, AND PAINTED TO MATCH NEW UV UNIT. ATTACH TO UV UNIT AND WINDOW FRAME AS REQUIRED. SIZE AND SHAPE TO BE CONFIRMED IN FIELD. HEIGHT TO BE FULL HEIGHT OF EXPOSED PORTION OF BLANK OFF PANEL.
14 EXISTING MECHANICAL ROOF EQUIPMENT TO REMAIN - SEE MECHANIICAL DRAWINGS.
15 NEW MECHANICAL ROOF EQUIPMENT ON EXISTING ROOF CURB FLASH WEATHER TIGHT - SEE MECHANICAL DRAWINGS.
16 NEW MECHANICAL CONDENSING UNITS SET ON ROOF. WITH NEW PIPE PENETRATIONS THROUGH ROOF FLASHED WEATHER TIGHT - SEE MECHANICAL DRAWINGS. DEMO EXISTING ROOF AS REQUIRED.
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19 NEW EXHAUST FAN / RELIEF HOOD ON EXISTING ROOF CURB FLASH WEATHER TIGHT
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21 AT TOP OF CORRIDOR WALL ADD 1 HOUR SHAFT WALL CONSTRUCTION TO MAKE EXISTING CMU CORRIDOR WALL 1 HOUR RATED TO DECK ABOVE AND FIRE CAULK. TYPICAL FOR ALL CORRIDOR WALLS AS INDICATED IN PLAN. FIRE CAULK ALL PIPES, ROOF BEAMS, STEEL BRIDGING, AND ANY OTHER PENETRATIONS EXISTING AND NEW.
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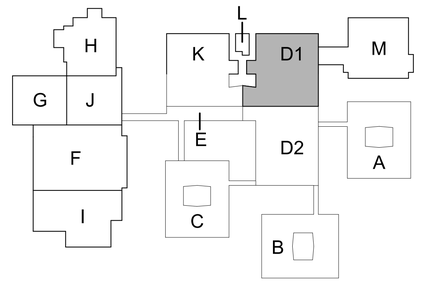
PHOTO 8: TYPICAL FOR CLASSROOM D-2 & D-5

CLEAN AND SEAL AS REQUIRED EDGE OF SOLID SURFACE TO NEW MECH. EQUIPMENT.

PATCH, PRIME AND PAINT ENTIRE CMU EXTERIOR WALL PRIOR TO MECH. INSTALLATION, TYP. REFER TO FLOOR PLAN FOR FULL PAINT SCOPE.

LOY NORRIX HIGH SCHOOL



KEY PLAN

SCALE: NO SCALE

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ADDENDUM NO. 2 November 25, 2025

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PROJECT TITLE
LOY NORRIX HIGH SCHOOL MECHANICAL IMPROVEMENTS PROJECT

OWNER
KALAMAZOO PUBLIC SCHOOLS

Kalamazoo, Michigan

SHEET TITLE
LOWER LEVEL FLOOR PLAN - UNIT D1

DATE
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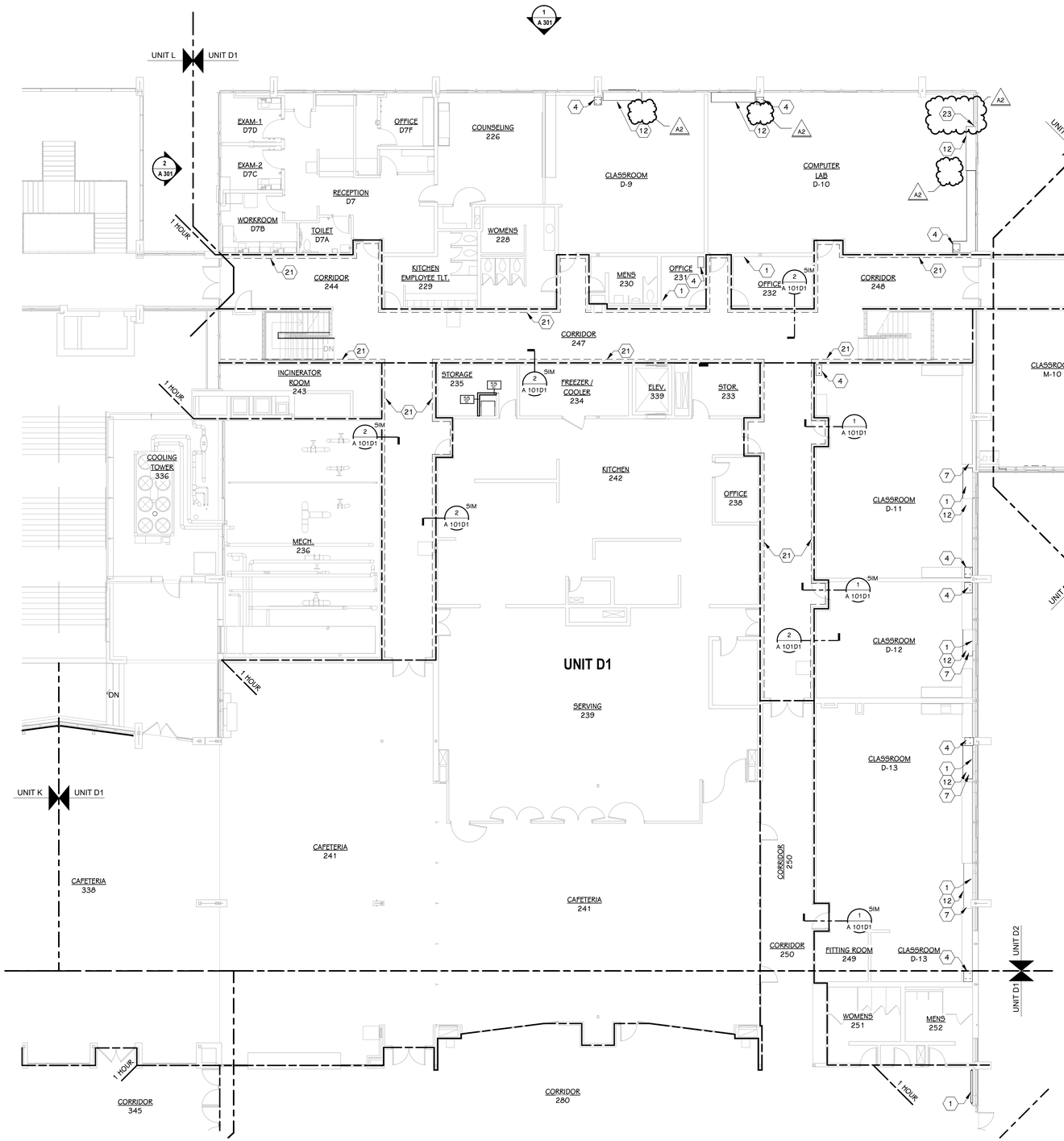
SHEET NUMBER
A 100D1

23-637.00



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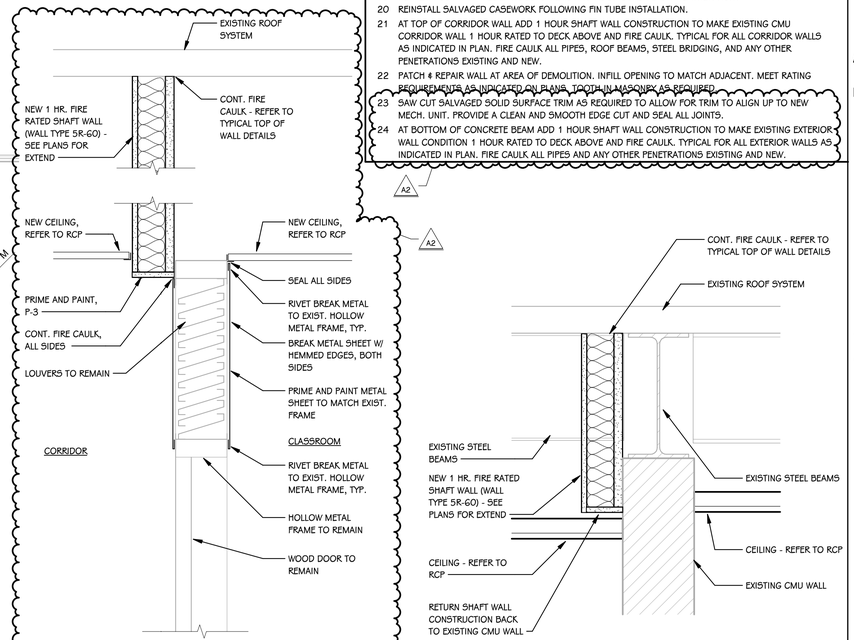
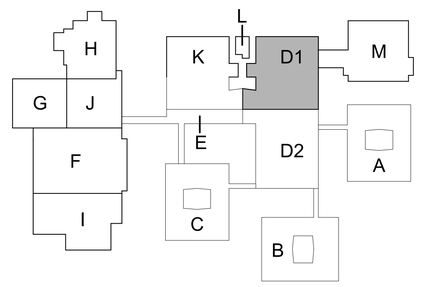


1 A 101D1 WALL DETAIL @ DOOR TRANSOM
1 1/2" = 1'-0"

2 A 101D1 CORRIDOR WALL DETAIL
1 1/2" = 1'-0"

PHOTO 9 (TYPICAL FOR CLASSROOM D-11, D-12, D-13

LOY NORRIX



KEY PLAN
SCALE: NO SCALE

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OWNER
KALAMAZOO PUBLIC SCHOOLS
Kalamazoo, Michigan

SHEET TITLE
LEVEL 1 FLOOR PLAN - UNIT D1

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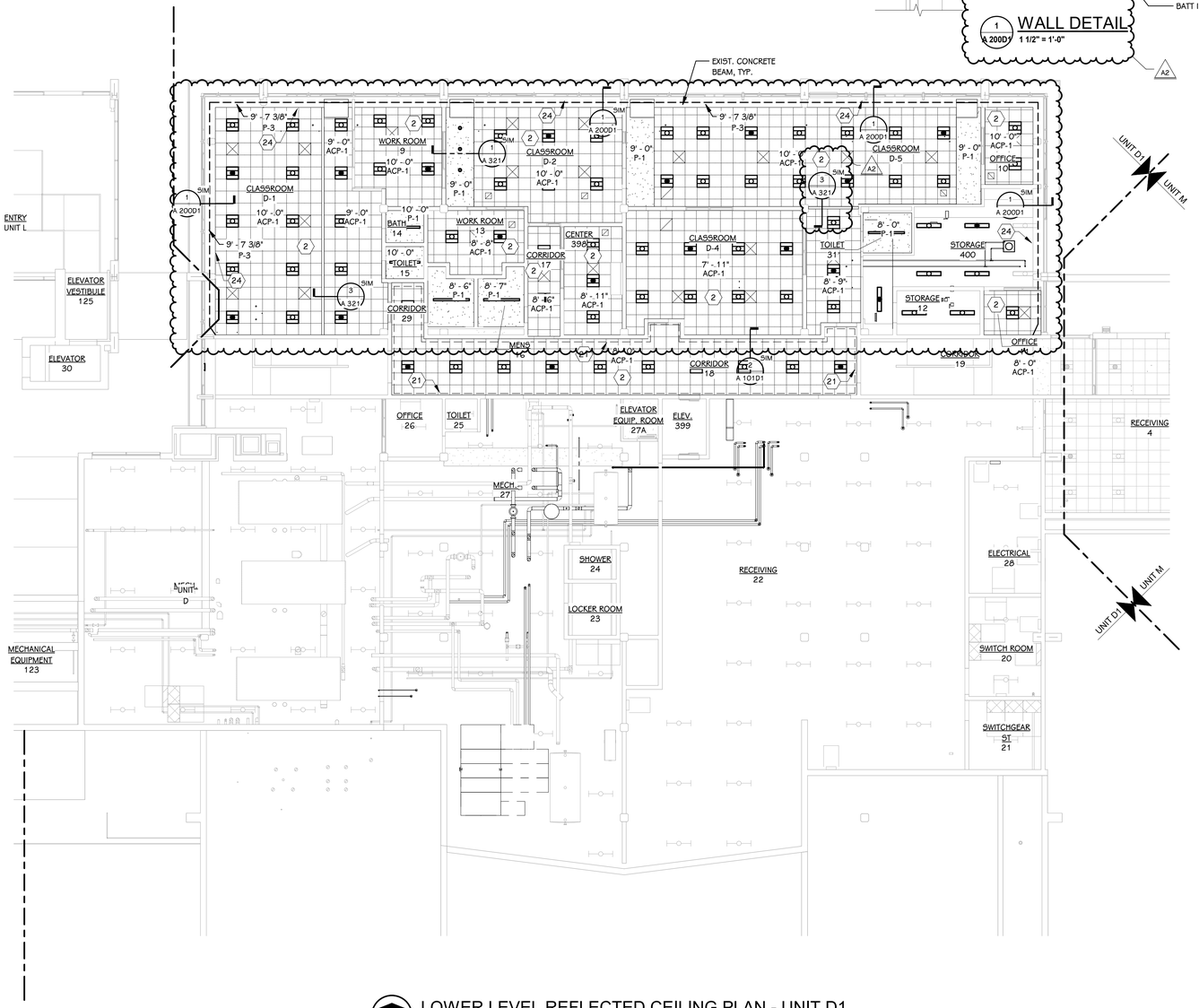

LOWER LEVEL REFLECTED CEILING PLAN - UNIT D1
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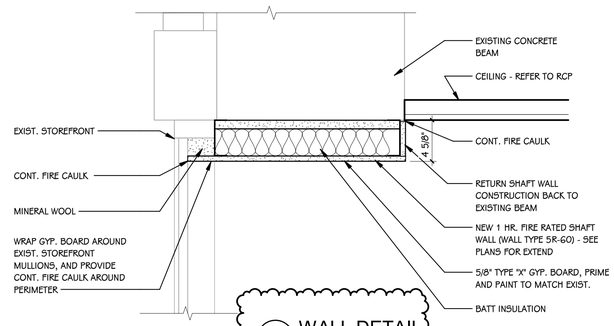

1 A 200D1 WALL DETAIL
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- SALVAGED EGG CRATE CEILING PANEL
- EXISTING ACP LAY-IN ACOUSTICAL TILE CEILING TO REMAIN
- LIGHTING - REFER TO ELECTRICAL LIGHTING PLAN (OR)
- MECHANICAL - REFER TO MECHANICAL SHEET METAL PLAN

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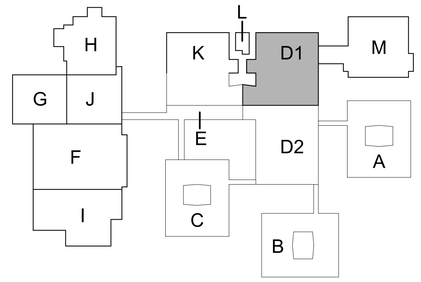
1. WHERE CEILING TILE IS LESS THAN 3" AT PERIMETER OF ROOM PROVIDE A CUT 2x4 TILE IN LIEU OF FULL 2x2 TILE AND SMALL PIECE OF TILE OR DOUBLE GRID - MATCH 2x2 FOR STYLE AND COLOR.

LOY NORRIX HIGH SCHOOL



KEY PLAN
SCALE: NO SCALE

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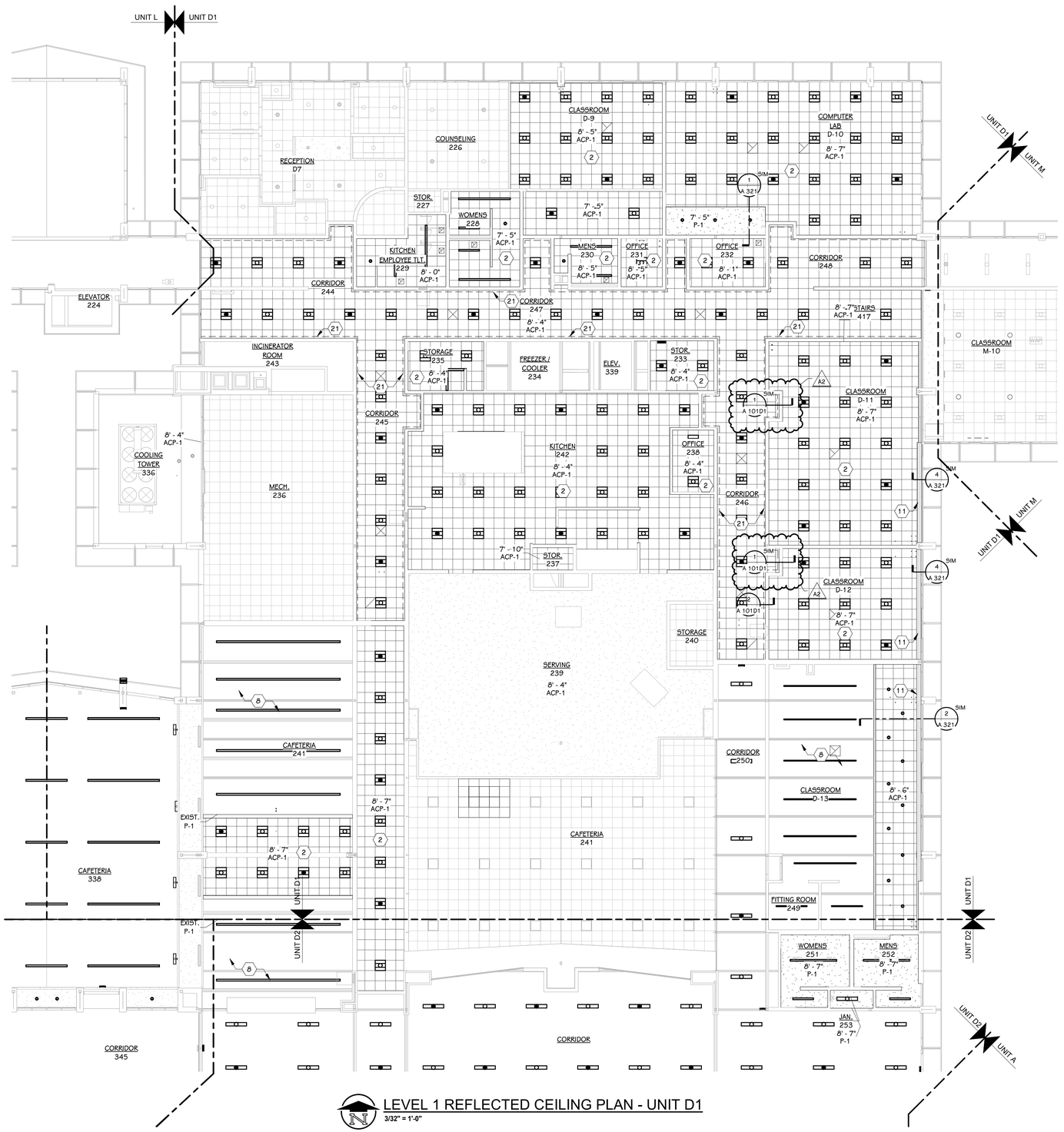

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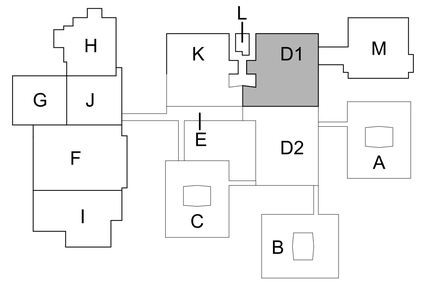

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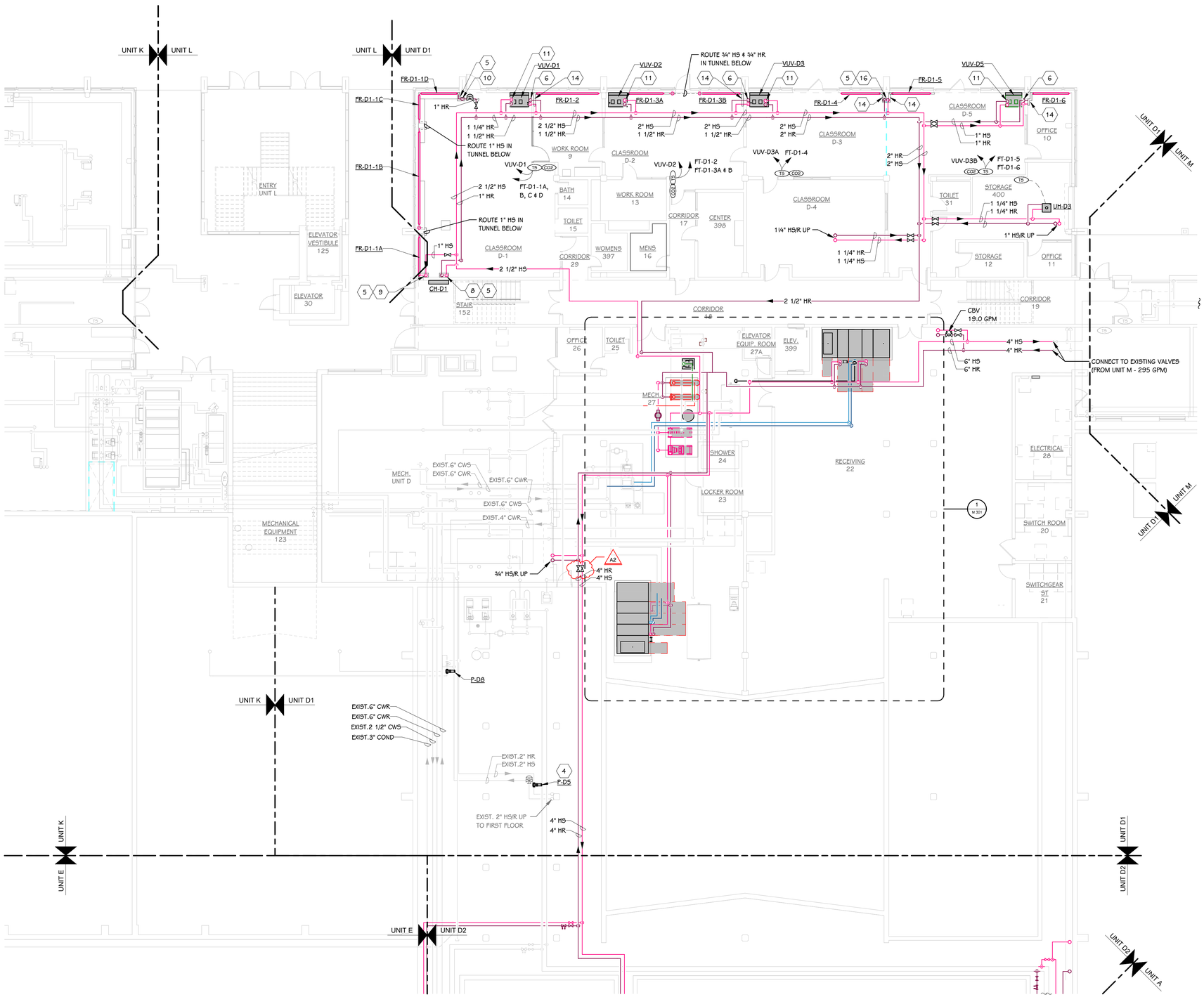
A 201D1
23-637.00



LOWER LEVEL HVAC PIPING PLAN - UNIT D1

3/32" = 1'-0"

THIS DRAWING SHEET IS INTENDED TO BE PLOTTED IN COLOR. IF THIS TEXT APPEARS IN BLACK AND WHITE, IT IS PLOTTED INCORRECTLY. DISCARD AND OBTAIN AN ACCURATE DRAWING.

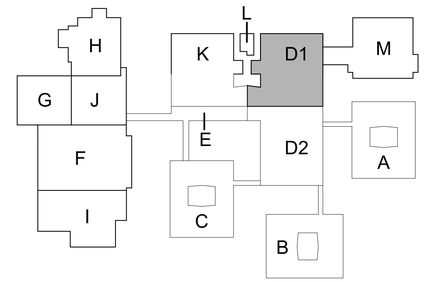
KEYED NOTES - HVAC PIPING

1. REFRIGERANT PIPING UP TO ACCU ON ROOF. REFRIGERANT PIPING TO BE SIZED PER MANUFACTURER'S RECOMMENDATIONS.
2. 3/4" HEATING SUPPLY UP TO FIN TUBE RADIATION ABOVE.
3. 3/4" HEATING RETURN DOWN FROM FIN TUBE RADIATION ABOVE.
4. MODIFY EXISTING PIPING AS REQUIRED TO INSTALL NEW PUMP.
5. COVER EXPOSED PIPING WITH METAL PIPE ENCLOSURE.
6. ¾" HEATING SUPPLY AND RETURN DOWN TO FIN TUBE.
7. REWORK EXISTING CHILLED WATER PIPING FROM TUNNEL AS REQUIRED TO CONNECT NEW UNIT VENTILATOR.
8. 1" HEATING SUPPLY AND RETURN DOWN TO CABINET HEATER.
9. 1" HEATING SUPPLY DN TO FIN TUBE.
10. 1" HEATING RETURN FROM FIN TUBE.
11. 1" HEATING SUPPLY AND RETURN TO UNIT VENTILATOR.
12. ROUTE HEATING SUPPLY & RETURN AND REFRIGERANT PIPING THRU EXISTING PIPE ENCLOSURE. REMOVE AND REINSTALL PIPE ENCLOSURE AS REQUIRED TO INSTALL PIPING.
13. ROUTE PIPING BEHIND CASEWORK TO UNIT VENTILATOR.
14. EXTEND FIN TUBE COVER TO CONCEAL PIPING.
15. 1" HS/R UP TO UNIT VENTILATOR ABOVE ABOVE.
16. ¾" HS/R DOWN TO FIN TUBE. ROUTE ¾" HS/R TO EACH PIECE OF FIN. EACH PIECE OF FIN IS TO BE INDEPENDENTLY CONTROLLED WITH IT'S OWN CONTROL VALVE.
17. ¾" CONDENSATE DRAIN FROM FAN COIL CONDENSATE PUMP UP THROUGH ROOF. REFER TO PIPING PORTAL/CURB DETAIL ON SHEET M504.

GENERAL STRUCTURAL NOTES: (SEE STRUCTURAL DRAWINGS)

1. DO NOT CUT REINFORCING STEEL DURING CONCRETE DRILLING OR CORING OPERATIONS. LOCATE REINFORCING WITH A PACHOMETER OR OTHER NON-DESTRUCTIVE TESTING DEVICE PRIOR TO DRILLING OR CORING OPERATIONS, TYPICAL AT ALL OPENINGS, NOT SHOWN. ADDITIONALLY, DO NOT DRILL OR CORE THROUGH CONCRETE BEAMS.
2. ALL NEW 4" PIPES HANGING FROM EXISTING CONCRETE BEAMS AND SLABS TO SUPPORT A MAXIMUM OF 12 LINEAR FEET OF PIPE.
3. ALL NEW 6" PIPES HANGING FROM EXISTING CONCRETE BEAMS AND SLABS TO SUPPORT A MAXIMUM OF 7 LINEAR FEET OF PIPE.

LOWER LEVEL - KEY PLAN



KEY PLAN
SCALE: NO SCALE

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ISSUED FOR	DATE
ADDENDUM #2	11/25/2025

PROJECT TITLE
LOY NORRIX HIGH SCHOOL MECHANICAL IMPROVEMENTS PROJECT

OWNER
KALAMAZOO PUBLIC SCHOOLS
Kalamazoo, Michigan

SHEET TITLE
LOWER LEVEL HVAC PIPING PLAN - UNIT D1

DATE
OCTOBER 31, 2025

SHEET NUMBER
M 200D1
23-637.00

GRILLES, REGISTERS, & DIFFUSERS — BASED ON PRICE

MARK	PANEL SIZE	FACE SIZE	NECK SIZE	MODEL	CFM RANGE	VCD	THROW	MATERIAL	FINISH	INSTALLATION	REMARKS
SA-1	24x24	-	6" Ø	ASCDA	120-200	NO	4-WAY	ALUMINUM	WHITE	LAY-IN	
SA-2	24x24	-	8" Ø	ASCDA	175-315	NO	4-WAY	ALUMINUM	WHITE	LAY-IN	
SA-3	-	-	14"x6"	620	275-350	NO	DBL. DEFL.	ALUMINUM	WHITE	DUCT MTD.	
SA-4	-	-	6"x4"	620	50-100	NO	DBL. DEFL.	ALUMINUM	WHITE	DUCT MTD.	
RA-1	12"x12"	-	-	80	0 - 500	NO	-	ALUMINUM	WHITE	SURFACE	
RA-2	24"x24"	-	22"x22"	80	500 - 2000	NO	-	ALUMINUM	WHITE	LAY-IN	
RA-3	-	-	16"x8"	610Z	300 - 400	NO	-	ALUMINUM	WHITE	DUCT MTD.	
RA-4	-	-	30"x32"	530	0 - 2100	NO	-	STEEL	WHITE	SURFACE	
EA-1	12"x12"	-	12"x12"	80	0-500	NO	-	ALUMINUM	WHITE	SURFACE	
EA-2	24"x24"	-	22"x22"	80	500 - 2000	NO	-	ALUMINUM	WHITE	LAY-IN	
EA-3	-	-	20"x18"	610Z	0 - 2000	NO	-	ALUMINUM	WHITE	DUCT MTD.	

FINNED TUBE RADIATION - WATER — BASED ON VULCAN

MARK	MODEL	HEATING ELEMENT (1) SIZE	ROWS	LENGTH (2)	EWT (°F)	CAPACITY (BTUH/FT)	FLOW (GPM)	COVER (5) TYPE	HEIGHT	FINISH	MOUNT HEIGHT	REMARKS
FR-D1-1A	VC45	1"C - 4¼"x4¼" - 50/.020	3	8' - 0"	130 °F	830	1	LV4-T24	2' - 0"	(3)	(4)	
FR-D1-1B	VC45	1"C - 4¼"x4¼" - 50/.020	3	19' - 6"	130 °F	830	2	LV4-T24	2' - 0"	(3)	(4)	
FR-D1-1C	VC45	1"C - 4¼"x4¼" - 50/.020	3	5' - 0"	130 °F	830	1	LV4-T24	2' - 0"	(3)	(4)	
FR-D1-1D	VC45	1"C - 4¼"x4¼" - 50/.020	3	7' - 6"	130 °F	830	1	LV4-T24	2' - 0"	(3)	(4)	
FR-D1-2	VC3/4-44	¾"C - 4¼"x4¼" - 40/.020	3	13' - 0"	130 °F	950	1	LV4-S24	2' - 0"	(3)	28"	
FR-D1-3A	VC3/4-44	¾"C - 4¼"x4¼" - 40/.020	3	8' - 6"	130 °F	950	1	LV4-S24	2' - 0"	(3)	28"	
FR-D1-3B	VC3/4-44	¾"C - 4¼"x4¼" - 40/.020	3	8' - 0"	130 °F	950	1	LV4-S24	2' - 0"	(3)	28"	
FR-D1-4	VC3/4-44	¾"C - 4¼"x4¼" - 40/.020	3	8' - 0"	130 °F	950	1	LV4-S24	2' - 0"	(3)	28"	
FR-D1-5	VC3/4-44	¾"C - 4¼"x4¼" - 40/.020	3	8' - 0"	130 °F	950	1	LV4-S24	2' - 0"	(3)	28"	
FR-D1-6	VC3/4-44	¾"C - 4¼"x4¼" - 40/.020	3	7' - 6"	130 °F	950	3	LV4-S24	2' - 0"	(3)		
FR-D2-1	VC3/4-44	¾"C - 4¼"x4¼" - 40/.020	3	28' - 0"	130 °F	950	3	LV4-S24	2' - 0"	(3)	28"	
FR-D2-2	VC3/4-44	¾"C - 4¼"x4¼" - 40/.020	3	28' - 0"	130 °F	950	3	LV4-S24	2' - 0"	(3)	28"	
FR-D2-3	VC3/4-44	¾"C - 4¼"x4¼" - 40/.020	3	28' - 0"	130 °F	950	3	LV4-S24	2' - 0"	(3)	28"	
FR-D2-4	VC3/4-44	¾"C - 4¼"x4¼" - 40/.020	3	28' - 0"	130 °F	950	3	LV4-S24	2' - 0"	(3)	28"	
FR-D2-5	VC3/4-44	¾"C - 4¼"x4¼" - 40/.020	3	28' - 0"	130 °F	950	3	LV4-S24	2' - 0"	(3)	28"	
FR-D2-6	VC3/4-44	¾"C - 4¼"x4¼" - 40/.020	3	28' - 0"	130 °F	950	3	LV4-S24	2' - 0"	(3)	28"	
FR-D2-7	VC3/4-44	¾"C - 4¼"x4¼" - 40/.020	3	28' - 0"	130 °F	950	3	LV4-S24	2' - 0"	(3)	28"	
FR-D2-8	VC3/4-44	¾"C - 4¼"x4¼" - 40/.020	3	28' - 0"	130 °F	950	3	LV4-S24	2' - 0"	(3)	28"	
FR-D2-9	VC3/4-44	¾"C - 4¼"x4¼" - 40/.020	3	6' - 0"	130 °F	950	1	LV4-S24	2' - 0"	(3)	28"	

NOTES:
1 BASED ON 130°F EWT, 110°F LWT, AND 65° F EAT.
2 LENGHTS ARE APPROXIMATE. FINAL ELEMENT LENGTHS ARE TO BE MEASURED IN FIELD.
3 COLOR TO BE SELECTED BY ARCHITECT FROM MANUFACTURES FULL RANGE OF STANDARD COLORS.
4 MOUNTING HEIGHT TO MATCH TOP OF EXISTING FIN TUBE AND TO BE AT TOP OF CASEWORK / BOOK SHELVES.
5 ENCLOSURE TO BE 14 GAUGE STEEL.

PANEL RADIATION - HOT WATER — BASED ON RUNTAL

MARK	MODEL	LENGTH (2)	ROWS	GPM	BTU/FT (1)	EAT (°F)	FINISH	MOUNTING HEIGHT	MOUNTING TYPE	COMMENTS
PR-D1	R2F-2	13' - 6"	2	0.5	427	65	(3)	(4)	PEDESTAL	(5)
PR-D2	R2F-2	13' - 6"	2	0.5	427	65	(3)	(4)	PEDESTAL	(5)

NOTES:
1. BASED ON 130°F EWT, 110°F LWT, AND 65° F EAT.
2. VERIFY ALL LENGTHS IN FIELD.
3. FINAL COLOR SELECTION BY ARCHITECT FROM MANUFACTURE'S FULL RANGE OF STANDARD COLORS.
4. PEDESTAL MOUNTED ON FLOOR.
5. PROVIDE WITH TOP GRILLE.

OUTDOOR AIR INTAKE / RELIEF HOODS — BASED ON GREENHECK

MARK	MODEL	THROAT SIZE	HOOD SIZE	CURB HEIGHT	AIR FLOW (CFM)	MAX APD (IN WC)	CONTROL DAMPER	REMARKS
RH-D1	FGR	18"x18"	28"x36"	2' - 6"	1,250	0.07	Yes	
RH-D2	FGR	24"x30"	34"x48"	2' - 6"	3,000	0.00	Yes	
RH-D3	FGR	18"x18"	28"x36"	2' - 6"	1,250	0.07	Yes	
RH-D4	FGR	16"x16"	26"x36"	2' - 6"	1,000	0.07	Yes	
RH-D5	FGR	20"x24"	30"x36"	2' - 6"	2,000	0.07	Yes	
RH-D6	FGR	48"x62"	71"x84"	2' - 6"	12,000	0.07	Yes	SLOPED ROOF CURB
RH-D7	FGR	20"x24"	30"x36"	2' - 6"	2,000	0.07	Yes	

HEATING COILS - HOT WATER (AHU REPLACEMENT COIL) — BASED ON TRANE

MARK	SIZE	ROWS	CFM	TMBH (1)	E.A.T. (°F)	L.A.T. (°F)	GPM	A.P.D. (IN WC)	W.P.D. (FT)	MAX AIR VELOCITY (FPM)	REMARKS
HC-1D	68" x 52" (2)	2	13,070	680	0	48	45	0.15	1.29	500	HEATING COIL FOR EXISTING AHU

NOTES:
1. HEATING COIL SIZING BASED ON 130°F EWT, 100°F LWT.
2. CONTRACTOR SHALL FIELD VERIFY SIZE.

HEATING COILS - HOT WATER (DUCT MOUNTED) — BASED ON CARRIER

MARK	SIZE	ROWS	CFM	TMBH (1)	E.A.T. (°F)	L.A.T. (°F)	GPM	A.P.D. (IN WC)	W.P.D. (FT)	MAX AIR VELOCITY (FPM)	REMARKS
RHC-245	16" x 6"	2	300	15	50	95	2	0.15	1.20	500	(2)
RHC-246	16" x 6"	2	300	15	50	95	2	0.15	1.20	500	

NOTES:
1. HEATING COIL SIZING BASED ON 130°F EWT, 110°F LWT.
2. PROVIDE WITH 3-WAY CONTROL VALVE.

A2

A2

FAN COIL UNITS - DX COOLING — BASED ON MITSUBISHI

MARK	INDOOR UNIT MODEL	AIR FLOW (CFM)	MAX SOUND (dB)	LOCATION	COOLING COIL TOTAL CAPACITY (MBH)	COOLING COIL EAT (MAX/MIN °F)	OUTDOOR UNIT MARK	OUTDOOR UNIT MODEL	AIR FLOW (CFM)	EAT (MAX/MIN °F)	MAX SOUND (dB)	ELECTRICAL DATA MCA	PHASE	VOLTAGE	REMARKS
FCU-245	CNH09HDB	300	30	COORDOR 245	90.0	60 / 64	ACCU-245	CXH09ADB	1060	122 / 0	46	10.9	1	208 V	(1)(2)(3)(4)
FCU-246	CNH09HDB	300	30	COORDOR 246	90.0	60 / 64	ACCU-246	CXH09ADB	1060	122 / 0	46	10.9	1	208 V	(1)(2)(3)(4)

NOTES:
1. PROVIDE WITH INTEGRAL CONDENSATE PUMP WITH 29" LIFT WITH CHECK VALVE AND FLOAT SWITCH THAT DISABLE INDOOR UNIT SHOUD CONDENSATE OVERFLOW BE DETECTED.
2. PROVIDE WITH WIND BAFFLES FOR OPERATING TEMPERATURES OF 0°F - 115°F.
3. PROVIDE WITH 1" PLEATED (MERV 8) FILTER.
4. MOUNT CONDENSER ON 24" STAND.

TERMINAL UNITS — BASED ON PRICE

MARK	MAX CFM	TYPE	NC (MAX)	SP DROP (MAX)	INLET SIZE	REHEAT COIL (1) MBH	REHEAT COIL (1) TR	REHEAT COIL (1) W.P.D.	REHEAT COIL (1) GPM	MIN. CFM	REMARKS
TU-257	2,020	SDV	25	0.4"	16	98.6	45	5' MAX	9.75	673	
TU-266	1,490	SDV	25	0.4"	14	72.7	45	5' MAX	7.25	497	(2)
TU-271	800	SDV	25	0.4"	10	39.1	45	5' MAX	4.00	267	
TU-276	1,340	SDV	25	0.4"	14	65.4	45	5' MAX	6.50	447	
TU-277A	3,045	SDV	25	0.4"	24x16	148.7	45	5' MAX	14.75	1015	(2)
TU-277B	1,380	SDV	25	0.4"	14	67.4	45	5' MAX	6.75	460	
TU-D14	1,000	SDV	25	0.4"	12	48.8	45	5' MAX	5.00	333	
TU-D15	1,820	SDV	25	0.4"	16	88.9	45	5' MAX	9.00	607	

NOTES:
1 REHEAT COIL SIZING BASED ON 130°F EWT, 110°F LWT, W/ BOX AT MAXIMUM FLOW.
2 PROVIDE WITH 3-WAY CONTROL VALVE.

EXHAUST FANS — BASED ON GREENHECK

MARK	MODEL	TYPE	AIR FLOW (CFM)	ESP (IN WC)	SONES	MOTOR EC MOTOR	MOTOR NOMINAL HP	MOTOR BRAKE HP	MOTOR RPM	MOTOR VOLTAGE	REMARKS
EF-D1	G-200-VG	DOWNBLAST	2,825	0.50	9.0	Yes	1	0.46	900	208/1	(1)(2)(3)
EF-D2	G-095-VG	DOWNBLAST	235	0.25	3.5	Yes	0.17	0.02	1725	115/1	(1)(2)(3)
EF-D3	G-095-VG	DOWNBLAST	235	0.25	3.5	Yes	0.17	0.02	1725	115/1	(1)(2)(3)
EF-D4	G-095-VG	DOWNBLAST	275	0.35	5.3	Yes	0.17	0.04	1725	115/1	(1)(2)(3)
EF-D5	G-095-VG	DOWNBLAST	275	0.35	5.3	Yes	0.17	0.04	1725	115/1	(1)(2)(3)
EF-D6	G-120-VG	DOWNBLAST	875	0.35	6.3	Yes	0.25	0.09	1725	115/1	(1)(2)(3)

NOTES:
1. RE-USE EXISTING ROOF CURB. PROVIDE CURB ADAPTER.
2. PROVIDE WITH DISCONNECT & VARI-GREEN MOTOR FOR BALANCING.
3. PROVIDE NEW THERMALLY ISOLATED CONTROL DAMPER FOR INSTALLATION IN EXIST. CURB. FIELD VERIFY SIZE.

STEAM TO WATER HEAT EXCHANGERS — BASED ON BELL & GOSSETT

MARK	MODEL	CAPACITY (MBH)	STEAM SIDE FLOW (LB/HR)	STEAM SIDE PRESS. (PSI)	WATER SIDE FLOW (GPM)	WATER SIDE WPD (FT)	WATER SIDE FLUID TYPE	WATER SIDE EWT (°F)	WATER SIDE LWT (°F)	SYSTEM	LOCATION	REMARKS
HX-D3	QSU-144-2	7431	7761.4	10	600	6.5	WATER	100 °F	130 °F	UNITS D & M HEATING WATER	MECH ROOM	
HX-D4	QSU-144-2	7431	7761.4	10	600	6.5	WATER	100 °F	130 °F	UNITS D & M HEATING WATER	MECH ROOM	

PUMPS — BASED ON BELL & GOSSETT

MARK	MODEL	FLOW RATE (GPM)	HEAD (FT)	PEIcl	MOTOR DATA HP	MOTOR DATA BHP	MOTOR DATA RPM	MOTOR DATA VOLTAGE	SYSTEM	LOCATION	REMARKS
P-D3	e-1510-4EB	600	80		20	14.7	1800	480/3	UNITS D & M HEATING WATER	MECH. 27	(1)
P-D4	e-1510-4EB	600	80		20	14.7	1800	480/3	UNITS D & M HEATING WATER	MECH. 27	(1)
P-D5	e-60 STOCK 1.5x1.5x6.25	28	30		0.75	0.4	1800	208/3	RTU-D1 HEATING COIL	TUNNEL	
P-D6	e-60 STOCK 1.5x1.5x5.25	42	20		0.75	0.34	1800	208/3	AHU-D1 HEATING COIL	MECH. 27	
P-D7	e-60 STOCK 1.5x1.5x5.25	50	20		0.75	0.39	1800	208/3	AHU-D2 HEATING COIL	MECH. 27	
P-D8	e-60 STOCK 1.5x1.5x5.25	45	20		0.75	0.36	1800	208/3	NEW HEATING COIL (MEDIA CENTER AHU)	PENTHOUSE	
P-D8	ECOCIRC 20-18	4	20		0	0	0	120/1	CAFE PANEL RADIATION	TUNNEL	

NOTES:
1. VFD PROVIDED BY TEMPERATURE CONTROLS CONTRACTOR.

UNIT HEATER - HOT WATER — BASED ON VULCAN

MARK	MODEL	TYPE	CFM	MBH (1)	GPM	WPD	HP	RPM	VOLTAGE	REMARKS
UH-D1	HV-84	HORIZONTAL	1,400	30.5	6	.24	1/12	1000	120/1/60	
UH-D2	HV-84	HORIZONTAL	1,400	30.5	6	.24	1/12	1000	120/1/60	
UH-D3	VV-77	VERTICAL	1,200	24.2	5	.18	1/20	1150	120/1/60	

NOTES:
1. 1. BASED ON 130°F EWT, 20°F dT, 60°F EAT.

CABINET UNIT HEATERS - HOT WATER — BASED ON VULCAN

MARK	MODEL	TYPE	CFM	MBH (1)(2)	GPM	HP	RPM	VOLTAGE	MAX RECESS	MOUNTING HEIGHT	REMARKS
CH-D1	WI-1110-04	WALL INVERTED FLOW	420	22.7	4	0.1	1050	120/1	SURFACE MTD.	(3)	

NOTES:
1. BASED ON 130°F EWT, 20°F dT, 60°F EAT.
2. PROVIDE WITH 2 ROW HIGH CAPACITY COIL.
3. MOUNTING HEIGHT TO MATCH EXISTING CABINET HEATER.

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ADDENDUM #2 11/25/2025
ISSUED FOR DATE

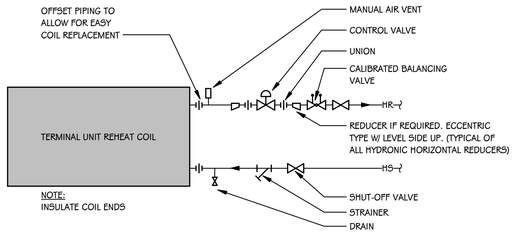
PROJECT TITLE
LOY NORRIX HIGH SCHOOL MECHANICAL IMPROVEMENTS PROJECT

OWNER
KALAMAZOO PUBLIC SCHOOLS
Kalamazoo, Michigan

SHEET TITLE
MECHANICAL SCHEDULES AND DETAILS

DATE
OCTOBER 31, 2025

SHEET NUMBER
M 502
23-637.00



TERMINAL UNIT REHEAT COIL PIPING DETAIL (2-WAY)
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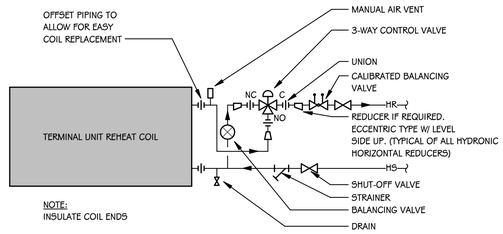

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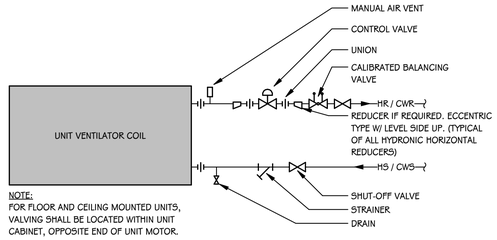
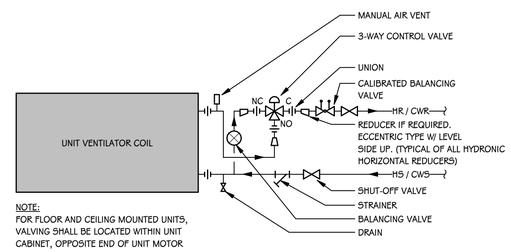
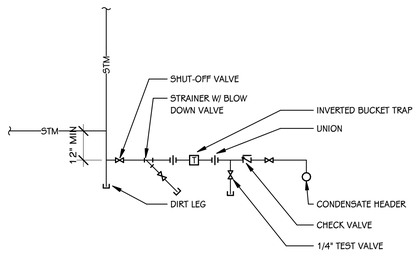


UNIT VENTILATOR PIPING DETAIL (2-WAY)
SCALE: NONE



UNIT VENTILATOR PIPING DETAIL (3-WAY)
SCALE: NONE



STEAM TRAP DETAIL
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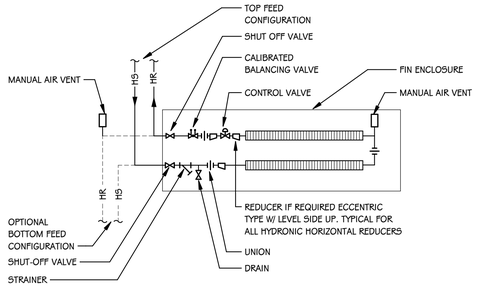
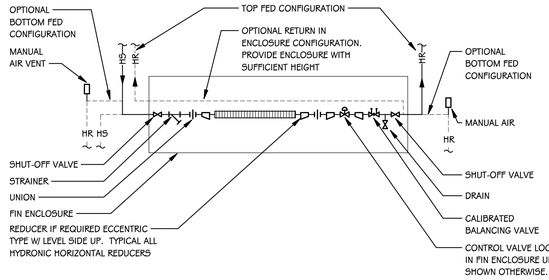


FIN RADIATION PIPING DETAIL - TWO ROW
SCALE: NONE



FIN RADIATION PIPING DETAIL - SINGLE ROW
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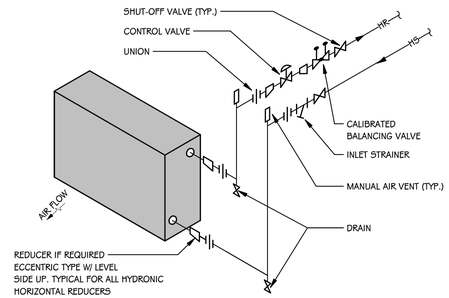
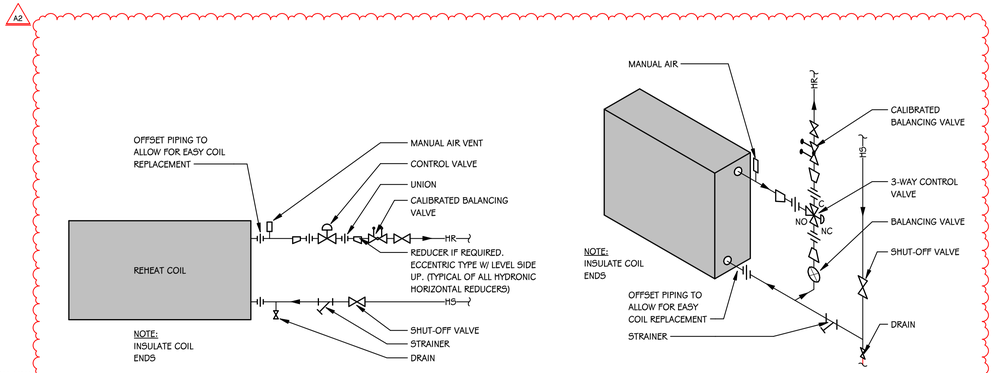
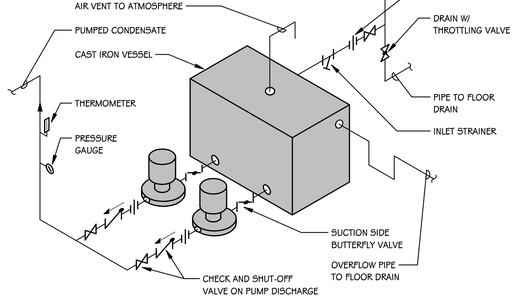


CABINET HEATER PIPING DETAIL
SCALE: NONE



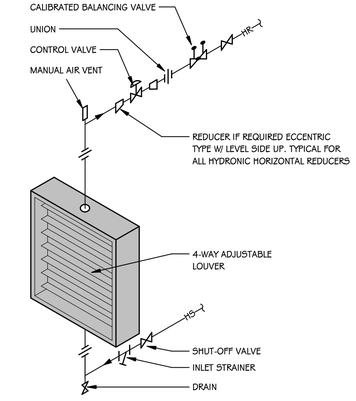
REHEAT COIL PIPING DETAIL (2-WAY)
SCALE: NONE

REHEAT COIL PIPING DETAIL (3-WAY)
SCALE: NONE

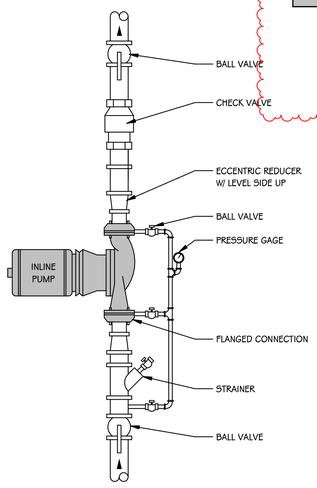


CR-D2:
CONDENSATE RECEIVER BASED ON "BELL AND GOSSETT" MODEL WCD30-30B-MA 30 GAL. CAPACITY, 30 PSI DISCHARGE PRESSURE, 30 GAL PUMP CAPACITY, 1 HP MOTOR DUPLEX PUMP @ 3,500 RPM, 115/1/60 ELECTRICAL.

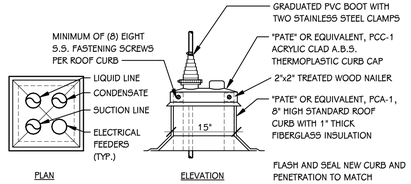
CONDENSATE RECEIVER PIPING DETAIL - DUPLEX
SCALE: NONE



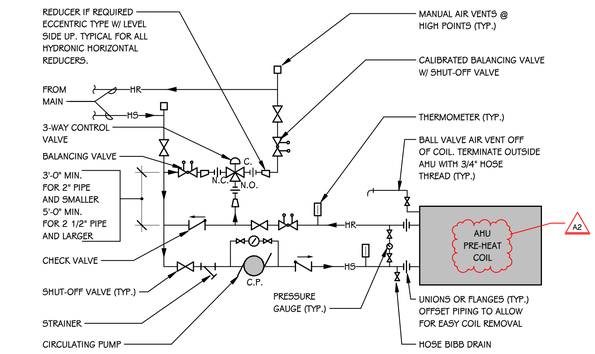
UNIT HEATER PIPING DETAIL - HORIZONTAL(B)
SCALE: NONE



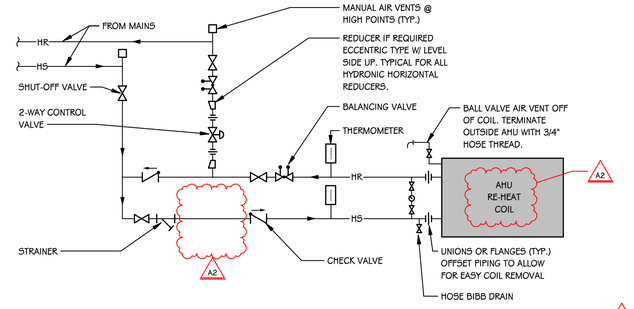
PUMP - INLINE PIPING DETAIL
SCALE: NONE



PIPING PORTAL / CURB DETAIL
SCALE: NONE



AHU PRE-HEAT COIL PIPING DETAIL - SINGLE COIL 3-WAY VALVE
SCALE: NONE



AHU RE-HEAT COIL PIPING DETAIL - SINGLE COIL 2-WAY VALVE
SCALE: NONE

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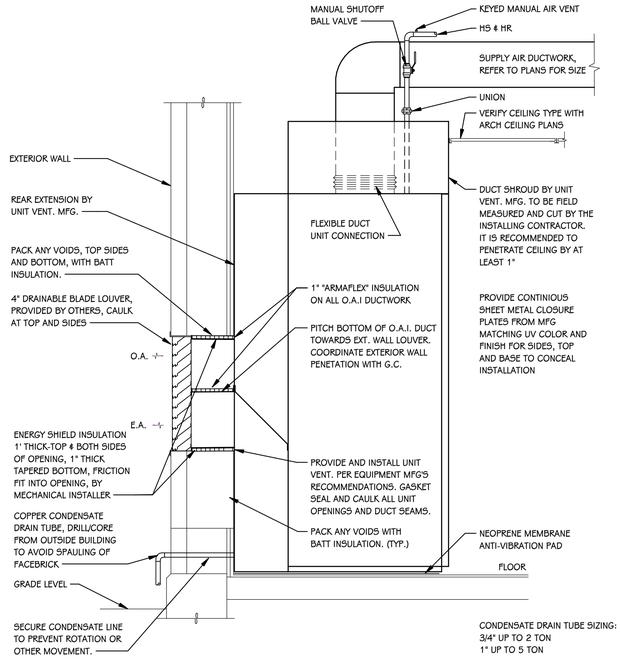
PROJECT TITLE
LOY NORRIX HIGH SCHOOL MECHANICAL IMPROVEMENTS PROJECT

OWNER
KALAMAZOO PUBLIC SCHOOLS
Kalamazoo, Michigan

SHEET TITLE
MECHANICAL SCHEDULES AND DETAILS

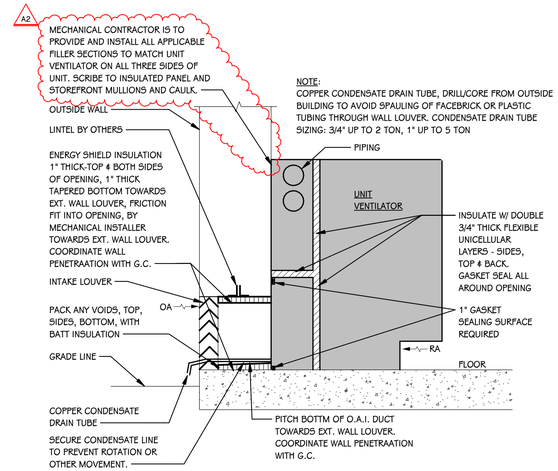
DATE
OCTOBER 31, 2025

SHEET NUMBER
M 504
23-637.00



UNIT VENTILATOR DETAIL - VERTICAL

SCALE: NONE



UNIT VENTILATOR DETAIL - FLOOR MOUNTED

SCALE: NONE

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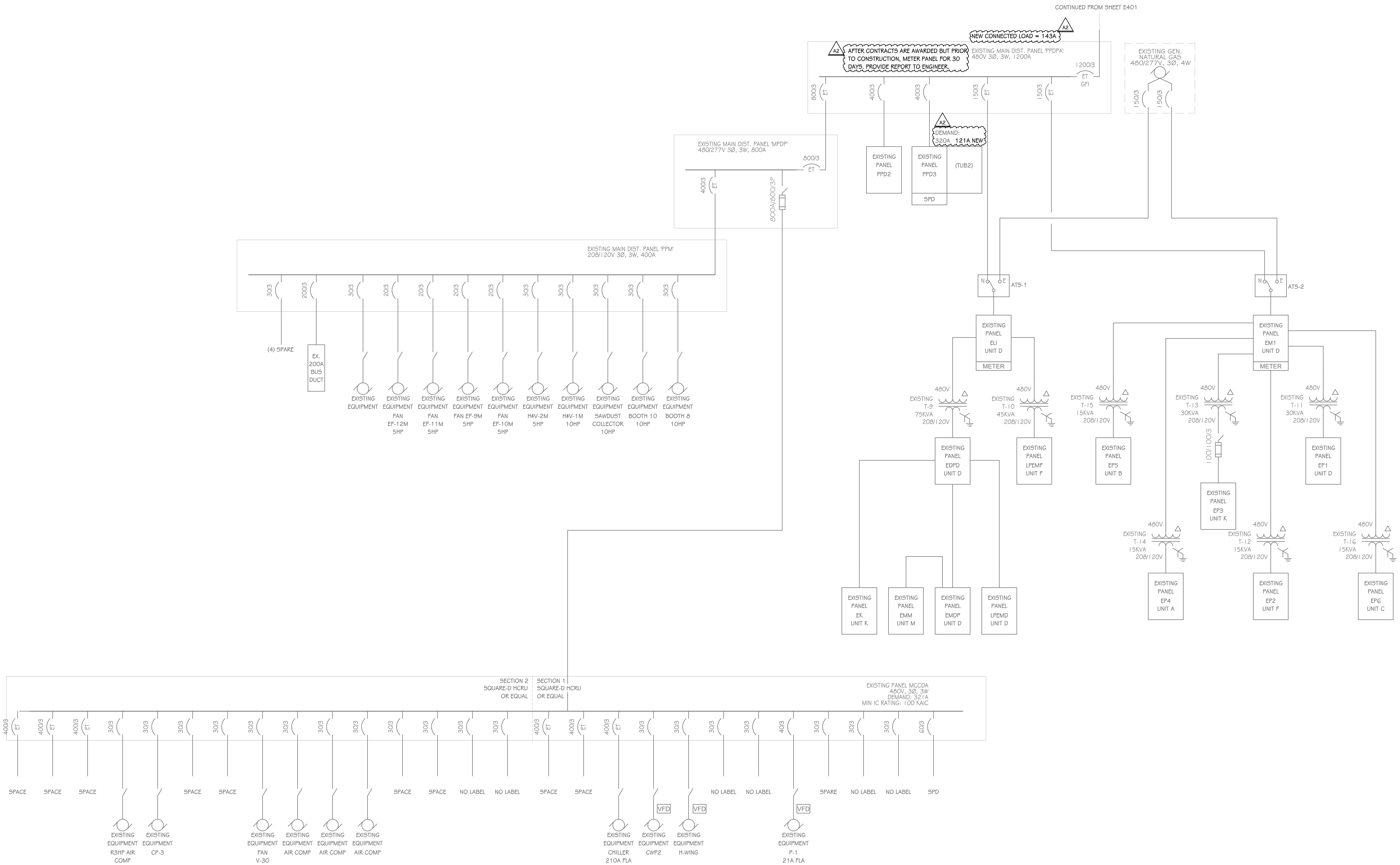

ONE LINE - #2 PARTIAL

SCALE: NONE

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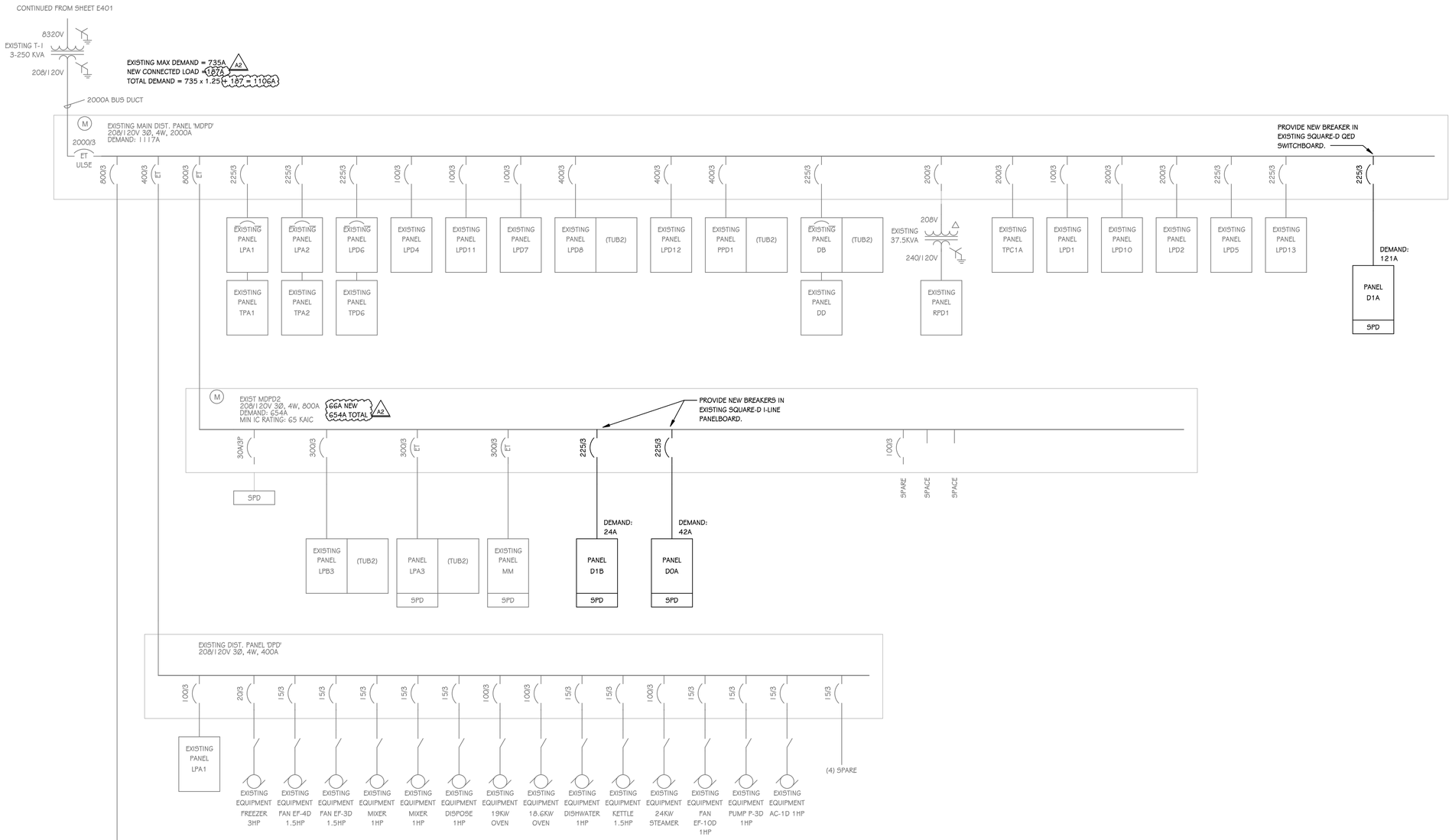
Kalamazoo, Michigan

SHEET TITLE
ELECTRICAL ONE LINE - PARTIAL #2

DATE
OCTOBER 31, 2025

SHEET NUMBER
E 403

23-637.00



ONE LINE - PARTIAL #4

SCALE: NONE

SERVICE ENTRANCE SPD SCHEDULE

VOLTAGE	SWITCHBOARD AMPS	RAYVOSS SPD MODEL	SURGE RATING	PROTECTION MODES	MAX WIRE	MIN BREAKER
208/120V Wye	Up to 2000A	120-3Y-N3-7-04-A-H	140kA/Mode	L-N, L-G, N-G	4/0	100A
208/120V Wye	2000A-4000A	120-3Y-A1-7-04-A-H	200kA/Mode	L-N, L-G, N-G	4/0	100A
480/277V Wye	Up to 2000A	277-3Y-N3-7-04-C-H	140kA/Mode	L-N, L-G, N-G	4/0	100A
480/277V Wye	2000A-4000A	277-3Y-A1-7-04-C-H	200kA/Mode	L-N, L-G, N-G	4/0	100A
480 Delta	Up to 2000A	480-3D-M3-3-04-D-H	140kA/Mode	L-G	#2 AWG	60A
480 Delta	2000A-4000A	480-3D-N1-3-04-D-H	200kA/Mode	L-G	#2 AWG	60A

*FOR ALL SERVICE ENTRANCE, GENERATOR ENTRANCE AND OTHER HIGH RISK ELECTRICAL ENTRANCE/EXITS. ALL SERVICE ENTRANCE DEVICES TO HAVE TIME STAMP EVENT MONITORING. MOUNT DEVICES WITHIN 10' OF PANELSWITCHBOARD BUS.

BRANCH PANEL SPD SCHEDULE

VOLTAGE	PANEL AMPS	RSE2 SPD MODEL	SURGE RATING	PROTECTION MODES	BREAKER AMPS
208/120V Wye	Up to 400A	RSE-2-120-3Y-A-05-E-F-S	50kA/Mode	L-N, L-G, N-G	30A
208/120V Wye	400A-2000A	RSE-2-120-3Y-A-10-E-F-S	100kA/Mode	L-N, L-G, N-G	60A
480/277V Wye	Up to 400A	RSE-2-277-3Y-A-05-E-F-S	50kA/Mode	L-N, L-G, N-G	30A
480/277V Wye	400A-2000A	RSE-2-277-3Y-A-10-E-F-S	100kA/Mode	L-N, L-G, N-G	60A

*FOR CASCADED PROTECTION DIRECTLY DOWNSTREAM OF SERVICE ENTRANCE AND ALL SUB PANELS. ALL SPD DEVICES TO HAVE TIME STAMP EVENT MONITORING. MOUNT DEVICES WITHIN 10' OF PANELSWITCHBOARD BUS.

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OWNER
KALAMAZOO PUBLIC SCHOOLS
Kalamazoo, Michigan

SHEET TITLE
ELECTRICAL ONE LINE - PARTIAL #4

DATE
OCTOBER 31, 2025

SHEET NUMBER
E 405
23-637.00

ELECTRICAL PANEL FEEDER SCHEDULE

DESCRIPTION	FED FROM	CURRENT (FLA)	DEMAND (FLA)	BREAKER / POLES	FEEDER # OF SETS	FEEDER WIRE	FEEDER GROUND	FEEDER EMT	ACCUM VOLT DROP %	NOTES
208 V										
D0A	MDPD2	42 A	42 A	225 A / 3	1 SET	4 #4/0	#4 GND.	2 1/2"	1.2%	
D1A	MDPD2	121 A	121 A	225 A / 3	1 SET	4 #4/0	#4 GND.	2 1/2"	2.2%	
D1B	MDPD2	24 A	24 A	225 A / 3	1 SET	4 #4/0	#4 GND.	2 1/2"	1.4%	

ELECTRICAL HVAC FEEDER SCHEDULE

DESCRIPTION	FED FROM	DISCONNECT MEANS	CURRENT (FLA)	BREAKER / POLES	FEEDER # OF SETS	FEEDER WIRE	FEEDER GROUND	FEEDER EMT	ACCUM VOLT DROP %	NOTES
480 V										
HVAC - AHU-D1	PPD3	PROVIDED BY DIV 23	21 A	45 A / 3	1 SET	4 #8	#10 GND.	1"	1.4%	
HVAC - AHU-D2	PPD3	PROVIDED BY DIV 23	14 A	30 A / 3	1 SET	4 #10	#10 GND.	3/4"	1.1%	
HVAC - P-D3	PPDPA	PROVIDED BY DIV 23	11 A	20 A / 3	1 SET	4 #12	#12 GND.	3/4"	1.2%	
HVAC - P-D4	PPDPA	PROVIDED BY DIV 23	11 A	20 A / 3	1 SET	4 #12	#12 GND.	3/4"	1.2%	
HVAC - RTU-D1	PPD3	PROVIDED BY DIV 23	86 A	110 A / 3	1 SET	4 #2	#6 GND.	1 1/2"	2.1%	
208 V										
HVAC - P-D5	D0A	PROVIDED BY DIV 23	4 A	20 A / 3	1 SET	4 #12	#12 GND.	3/4"	2.5%	
HVAC - P-D6	D0A	PROVIDED BY DIV 23	4 A	20 A / 3	1 SET	4 #12	#12 GND.	3/4"	2.2%	
HVAC - P-D7	D0A	PROVIDED BY DIV 23	4 A	20 A / 3	1 SET	4 #12	#12 GND.	3/4"	1.6%	
HVAC - P-D8	D1B	PROVIDED BY DIV 23	3 A	20 A / 3	1 SET	4 #12	#12 GND.	3/4"	2.3%	
HVAC - P-D8	D0A	PROVIDED BY DIV 23	4 A	20 A / 3	1 SET	4 #12	#12 GND.	3/4"	2.5%	
HVAC - VUV-D1	D0A	MANUFACTURER	5 A	20 A / 3	1 SET	4 #12	#12 GND.	3/4"	2.7%	
HVAC - VUV-D2	D0A	MANUFACTURER	5 A	20 A / 3	1 SET	4 #12	#12 GND.	3/4"	2.5%	
HVAC - VUV-D3	D0A	MANUFACTURER	5 A	20 A / 3	1 SET	4 #12	#12 GND.	3/4"	2.3%	
HVAC - VUV-D5	D0A	MANUFACTURER	5 A	20 A / 3	1 SET	4 #12	#12 GND.	3/4"	1.9%	
208 V										
HVAC - ACCU-245	D1A	30/3 NEMA 3R NFDS	20 A	45 A / 2	1 SET	3 #8	#10 GND.	3/4"	4.4%	
HVAC - ACCU-246	D1A	30/3 NEMA 3R NFDS	20 A	30 A / 2	1 SET	3 #8	#10 GND.	3/4"	3.8%	
HVAC - ACCU-D9	D1A	30/3 NEMA 3R NFDS	18 A	30 A / 2	1 SET	3 #10	#10 GND.	3/4"	3.8%	
HVAC - ACCU-D10A	D1A	30/3 NEMA 3R NFDS	30 A	50 A / 2	1 SET	3 #8	#10 GND.	3/4"	3.7%	
HVAC - ACCU-D10B	D1A	30/3 NEMA 3R NFDS	30 A	50 A / 2	1 SET	3 #8	#10 GND.	3/4"	3.9%	
HVAC - ACCU-D11	D1A	30/3 NEMA 3R NFDS	18 A	30 A / 2	1 SET	3 #8	#10 GND.	3/4"	3.4%	
HVAC - ACCU-D12	D1A	30/3 NEMA 3R NFDS	15 A	20 A / 2	1 SET	3 #10	#10 GND.	3/4"	4.2%	
HVAC - ACCU-D13A	D1A	30/3 NEMA 3R NFDS	15 A	20 A / 2	1 SET	3 #10	#10 GND.	3/4"	4.6%	
HVAC - ACCU-D13B	D1B	30/3 NEMA 3R NFDS	15 A	20 A / 2	1 SET	3 #10	#10 GND.	3/4"	3.3%	
HVAC - CR-D2	D0A	NON-FUSED	8 A	20 A / 2	1 SET	3 #12	#12 GND.	3/4"	2.9%	
HVAC - EF-D1	D1A	MANUFACTURER	2 A	20 A / 2	1 SET	3 #12	#12 GND.	3/4"	2.7%	
HVAC - HUV-277A	D1B	MANUFACTURER	3 A	20 A / 2	1 SET	3 #12	#12 GND.	3/4"	2.5%	
HVAC - HUV-277B	D1B	MANUFACTURER	3 A	20 A / 2	1 SET	3 #12	#12 GND.	3/4"	2.6%	
HVAC - HUV-D9	D1A	MANUFACTURER	3 A	20 A / 2	1 SET	3 #12	#12 GND.	3/4"	2.7%	
HVAC - HUV-D10A	D1A	MANUFACTURER	3 A	20 A / 2	1 SET	3 #12	#12 GND.	3/4"	2.6%	
HVAC - HUV-D10B	D1A	MANUFACTURER	3 A	20 A / 2	1 SET	3 #12	#12 GND.	3/4"	2.8%	
HVAC - HUV-D11	D1A	MANUFACTURER	3 A	20 A / 2	1 SET	3 #12	#12 GND.	3/4"	2.7%	
HVAC - HUV-D12	D1A	MANUFACTURER	3 A	20 A / 2	1 SET	3 #12	#12 GND.	3/4"	2.9%	
HVAC - HUV-D13A	D1A	MANUFACTURER	3 A	20 A / 2	1 SET	3 #12	#12 GND.	3/4"	3.0%	
HVAC - HUV-D13B	D1A	MANUFACTURER	3 A	20 A / 2	1 SET	3 #12	#12 GND.	3/4"	3.1%	
HVAC - HUV-D18	D1B	MANUFACTURER	3 A	20 A / 2	1 SET	3 #12	#12 GND.	3/4"	2.8%	
120 V										
HVAC - EF-D2	D1A	MANUFACTURER	4 A	20 A / 1	1 SET	2 #10	#10 GND.	3/4"	4.6%	
HVAC - EF-D3	D1A	MANUFACTURER	4 A	20 A / 1	1 SET	2 #12	#12 GND.	3/4"	4.6%	
HVAC - EF-D4	D1B	MANUFACTURER	4 A	20 A / 1	1 SET	2 #12	#12 GND.	3/4"	3.4%	
HVAC - EF-D5	D1B	MANUFACTURER	4 A	20 A / 1	1 SET	2 #12	#12 GND.	3/4"	4.2%	
HVAC - EF-D6	D1B	MANUFACTURER	4 A	20 A / 1	1 SET	2 #12	#12 GND.	3/4"	3.4%	
HVAC - FCU-245	D1A	NON-FUSED	5 A	20 A / 1	1 SET	2 #10	#10 GND.	3/4"	4.8%	
HVAC - FCU-246	D1A	NON-FUSED	5 A	20 A / 1	1 SET	2 #10	#10 GND.	3/4"	4.6%	
HVAC - UH-D1	D1B	NON-FUSED	2 A	20 A / 1	1 SET	2 #10	#10 GND.	3/4"	3.1%	
HVAC - UH-D2	D1B	NON-FUSED	2 A	20 A / 1	1 SET	2 #10	#10 GND.	3/4"	3.3%	
HVAC - UH-D3	D0A	NON-FUSED	2 A	20 A / 1	1 SET	2 #12	#12 GND.	3/4"	2.4%	

ELECTRICAL PANEL AND HVAC FEEDER SCHEDULE GENERAL NOTES

1. CONDUIT SIZES BASED ON EMT AND COPPER CONDUCTORS (UNLESS OTHERWISE INDICATED WITH AN "AL" FOR ALUMINUM). UPSIZE AS REQUIRED WHERE PVC OR GALVANIZED IS USED OR REQUIRED PER SPECIFICATIONS.
2. G.E.C. = GROUNDING ELECTRODE CONDUCTOR FOR SEPARATELY DERIVED SYSTEM (PER SET, USE EQUIVALENT CMIL AND GEC FROM 250.66)
3. GND. = EQUIPMENT GROUNDING CONDUCTOR (E.G.C.)

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LOY NORRIX HIGH SCHOOL MECHANICAL IMPROVEMENTS PROJECT

OWNER
KALAMAZOO PUBLIC SCHOOLS
Kalamazoo, Michigan

SHEET TITLE
ELECTRICAL FEEDER SCHEDULES

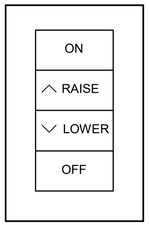
DATE
OCTOBER 31, 2025

SHEET NUMBER
E 406
23-637.00

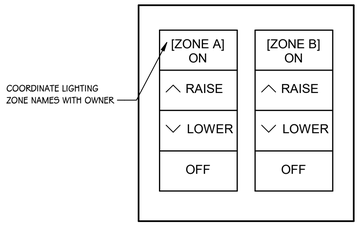
LIGHT FIXTURE SCHEDULE

TYPE	DESCRIPTION	MOUNTING	DRIVER	MANUFACTURER	NOTES
CA	6" DOWNLIGHT	RECESSED	0-10V	GOTHAM #EVOG-40K-2000LM-AR-LSS-UNV-MD-GZ10 EQUAL: ALPHABET #NUG-RD-SW-20LM-40K-80-35D-CL-MC-MC-NC-UNV-DIM10	1, 2, 3
DA	4' DRUM	RECESSED	0-10V	MARK LIGHTING #MGLR-48IN-TG-80CRI-40K-10500LM-MIN10-FLL-ZT	1, 2, 3
HA	1x4 WRAP	SURFACE	0-10V	KENALL #MLHA8-48-R-MW-PP-45L40K-120V-F5-PH EQUAL: FAILSAFE #ATO-HV5L8/B-4-LD4-1HI-40-UNV-O-EDC1-GL-ALH	1, 2, 3
HAE	1x4 WRAP	SURFACE	0-10V	KENALL #MLHA8-48-R-MW-PP-45L40K-120V-F5-PH-LEL EQUAL: FAILSAFE #ATO-HV5L8/B-4-LD4-1HI-40-UNV-O-EDC1-GL-EL10W-ALH	1, 2, 3
ID	INDUSTRIAL	SURFACE / CABLE	0-10V	LITHONIA #ZL1D-L96-5000LM-F5T-MVOLT-40K-80CRI-WH EQUAL: MLX #BT5NX-525L-5LW-UNV-L840-CD1-U	1, 2, 3
LA14*	PENDANT LINEAR	PENDANT	0-10V	FINELITE: #HP2-P-D-XX-B-840-F-96LG-277-SC-FC-DALI-1%-FA50-FE-SW EQUAL: AXIS #TB2DLED-405-80-40-SO-S(14')-W-277-O(DALI 1%)-1-CA(50")	1, 2, 3
LB12*	PENDANT LINEAR	PENDANT	0-10V	FINELITE: #HP2-P-D-XX-B-840-F-96LG-277-SC-FC-DALI-1%-FA50-FE-SW EQUAL: AXIS #TB2DLED-405-80-40-SO-S(12')-W-277-O(DALI 1%)-1-CA(50")	1, 2, 3
LC6*	PENDANT LINEAR	PENDANT	0-10V	FINELITE: #HP2-P-D-XX-B-840-F-96LG-277-SC-FC-DALI-1%-FA50-FE-SW EQUAL: AXIS #TB2DLED-405-80-40-SO-S(6')-W-277-O(DALI 1%)-1-CA(50")	1, 2, 3
RB	2x2 TROFFER	RECESSED	0-10V	FINELITE #HPR-A-2X2-DCO-H-840-120V-SC-C1 EQUAL: CORELITE #22D3X-LP-WO-50-L840-UNV-STD-U	1, 2, 3
RD4*	RECESSED LINEAR	RECESSED	0-10V	FINELITE #HP-4-R-D-XX'-B-840-F-96LG-120-SC-FC-10%-SF-FE-SW EQUAL: AXIS #BBRLED-479-80-40K-FL-S(XX')-W-DP-1-D5	1, 2, 3
RD9*	RECESSED LINEAR	RECESSED	0-10V	FINELITE #HP-4-R-D-XX'-B-840-F-96LG-120-SC-FC-10%-SF-FE-SW EQUAL: AXIS #BBRLED-479-80-40K-FL-S(XX')-W-DP-1-D5	1, 2, 3
RG4*	RECESSED LINEAR	RECESSED	0-10V	FINELITE #HP-4-R-D-XX'-B-840-F-96LG-120-SC-FC-10%-C1-FE-SW EQUAL: AXIS #BBRLED-479-80-40K-FL-S(XX')-W-DP-1-TB1	1, 2, 3
RG5*	RECESSED LINEAR	RECESSED	0-10V	FINELITE #HP-4-R-D-XX'-B-840-F-96LG-120-SC-FC-10%-C1-FE-SW EQUAL: AXIS #BBRLED-479-80-40K-FL-S(XX')-W-DP-1-TB1	1, 2, 3
RG6*	RECESSED LINEAR	RECESSED	0-10V	FINELITE #HP-4-R-D-XX'-B-840-F-96LG-120-SC-FC-10%-C1-FE-SW EQUAL: AXIS #BBRLED-479-80-40K-FL-S(XX')-W-DP-1-TB1	1, 2, 3
RG8*	RECESSED LINEAR	RECESSED	0-10V	FINELITE #HP-4-R-D-XX'-B-840-F-96LG-120-SC-FC-10%-C1-FE-SW EQUAL: AXIS #BBRLED-479-80-40K-FL-S(XX')-W-DP-1-TB1	1, 2, 3
RG10*	RECESSED LINEAR	RECESSED	0-10V	FINELITE #HP-4-R-D-XX'-B-840-F-96LG-120-SC-FC-10%-C1-FE-SW EQUAL: AXIS #BBRLED-479-80-40K-FL-S(XX')-W-DP-1-TB1	1, 2, 3
RG10*	RECESSED LINEAR	RECESSED	0-10V	FINELITE #HP-4-R-D-XX'-B-840-F-96LG-120-SC-FC-10%-C1-FE-SW EQUAL: AXIS #BBRLED-479-80-40K-FL-S(XX')-W-DP-1-TB1	1, 2, 3
S8*	RECESSED LINEAR	RECESSED	0-10V	FINELITE #HP-4-SM-D-XX'-B-840-F-96LG-120-SC-FC-10%-C1-FE-SW EQUAL: AXIS BEAM SURFACE LINEAR	1, 2, 3
S12*	RECESSED LINEAR	RECESSED	0-10V	FINELITE #HP-4-SM-D-XX'-B-840-F-96LG-120-SC-FC-10%-C1-FE-SW EQUAL: AXIS BEAM SURFACE LINEAR	1, 2, 3
S14*	RECESSED LINEAR	RECESSED	0-10V	FINELITE #HP-4-SM-D-XX'-B-840-F-96LG-120-SC-FC-10%-C1-FE-SW EQUAL: AXIS BEAM SURFACE LINEAR	1, 2, 3
S24*	RECESSED LINEAR	RECESSED	0-10V	FINELITE #HP-4-SM-D-XX'-B-840-F-96LG-120-SC-FC-10%-C1-FE-SW EQUAL: AXIS BEAM SURFACE LINEAR	1, 2, 3
TA	2x2 TROFFER	RECESSED	0-10V	FINELITE #HPR-A-2X2-DCO-B-840-120V-SC-C1 EQUAL: CORELITE #22D3X-LP-WO-45-L840-UNV-STD-U	1, 2, 3
U	LED WALL PACK	WALL	0-10V	LITHONIA: # CSXWLED-1-30B530K-SR3-277-SF-DNAXD EQUAL: MCGRAW #GWC-9A1A-740-4-T3-GM	1, 2, 3
X1	EXIT SIGN - SINGLE FACE	UNIVERSAL	N/A	LITHONIA #LQC-W-1-R EQUAL: SURELITE #CXG1WH	1, 2
X2	EXIT SIGN - DOUBLE FACE	UNIVERSAL	N/A	LITHONIA #LQC-W-2-R EQUAL: SURELITE #CXG2WH	1, 2

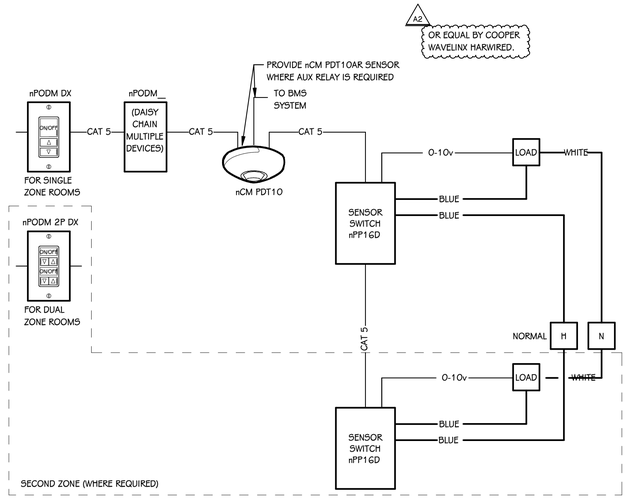
1. ALL LED FIXTURES TO HAVE WARRANTY TO MEET OR EXCEED WARRANTY INCLUDED IN BASIS OF DESIGN. FIXTURES LISTED AS EQUALS SHALL MEET DELIVERED LUMENS, CRI, EFFICACY AND OPTIONS OF THAT SPECIFIED. REFER TO SPECIFICATIONS 265100 AND 265600 FOR ADDITIONAL REQUIREMENTS.
2. THE MOUNTING DESCRIPTION IS GENERAL. REFER TO SHOP DRAWINGS AND MANUFACTURER'S INSTALLATION INSTRUCTIONS FOR SPECIFIC MOUNTING DETAILS.
3. FIXTURES WITH THE CENTER CIRCLE SHADED SHALL BE CONNECTED TO EMERGENCY POWER. FIXTURES WITH CENTER CIRCLE SHADED THAT ARE SWITCHED SHALL BE PROVIDED WITH BODINE "ELD" TRANSFER DEVICE. FOR INDIVIDUAL FIXTURES DEVICE SHALL BE MOUNTED INTERNAL TO THE FIXTURE. PROVIDE LABEL ON INSIDE OF FIXTURE INDICATING FED FROM MULTIPLE CIRCUITS. WHERE DEVICE CANNOT BE MOUNTED INSIDE OF FIXTURE, MOUNT ADJACENT TO FIXTURE IN ACCESSIBLE CEILING SPACE.



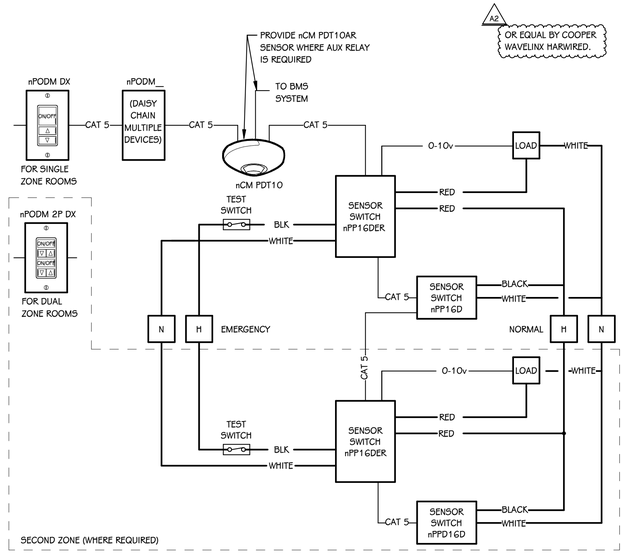
SINGLE ZONE
DIMMING CONTROLLER
SCALE: NONE



DUAL ZONE
DIMMING CONTROLLER
SCALE: NONE



OCCUPANCY SENSOR WIRING DIAGRAM
SCALE: NONE



EMERGENCY
OCCUPANCY SENSOR WIRING DIAGRAM
SCALE: NONE

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ADDENDUM NO. 2	11-25-2025
ISSUED FOR	DATE

PROJECT TITLE
LOY NORRIX HIGH SCHOOL MECHANICAL IMPROVEMENTS PROJECT

OWNER
KALAMAZOO PUBLIC SCHOOLS
Kalamazoo, Michigan

SHEET TITLE
ELECTRICAL LIGHTING DETAILS

DATE
OCTOBER 31, 2025

SHEET NUMBER
E 407
23-637.00