

ADDENDUM NO. 2

State of Maine Ray Building Renovation
28 Tyson Drive
Augusta, ME

April 26, 2022

From: Wood
Environment & Infrastructure Solutions
511 Congress Street
Portland, Maine 04101

To: Prospective Bidders

This Addendum forms a part of the Contract Documents and modifies the original bidding documents dated March 31, 2022, as noted below. Bidders shall acknowledge receipt of this Addendum in the space provided on the Contractor Bid Form, failure to do so may subject the bidder to disqualification.

I. GENERAL

A. RFI RESPONSES

1. See attached numbered RFI responses: 1-49.

B. See attached: Sign-in sheet from the 4/12/2022 PreBid Meeting.

C. Existing building information will be posted to the plan room by 4/27/2022.

1. 1935 Ray Bldg. Original Dwgs
2. 1935 Ray Bldg. Original Specs
3. 1974 Ray Bldg. Renovations
4. 1993 Ray Bldg. Basement Renovations
5. 2004 HVAC Improvements
6. 2005 Ray Bldg. Basement & First Flr Reno
7. 2011 Ray Bldg. HVAC Reno
8. 2017 East Campus Utilities & Steam MAY 24
9. Pages from 1974 Ray Bldg. Renovations
10. Pages from 1993 Ray Bldg. Basement Renovations
11. 2009 Ray Bldg. Roof Audit & Repair

12. 2010 HVAC Reno Complete Report
13. 2018 ME Ray Bldg. HVAC Report
14. 2018 ME Ray Bldg. Water Infiltration Report
15. 2018 Wood Site Visit Report Revised 2018-06-06
16. Historic Register

D. CLARIFICATION OF TELECOM AND SECURITY SCOPE

1. Telecom:
 - a) Boxes and conduit for voice/data are by the GC
 - b) Wiring between the devices, the telecom closets, ground level telecom room (Centrex) and the vault is by the Owner
2. Security:
 - a) The existing security system shall be reused to the fullest extent possible.
 - b) Boxes, conduit, and new wiring (where required) are by the GC
 - c) Electrified door hardware is by the GC
 - d) Access control and security devices are by the Owner

II. SPECIFICATIONS

- A. DELETE Specification Section 00 11 13 NOTICE TO CONTRACTORS in its entirety, ADD Specification Section 00 11 13 NOTICE TO CONTRACTORS dated 04-26-2022.
- B. DELETE Specification Section 072119 FOAMED-IN-PLACE INSULATION in its entirety, ADD Specification Section 072119 FOAMED-IN-PLACE INSULATION dated 04-26-2022.
- C. DELETE Specification Section 085200 WOOD WINDOWS in its entirety, ADD Specification Section 085200 WOOD WINDOWS dated 04-26-2022.
- D. DELETE Specification Section 230923 DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC in its entirety, ADD Specification Section 230923 DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC dated 04-26-2022.
- B. DELETE Specification Section 233113 METAL DUCTS in its entirety, ADD Specification Section 233113 METAL DUCTS dated 04-26-2022.
- C. DELETE Specification Section 233300 AIR DUCT ACCESSORIES in its entirety, ADD Specification Section 233300 AIR DUCT ACCESSORIES dated 04-26-2022.

III. DRAWINGS

- A. Replace sheet AE611 in its entirety, Add attached sheet AE611 with Revision 1 dated 04-26-2022. Door schedule was revised to remove erroneous columns.
- B. Replace sheet AE621 in its entirety, Add attached sheet AE621 with Revision 1 dated 04-26-2022. Casing and subsill profiles revised to custom profiles to match existing window aesthetics.
- C. Replace sheet AE622 in its entirety, Add attached sheet AE622 with Revision 1 dated 04-26-2022. Casing and subsill profiles revised to custom profiles to match existing window aesthetics.
- D. Replace sheet M-501 in its entirety, Add attached sheet M-501 with Revision 1 dated 04-26-2022. Removed Detail C1 entirely and deleted texts pertaining for diffuser supports from Detail E1. Revised Notes 1 and 2 and deleted text on Detail A1 pertaining to bracing, canvas and arabol seal.

END OF ADDENDUM NO. 2

ATTACHMENTS:

Summary of RFI responses

Prebid sign-in sheet

00 11 13

072119

085200

230923

233113

233300

AE611

AE621

AE622

M-501

State of Maine Ray Building Renovation

Pre-Bid Questions

Question No.	Discipline	Question	Date Received	Response	Response Issued Via
1	Architectural	Will Kewaunee be an acceptable manufacturer for the fume hood and cabinets-proving they meet specifications.	4/6/2022	Please submit a formal substitution request for the Kewaunee fume hood.	
2	Architectural	1. Specifications has operator and manual operation. With the location of the door, I am not sure where the operator is to be located. 2. It appears that the slide locks are between the counter and the grill. Not sure that the slide locks will be operable as shown. 3. With the coiling unit closed in a soffit, it is going to be difficult if not impossible to service the unit.	4/6/2022	Please see attached drawings in the Addendum.	Addendum 01 04/13/2022
3	General	Specification Section 01 10 00, pg. 6, Art. 1.11.G notes; "...Contractor personnel working on Project Site. Utilize the Background Check Application attached..." Questions: 1. Regarding the Mandatory Pre Bid Conference on Tuesday, April 12, 2022 10:00 AM, do you and or BGS require a list of our attending employees and must they fill out and submit a Background Check Authorization prior to the meeting? a. If the form is required, what is the deadline for submission and who shall it be sent to?	4/7/2022	The background check is not required for the Pre-Bid Conference Meeting. The background check is required for the successful bidder and all personnel on-site during construction including subcontractors. The Background Check Authorization form is to be completed and submitted during the submittals submission phase.	Addendum 01 04/13/2022
4	Mechanical	Can Johnson Controls be listed as an acceptable controls manufacturer under specification section "230923 – 9 – 2.1 - A.1?"	4/7/2022	Yes, any qualified BACnet controls contractor can bid, as long as they can interface with the State of Maine Honeywell EBI system. Spec will be clarified in addendum.	Addendum 01 04/13/2022
5	Food Service	A food equipment service supplier would like to verify that item 19A (Ansul fire protection) is required or is in addition to the fire suppression system provided with the ventless hood. The ventless hood comes with Ansul fire protection system.	4/11/2022	Item No. 19A – Fire Suppression System is not required. The ventless hood is provided with an Ansul R-102 system as standard.	Addendum 01 04/13/2022
6	General	Is the Ray Building currently occupied or vacant and what type of access will we be allowed during the Pre-Bid Conference?	4/11/2022	The Building is mostly vacant except for staff supporting the move out of building occupants. Contractors will have full access with the possible exception of the existing bio-labs on the ground floor which need key card access.	Addendum 01 04/13/2022
7	General	Will photos of specific building details be allowed during the Pre-Bid Conference tour?	4/11/2022	Photos are allowed	Addendum 01 04/13/2022
8	General	There is no specific location noted to meet. Should we gather at the main entrance?	4/11/2022	Yes, please gather at the main entrance.	Addendum 01 04/13/2022
9	General	Specification Sect. 01 10 00, pg. 2, Art. 1.5.A.1.b & c SCHEDULE. Article 1.5.A.1.b states Substantial Completion of 31 August 2023 and Art. 1.5.A.1.C notes Final Completion: 31 October 31, 2023. a. Section 00 52 13 State of Maine Construction Contract Art. 2.2 states Substantial Completion shall be 15 December 2023 and Art. 2.3 states Contract Final Completion date of 31 December 2023. Can you please clarify which dates should prevail for Substantial and Final Completion?	4/11/2022	The contractor is to use the dates shown in the Bid Notice to Contractors and the Summary Section 011000. Section 005213 Construction Contract is a sample of the contract that will be utilized with the successful bidder. The dates listed within the sample contract are examples only.	Addendum 01 04/13/2022

Question No.	Discipline	Question	Date Received	Response	Response Issued Via
10	Architectural	A door supplier is asking for the following clarifications: 1) Confirm wood door species from the existing building. 2) Confirm Existing Operators are available for doors 102A, 103, 103A as specified. 3) Missing Hardware Set 3B - Please advise. 4) Confirm Aluminum Doors are wide stile that will accept specified sargent mortise locks. 5) Hardware Set 9 - Does the owner want electric strike or electric lock? Both listed. 6) Hardware Set 9A & 9B - Does the owner want electric strike or electric exit device? Both listed.	4/11/2022	1) For pricing purposes, assume all existing wood door species are birch. Field verify prior to ordering. 2) Existing operators are available for those doors. Please verify in field. 3) Hardware set 3B shall consist of: 3 Pairs Hinges, 1 Lockset, Passage Function with Lever Handle, 2 Wall Stops, 1 Astragal, Surface-Mounted Manual Flush Bolts, 4 Kick Plates, 2 Each Side, 1 Threshold, Perimeter Weatherstripping 4) Confirmed aluminum door is wide stile. 5) All electrified locking will be via electric strike. 6) All electrified locking will be electric strike	
11	Architectural	A Window Shade contractor is asking for the following: 1. Specs need clarification A. Fabric to be light filtering - what open factor? - 1%, 3%, 5% 2. Are the ONLY shades to be provided are the ones noted on the Elevations AE201, AE202, AE203 Total of: A/AM (114), F(4), P2(1), P1(7) = 126 units 3. Specs states various "toppers" - Fascia is most common - please confirm if this is what is desired	4/12/2022	1) All windows will receive shades that are 5% openness factor 2) See specification 122413 article 3.2 paragraph A, for shade location. 3) Use fascia options at top of windows.	
12	Mechanical	Section 013100 Para. 1.6A states prepare coordination drawings according to requirements in individual sections. Division 22 and 23 do not appear to require coordination drawing. Please confirm.	4/12/2022	Yes, coordination drawings are required for Division 22 and 23.	
13	Mechanical	Sect. 230593 Para. 1.6 Quality Assurance appears to require certified balancer only. Would Yankee balancing be an acceptable balancer? Yankee has done many State of Maine buildings for many years.	4/12/2022	Yes, Yankee Balancing owned by Jake Laverdiere is an acceptable balancer.	Addendum 01 04/13/2022
14	General	The wage rates in the spec do not include mechanical insulators. Please let us know what rate to carry.	4/12/2022	The State does not have a wage rate specified for that particular classification therefore the contractor shall apply the typical wage rate utilized in a non-public project.	
15	Architectural	Spec section 098436 2.4 C 3 calls out item 6440W1 which is a Wood linear 3-3/4" wide plank. The detail D6/AE511 show a 5-1/4" wide plank. Please confirm which size we should have quoted.	4/12/2022	See response to RFI 42 number 4	

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16	Architectural	<p>The insulation contractor has question about the outside system and has asked their consultant to review. Please see their response and let me know if you see this as an issue.</p> <p>Exterior Wall Type F6a calls for 2" spray foam. What is this foam sprayed against? Is the foam sprayed against an existing masonry wall? If so, a drainage plane must be established at the exterior. Please see the forwarded email below from our corporate Building Science Expert regarding the exterior masonry walls. From Steve Carr regarding another historic building renovation with existing masonry walls....</p> <p>The builder will want to keep any insulation (batt, blown or SPF) off the brick fascia. Even though we have buildings made of thick brick walls, we need to treat them as a fascia that needs to be able to have a drainage plane and space for condensation to drip and come out the weep holes (out the bottom of the brick wall). This means even if there is no framing on the interior, a flashing, air barrier/drainage plane will need to be installed in a way to allow space for vapor moisture to change to liquid.</p> <p>The customer's concerns are valid, water vapor in the brick will deteriorate the brick over time. One method is to use a drainage mat as the substrate for the ccSPF (only use Closed Cell for this application and the minimum thickness to be a Class 2 Vapor Retarder assembly). The drainage mat can be right against the brick wall, yet needs to be inline with the flashing below and all seams sealed to not allow blockage by the ccSPF. Assuming there is some kind of framing on the interior for an air barrier, the Latex Paint normally used as a finish will suffice as the Class 3 Vapor Retarder over each framing member to allow drying to the interior of the building. There are more questions I have as to how the assembly is made up, but I would highly recommend a minimum thickness of foam to be a Class 2 VR in between any wood framing and the mat/brick along with you considering 3" of ccSPF in the cavities to make sure the dewpoint is reached in the foam from interior heat, vapor and air (pressure) transfer.</p>	4/12/2022	<p>Yes, intent is to spray against interior face of masonry which will create an air barrier and moisture barrier. We cannot extensively modify the exterior aesthetic, and create a dedicated exterior drainage plane, within budget given the historical requirements. The building is an almost 90yo brick mass masonry wall, with thru-wall flashing just above each finish floor level between the windows. There are no traditional weeps or dedicated drainage planes within the assembly, as seen in contemporary mass masonry. Because the existing assembly has successfully shed bulk-water over its life, and due to fact that we have specified selective repointing and rebuild of the brick masonry in deteriorated areas, there is confidence that ccSPF applied directly to the interior side of the mass masonry will allow the mass masonry to continue to absorb and wick to the exterior, or diffuse through the semi-permeable spray foam and vapor open interior mineral wool and GWB with latex paint finish. We would like to discuss our strategy further with you, and if there is a detail that could be shared with us regarding your recommendation(s) it would be helpful for that discussion.</p>	
17	Mechanical	Coordination Drawings – Section 233113 Part 1.4 lists coordination drawings as an informational submittal. There are no details offered on the format of the drawings. Are coordination drawings required for this project?	4/13/2022	Yes, coordination drawings are required. See section 013100 article 1.6.	
18	Mechanical	Duct Liner – Section 233113 Part 2.5 lists fiberglass free duct liner. The product has an FSK barrier on the air stream side. In Part 2.5.C.9 it is asking for a perforated inner wall. Is this needed since the insulation has an air stream side barrier encapsulating the lining material?	4/13/2022	Perforated sheet metal inner duct described in 2.5.C.9 is not required. Section 233113 will be revised to delete this item.	
19	Mechanical	Flexible Duct Connections – Section 233113 Part 2.8 lists how to connect the flexible ductwork. It does not list out what type of flexible ductwork is required. Could you please list the type of flexible duct that is acceptable for this project?	4/13/2022	Insulated, flexible duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier. Section 233300 AIR DUCT ACCESSORIES will be updated to include the above.	
20	Mechanical	Hangers – Section 233113 Part 2.9 states that all hangers shall meet SMACNA standards. On drawing M-501 detail A3 mirrors the SMACNA standards. Detail C1 is a much heavier hanger standard than SMACNA. Can you specify which hanger standards (SMACNA or detail C1) we should be using for this project?	4/13/2022	SMACNA. Disregard detail C1 on M-501. Details A3 and A5 are acceptable. Detail C1 on M-501 will be deleted in addenda.	
21	Mechanical	Hangers – On drawing M-501 detail C1 Note 1 says that all hanger hardware is to be 316L Stainless Steel. Does this apply to all hanger materials on the entire project?	4/13/2022	Per response to RFI-20, detail C1 on M-501 to be deleted. As such note 1 regarding hardware to be 316L stainless steel does not apply.	
22	Mechanical	Exterior Ductwork – Section 233113 Part 3.4 Ductwork exposed to weather lists both Stainless and galvanized for acceptable materials. Can you indicate where galvanized can be used for ducts exposed to weather?	4/13/2022	Hood exhaust stack is the location of where duct is exposed to weather. This is outlet of EF-1.	
23	Mechanical	Duct Cleaning – Section 233113 Part 3.10 Duct Cleaning – Says all new duct systems shall be cleaned. Since this is mostly all new ductwork and will be protected during construction will the new ducts need to be cleaned or will you require that only the existing ducts that are remaining in place to be cleaned?	4/13/2022	Cover ends of new ducts during storage and transportation such that dirt and debris cannot enter. The existing ducts that are remaining in place are the only ducts that need to be cleaned.	

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24	Mechanical	Lab, Fume Hood, & Process Exhaust – Section 233113 Part 3.12: D says all ducts should be 316 stainless but does not indicate fully welded ductwork. Are standard slip connections sealed to class A standards acceptable for this system?	4/13/2022	Yes, standard slip connection sealed to class A standards are acceptable. High temperature sealant recommended due to being more resistant to chemical attack.	
25	Mechanical	Duct Liner Locations – Section 233113 Part 3.12:G Lists liner (where indicated on drawings) will be lined with 1" natural fiber duct liner. The legend on M-001 does not have a symbol for lined ductwork. Looking through the drawings the only place liner is noted is on drawing M-501 detail C5 Transfer Duct Detail. Is this the only place duct liner is required?	4/13/2022	The only other occurrence of duct liner is in the duct silencers. The duct silencers specified are Price, Cross Talk and have a fiberglass liner.	
26	Mechanical	Control Damper Actuators – Section 233300 Part 3.2 D lists the requirements for the control damper actuators. Section 230923 Direct Digital Control (DDC) System for HVAC Part 2.6 also lists the requirements for the actuators for the control dampers. Can you indicate which spec section is responsible for providing the actuators?	4/13/2022	Spec section 230923 DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC is responsible for providing damper actuators. Dampers to be provided by 233300 AIR DUCT ACCESSORIES.	
27	Mechanical	Connection to Ceiling Diffuser Detail – On drawing M-501 detail A1 refers to SMACNA figure 2-17 which is a corner closure detail for flanged connections. Is it your intent to have a flanged connection between the plenum box and diffuser? This same detail mentions Arbol seal twice. Can you elaborate on what Arbol seal is?	4/13/2022	No, the intent is not to have a flanged connection between plenum box and diffuser. The reference to 2-17 and Arabol seal will be deleted. Use a collar and clamp or draw band to make the connection between plenum box and flexible duct. Detail A1 M-501 will be revised. Size diffuser plenum equal to diffuser inlet size. Secure boot to diffuser will screeves	
28	Mechanical	Return/Exhaust Grille Duct Connection Detail – On drawing M-501 shows diffuser supports. Is it your intent to have all Grilles, diffusers, & registers independently supported from the structure?	4/13/2022	No, the intent is to have grilles, diffusers and registers supported by ceiling grid. Details A1 and E1 on M-501 will be revised with bracing note and linework deleted.	
29	Mechanical	Return, Transfer, & Exhaust Grille Schedule – On drawing M-601 all of the scheduled items are to have an included filter frame. Grilles E-1, T-1, T-2 are not indicated to be supplied with filters as per schedule note #3. Is it correct that all the grilles except the three listed are to be supplied with filters?	4/13/2022	Yes, all grilles to be provided with filters except for E-1, T-1 and T-2.	
30	Mechanical	Duct Silencers – As per the schedule on drawing M-602 these are based on Price XTU Cross Talk silencers. These are used when using the ceiling space as a return plenum. On the drawings these are being used when the return is a fully ducted system. Are these silencers needed?	4/13/2022	Yes, the duct silencers are needed. Their purpose is to "connect" spaces that were determined to be below the Minimum Applied Volume (MAV) when refrigerant safety calculations were performed according to ASHRAE 15. In the unlikely event of a refrigerant leak the refrigerant will diffuse through duct silencers and prevent occupants from being asphyxiated. Note that these spaces have glass doors which could not be undercut. Many other spaces have door undercuts to "connect" spaces and gain compliance	
31	Architectural	I'm struggling with the bullet resistant transaction window portion of this job. -AE101 note #9 says "provide bullet resistive glazing." -AE521 shows a section detail, but it looks like the varous openings are different heights. -Spec calls out glass type and a deal tray and security speaker (all good there). -Specifcated manufacturer has a lot of options. https://www.armortex.com/windows/ What I can't really figure out is size and quantity of the openings that should receive aluminum framed bullet resistant glazing. Am I missing something?	4/14/2022	For pricing purposes assume 4 panels are (5' 4" x 4' 5") (5' 4" x 3' 9") (5' 4" x 3' 8") (5' 4" x 3' 8") field verify prior to fabrication.	
32	Architectural	Please provide clarification on what windows, size and quantity of the openings that should receive aluminum framed bullet resistant glazing.	4/14/2022	See response to RFI 31	
33	Architectural	Are there sizes for the coiling counter doors? I don't see anything on the plans other than the specs for them.	4/14/2022	Nominal size of the opening is 11' 4 1/2" x 7' 6" Chain operated system. Please field verify before fabrication.	
34	General	Will the batts in the metal stud walls fall under the scope of your Drywall Sub?	4/14/2022	This project is a "Single Prime" Contract and the successful contractor will determine which lower-tier contractor will perform the work.	

Question No.	Discipline	Question	Date Received	Response	Response Issued Via
35	Electrical/FP	Is the Fire Alarm System a total replacement of are we adding onto an existing system?	4/15/2022	The Fire Alarm System is a total replacement except the FACP is to be reused.	
36	Electrical/FP	Are they requesting a new Voice Evac panel next to the existing Honeywell, or are they wanting an all new Fire Alarm system with Voice Evac designed to code?	4/15/2022	Provide new Voice Evac System, including new Panel, next to the existing Honeywell FACP.	
37	General	Due to the size of the project, sourcing qualified subcontractors and response time from suppliers, we are requesting a two-week time extension for bidding on this project. Change the bid date from April 29th to May 13th.	4/18/2022	The Project Bid Date will not be modified at this time	
38	General	We are requesting that the substantial and final completion dates for this project be extended by 6 months, due to long lead time items, windows, roofing etc.	4/18/2022	Project completion dates will not be modified at this time. Per Specification Section 007213, BGS will work with the successful bidder to determine mutually agreed-upon time extensions if necessary due to material lead times or market conditions.	
39	General	With the inflationary cost of construction related materials continuing to escalate, is it the responsibility of the General Contractor to account and allow for this escalation during the bid process?	4/18/2022	Yes, it is the responsibility of the GC to pay for inflationary costs as part of the base bid.	
40	Architectural	Is it possible to check with the architect to see if they are willing to waive the AWI certification requirement for the millwork at the Ray Building? There are only a couple certified shops in the state and it will limit the quotes on the project and drive up cost.	4/19/2022	Please submit a formal substitution request for the non AWI certified product, including data that shows equivalent level of quality.	
41	Electrical/FP	What is the model of the existing Honeywell Fire Alarm Control Panel? Examples would be Silent Knight, Fire-Lite, etc.	4/19/2022	The existing FACP is a Honeywell XLS140-2.	
42	Architectural	1) Do we know the size of the trim on these ceilings? The specs and the plans do not seem to indicate a size. 2) Sheet A311 is listed on the RCPs. There is not Shet A311 in the documents. 3) Is there an ACT type specified for Dining Area 029, Vestibule Ramp 102, Vestibule 101, Elevator Lobby 103? a. As of right now only 030, 033, 031 and 032 are listed as ACT-2. The rest is ACT-1. 4) On the wood ceiling, spec calls out for item 6440W1 which is a wood linear 3-3/4" wide plank. The details show a 5-1/4" wide plank. Please confirm which size we should have quoted.	4/19/2022	1) For the edge trim use basis of design product AXIOM® Classic Straight 6". 2) Sheet A311 does not exist, please disregard reference to A311 3) ACT-2 will go into the lab room#. and kitchen. The rest of the suspended ceilings are ACT-1. 4) Please use the item number to 6460W1, 5 1/4" wide plank.	
43	Mechanical	I do not see where a piping material type is called out for the condensate piping. Are we to assume copper and PVC are both acceptable?	4/19/2022	Yes, copper and PVC are both acceptable piping materials for condensate.	
44	Abatement	ACM glue daubs on ground level measure more than 11,000 SF on HA100 but only 8,400 SF is presented on Table 1 from spec 022600. Which figure is accurate?	4/19/2022	The contractor shall bid the 11,000 SF as indicated in the Drawing HA100 The 8,400 SF indicated in Table 1 is in error.	
45	Abatement	Keynote 11 on the HA drawings references the lead based paint determination report, but we cannot locate this report. Is there a lead abatement scope of work on this project?	4/19/2022	The lead based paint report will be issued with the forthcoming Addendum	
46	Mechanical	The Specifications do not require spring or neoprene isolators on the VRF system FCU's and Ceiling Cassettes. Please confirm	4/21/2022	Affirmative, hang the indoor VRF FCU's and ceiling cassette units using threaded rod or M10 hanging bolts, per manufacturer's installation manual.	
47	Mechanical	Does the existing heat pump supply and return piping contain glycol?	4/21/2022	Wood's understanding is that the existing loop supply and return contains 20 to 30% propylene glycol.	
48	Architectural	Specs call for 3mm edging on cabinets, doors, drawer fronts, & shelves -drawings show solid wood edging on all with solid wood divider between drawer front door -please clarify how to price	4/25/2022	Use PVC and plastic laminate edging per specifications.	
49	Architectural	Specs call for solid surface window sills -drawings call for painted hardwood sills (details B3 & C1 on AE621 and detail E3 on AE622) -please clarify what to price	4/25/2022	Please use solid surface window sills for pricing purposes.	
Total		49		49	9

PRE-PROPOSAL MEETING SIGN-IN SHEET (ATTENDEES)

PROJECT NAME:	RAY BUILDING RENOVATIONS, AUGUSTA, MAINE			DATE: 04/12/2022
COMPANY	JOB TITLE	NAME	PHONE	EMAIL
Knowles Ind.	President	Travis Whitehead	207-854-1900	TWhitehead@Knowlesindustrial.com
Cianbro Stephen Williams	Sr. P.M.	Stephen Williams	207-708-0928	SWilliams@Cianbro.com
SHERIDAN	Bldg. Consultant	WES JORDAN	207-453-9311	sales@Sheridancorp.com
Cianbro	Sr. Project Manager	David Stenzel	207-679-7123	dstenzel@cianbro.com
CIANBRO	SOFTWINTENDENT	DAVE NICHOLS	207-708-0591	dnichols@cianbro.com
Bowman Const.	President	Kevin Bowman	207-368-2405	kb@bowmanconstruction.com
Benchmark	owner	Sam Rush	207-229-0459	srush@benchmarkconstruction.org
Ranor Mech	Estimator	Cody DeMillo	207-491-7750	cody@ranormech.com
COTE CRANE	PM	MATHEW COTE	207-838-5376	MJCOTE@COTE(CRANE).COM

PRE-PROPOSAL MEETING SIGN-IN SHEET (ATTENDEES)

PROJECT NAME:	RAY BUILDING RENOVATIONS, AUGUSTA, MAINE			DATE: 04/12/2022
<u>COMPANY</u>	<u>JOB TITLE</u>	<u>NAME</u>	<u>PHONE</u>	<u>EMAIL</u>
VA Preble Co.	Estimator	Steve Michaud	207-696-5581	steve@michaudpreble.com
Dan Bonin Masonry Inc	Estimator	Dean Bonin	207-323-5304	info@boninmasonry.com
DAVID MAJUMDAR GANNESTON CONSTRUCTION		BRUCE DAVENPORT	207-789-7461	BRUCE@GANNESTONCONSTRUCTION.COM
JACOB WALTMAN	EST	JACOB WALTMAN	207 816 0420	JWALTMAN@GANNESTONCONSTRUCTION.COM
TIM PORTER	ESTIMATOR	GANNESTON CON	207 441 0806	TPORTER@GANNESTONCONSTRUCTION.COM
DEREK NARVAEZ				
DEAN & ALLEN		DEREK NARVAEZ	207 657 5646	DNARVAEZ@DEANANDALLEN.COM
BLANE CASEY	ESTIMATOR	JEFF BECKER	207-622-5600	JBECKER@BLANCASEY.COM
Blanc Casey Bldg. Care.		Blanc Casey	207 622-5600	bcasey@blancCasey.com

PRE-PROPOSAL MEETING SIGN-IN SHEET (ATTENDEES)

PROJECT NAME:	RAY BUILDING RENOVATIONS, AUGUSTA, MAINE			DATE: 04/12/2022
<u>COMPANY</u>	<u>JOB TITLE</u>	<u>NAME</u>	<u>PHONE</u>	<u>EMAIL</u>
Nickerson & O'Day	Estimator	Randy Chute	989-7400	rchute@nickoday.com
Kennebec Cooling & Heating	owner	Anthony Michael	207-299-7426	KennebecHVAC@gmail.com
Lakeside Concrete Cutting + Abatement	Owner	Ryan Peters	207 773 1276	estimating@lakesideap.com
CIAMBRO CORP.	ESTIMATOR & MGR.	Tom Figura	207 679-2284	tfigura@ciambro.com
EnviroVantage	Sales	mark martin	603-583-1228	markm@EnviroVantage.com
CIAMBRO	ESTIMATING	TOBY DESMARCE	207-614-4347	Tdesmar@ciambro.com
RJ Enterprises, Inc	pres	Liz Storer	2073770744	info@rjenterprisesinc.net
ATLANTIC ENVIRONMENTAL	P.M	PETER JARBUSCH	202-240-6243	PJARBUSCH@ACHEMET
Doten's Construction	Estimator	Tyler Coffin	207-233-9005	Tyler@dotens.com

00 11 13
Notice to Contractors

Ray Building Renovation

PT 3106

The project is for a major renovation to the Ray Building of approximately 60,000 SF across four floors. The existing masonry structure is a contributing building located in the Augusta Mental Health Institute (AMHI) Historic District, which is listed on the National Register of Historic Places. The renovation consists of interior space reconfiguration; interior finish upgrades; mechanical, electrical, and plumbing systems upgrades; addition of a fire sprinkler system; foodservice equipment; thermal envelope upgrades; asbestos abatement; exterior masonry repairs; and site/civil and structural repairs. Interior spaces include office space, break rooms, restrooms and locker rooms, meeting spaces, a biology/water laboratory, file storage areas, and a commercial kitchen with dining area. Submit Requests for Information by email to lorrie.picard@woodplc.com by 2:00 PM on 19 April 2022.

The cost of the work is approximately \$ 12,000,000. The work to be performed under this contract shall be completed on or before the Final Completion date of *31 October 2023*.

1. Submit bids on a completed Contractor Bid Form, plus bid security when required, all scanned and included as an attachment to an email with the subject line marked "**Bid for Ray Building Renovation**" and addressed to the Bid Administrator at: BGS.Architect@Maine.gov, so as to be received no later than **2:00:00 p.m. on 6 May 2022**.

Bid submissions will be opened and read aloud at the time and date noted above at the Bureau of General Services office, accessible as a video conference call. Those who wish to participate in the call must submit a request for access to BGS.Architect@Maine.gov.

Any bid received after the noted time will not be considered a valid bid and will remain unopened. Any bid submitted by any other means will not be considered a valid bid. The Bid Administrator may require the Bidder to surrender a valid paper copy of the bid form or the bid security document in certain circumstances.

Questions on the bid opening process shall be addressed to the Bid Administrator: Jill Instasi, Bureau of General Services, 77 State House Station, Augusta, Maine 04333-0077, BGS.Architect@Maine.gov.

2. The bid shall be submitted on the Contractor Bid Form (section 00 41 13) provided in the Bid Documents. The Owner reserves the right to accept or reject any or all bids as may best serve the interest of the Owner.
3. Bid security *is required* on this project. If noted above as required, the Bidder shall include a satisfactory Bid Bond (section 00 43 13) or a certified or cashier's check for 5% of the bid amount with the completed bid form submitted to the Owner. The Bid Bond form is available on the BGS website.
4. Performance and Payment Bonds *are required* on this project. If noted above as required, or if any combination of Base Bid and Alternate Bids amounts selected in the award of the contract exceeds \$125,000.00, the selected Contractor shall furnish a 100% contract Performance Bond (section 00 61 13.13) and a 100% contract Payment Bond (section 00 61 13.16) in the contract amount to cover the execution of the Work. Bond forms are available on the BGS website.

00 11 13
Notice to Contractors

5. Filed Sub-bids *are not required* on this project.
6. There *are no* Pre-qualified General Contractors on this project.
If Pre-qualified General Contractors are identified for this project, the name of each company, with their city and state, are listed below.
7. An on-site pre-bid conference *will* be conducted for this project.
If a pre-bid conference is scheduled, it is *mandatory* for General Contractors and optional for Subcontractors and suppliers. Contractors who arrive late or leave early for a mandatory meeting may be prohibited from participating in this meeting and bidding. *Pre-bid conference will be conducted Tuesday, 12 April 2022 @ 10:00 am at the Ray Building, Tyson Drive, Augusta, Maine.*
8. Bid Documents - full sets only - will be available on or about *31 March 2022* and may be obtained *electronically or as printed sets purchased at cost* from:
Xpress Copy Plan Room
17 Westfield Street
Portland, ME 04101
(207) 775-2444 <https://www.xpressplanroom.com>
9. Bid Documents may be examined at:

<i>AGC Maine</i>	<i>Construction Summary</i>
<i>188 Whitten Road</i>	<i>734 Chestnut Street</i>
<i>Augusta, ME 04330</i>	<i>Manchester, NH 03104</i>
<i>Phone 207-622-4741 Fax 207-622-1625</i>	<i>Phone 603-627-8856 Fax 603-627-4524</i>

SECTION 072119 - FOAMED-IN-PLACE INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Closed-cell spray polyurethane foam insulation.
2. Accessories.

B. Related Requirements:

1. Section 072100 "Thermal Insulation" for foam-plastic board insulation.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Test and Evaluation Reports:

1. Product Test Reports: For each product, for tests performed by qualified testing agency.
2. Research Reports: For spray-applied polyurethane foam-plastic insulation, from ICC-ES.

B. Field Quality-Control Submittals:

1. Field quality-control reports.

C. Qualification Statements: For Installer.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

PART 2 - PRODUCTS

2.1 CLOSED-CELL SPRAY POLYURETHANE FOAM INSULATION

- A. Closed-Cell Spray Polyurethane Foam: ASTM C1029, Type II, minimum density of 2.5 lb/cu. ft. and a maximum density of 3.5 lb/cu ft. with a ~~and~~ minimum aged R-value at 1-inch thickness of 6.2 deg F x h x sq. ft./Btu at 75 deg F.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carlisle Spray Foam Insulation; Carlisle Construction Materials.
 - b. Gaco Western LLC.
 - c. Henry Company.
 - d. HUNTSMAN BUILDING SOLUTIONS (formerly Demilec, Icynene, Lapolla).
 - e. Icynene-Lapolla; Icynene.
 - f. Johns Manville; a Berkshire Hathaway company.
 - g. Master Builders Solutions.
 - h. NCFI Polyurethanes; a division of Barnhardt Manufacturing Company.
 - i. SWD Urethane Company.
 - j. Volatile Free, Inc.
2. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - a. Flame-Spread Index: 25 or less.
 - b. Smoke-Developed Index: 450 or less.
3. Fire Propagation Characteristics: Passes NFPA 285 and NFPA 276 testing as part of an approved assembly.

2.2 ACCESSORIES

- A. Primer: Material recommended by insulation manufacturer where required for adhesion of insulation to substrates.
- B. Thermal Barrier: Material barrier intended to prevent flame-source access to foam and delay temperature-rise of foam during a fire event.
 1. Gypsum Wallboard: 0.5-inch minimum thickness.
 2. Materials tested in accordance with and complying with acceptance criteria of both the Temperature Transmission Fire Test and the Integrity Fire Test of NFPA 275.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Verify that substrates are clean, dry, and free of substances that are harmful to insulation.
- B. Priming: Prime substrates where recommended by insulation manufacturer. Apply primer to comply with insulation manufacturer's written instructions. Confine primers to areas to be insulated; do not allow spillage or migration onto adjoining surfaces.

3.2 INSTALLATION

- A. Comply with insulation manufacturer's written instructions applicable to products and applications.
- B. Spray insulation to envelop entire area to be insulated and fill voids.
- C. Apply in multiple passes to not exceed maximum thicknesses recommended by manufacturer. Do not spray into rising foam.
- D. Framed Construction: Install into cavities formed by framing members to achieve thickness indicated on Drawings.
- E. Cavity Walls: Install into cavities as indicated on Drawings.
- F. Miscellaneous Voids: Apply according to manufacturer's written instructions.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect spray foam insulation installation, including accessories. Report results in writing.

3.4 PROTECTION

- A. Protect installed insulation from damage due to harmful weather exposures, physical abuse, and other causes.

END OF SECTION 072119

SECTION 085200 - WOOD WINDOWS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes aluminum-clad wood windows.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
 - 2. Review, discuss, and coordinate the interrelationship of wood windows with other exterior wall components. Include provisions for anchoring, flashing, weeping, sealing perimeters, and protecting finishes.
 - 3. Review and discuss the sequence of work required to construct a watertight and weathertight exterior building envelope.
 - 4. Inspect and discuss the condition of substrate and other preparatory work performed by other trades.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, glazing and fabrication methods, dimensions of individual components and profiles, hardware, and finishes for wood windows.
- B. Shop Drawings: For wood windows.
 - 1. Include plans, elevations, sections, hardware, accessories, insect screens, operational clearances, and details of installation, including anchor, flashing, and sealant installation.
- C. Samples for Initial Selection: For units with factory-applied finishes.
 - 1. Include Samples of hardware and accessories involving color selection.
- D. Samples for Verification: For wood windows and components required, prepared on Samples of size indicated below:

1. Exposed Finishes: 2 by 4 inches.
2. Exposed Hardware: Full-size units.

E. Product Schedule: For wood windows. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Product Test Reports: For each type of wood window, for tests performed by a qualified testing agency.
- C. Field quality-control reports.
- D. Sample Warranties: For manufacturer's warranties.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An installer acceptable to wood window manufacturer for installation of units required for this Project.
- B. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
 1. Existing, previously replaced windows are to act as mockups for new window assemblies.

1.7 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace wood windows that fail in materials or workmanship within specified warranty period.
 1. Failures include, but are not limited to, the following:
 - a. Failure to meet performance requirements.
 - b. Structural failures including excessive deflection, water leakage, and air infiltration.
 - c. Faulty operation of movable sash and hardware.
 - d. Deterioration of materials and finishes beyond normal weathering.
 - e. Failure of insulating glass.
 2. Warranty Period:
 - a. Window: 10 years from date of Substantial Completion.
 - b. Glazing Units: 10 years from date of Substantial Completion.
 - c. Aluminum-Cladding Finish: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Obtain wood windows from single source from single manufacturer. Window to match existing, previously replaced, historically approved windows.

1. Basis of Design Products:

a. Marvin ~~Ultimate-Custom~~ Double Hung

- 1) Dimensions as listed on drawings
- 2) Cladding: Aluminum Cladding color: White
- 3) 7/8" Low-E argon insulating glass
- 4) ~~7/8" white~~ White simulated divided lite muntions on both exterior and interior sides of the windows with spacer bars, profile and other dimensions to match existing.
- 5) Interior finish: Factory painted white
- 6) Interior casing: New painted 4" x 5/4" beech hardwood trim (prime and 2 coats)
- 7) Exterior casing: Custom clad exterior casing to match existing ~~(Ridgeland-A1446).~~ Verify profile in field
- 8) Screen: Painted aluminum screen Screen color: White
- 9) Jamb liner color: White
- 10) Window Hardware: Brass sash lock, routed finger pulls,
- 11) Installed installation brackets, 5 9/16" jamb depth
- 12) Applied custom exterior casing at sides and head and 2" frame expander (jamb extension)
- 13) Sash, meeting rails and jamb profile to match existing
- 14) Provide 1/4" Tremco Incorporated Spectrem 1 silicone sealant joint with appropriate backer rod at all four edges of window's perimeter. Provide pressure treated blocking in the dimensions required to shim window plumb. Foam shim space with non-expanding foam.

b. Marvin ~~Ultimate-Custom~~ Fixed / Picture

- 1) Dimensions as listed on drawings
 - 2) Cladding: Aluminum Cladding color: White
 - 3) 7/8" Low-E argon insulating glass
 - 4) ~~7/8" white~~ White simulated divided lite muntions on both exterior and interior sides of the windows with spacer bars, profile and other dimensions to match existing.
- a) Spacing as shown on drawings, and is to match existing installed window on east elevation, as shown on drawings.
- 5) Interior finish: Factory painted white
 - 6) Interior casing: New painted 4" x 5/4" beech hardwood trim (prime and 2 coats)

- 7) Exterior casing: Custom clad exterior casing to match existing. (~~Ridgeland-A1446~~) Verify profile in field
- 8) Screen: Painted aluminum screen Screen color: White
- 9) Jamb liner color: White
- 10) Window Hardware: Brass sash lock, routed finger pulls,
- 11) Installed installation brackets, 5 9/16" jamb depth
- 12) Applied custom exterior casing at sides and head and 2" frame expander (jamb extension)
- 13) Sash, meeting rails and jamb profile to match existing
- 14) Provide 1/4" Tremco Incorporated Spectrem 1 silicone sealant joint with appropriate backer rod at all four edges of window's perimeter. Provide pressure treated blocking in the dimensions required to shim window plumb. Foam shim space with non-expanding foam.

2.2 WINDOW PERFORMANCE REQUIREMENTS

- A. Product Standard: Comply with AAMA/WDMA/CSA 101/I.S.2/A440 for definitions and minimum standards of performance, materials, components, accessories, and fabrication unless more stringent requirements are indicated.
 1. Window Certification: WDMA certified with label attached to each window.

2.3 FABRICATION

- A. Fabricate wood windows in sizes indicated. Include a complete system for installing and anchoring windows.
- B. Glaze wood windows in the factory.
- C. Weather strip each operable sash to provide weathertight installation.
- D. Mullions: Provide mullions and cover plates, matching window units, complete with anchors for support to structure and installation of window units. Allow for erection tolerances and provide for movement of window units due to thermal expansion and building deflections. Provide mullions and cover plates capable of withstanding design wind loads of window units.
- E. Complete fabrication, assembly, finishing, hardware application, and other work in the factory to greatest extent possible. Disassemble components only as necessary for shipment and installation. Allow for scribing, trimming, and fitting at Project site.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine openings, substrates, structural support, anchorage, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

- B. Verify rough opening dimensions, levelness of sill plate, and operational clearances.
- C. Examine wall flashings, vapor retarders, water and weather barriers, and other built-in components to ensure weathertight window installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with manufacturer's written instructions for installing windows, hardware, accessories, and other components. For installation procedures and requirements not addressed in manufacturer's written instructions, comply with installation requirements in ASTM E2112.
- B. Install windows level, plumb, square, true to line, without distortion, anchored securely in place to structural support, and in proper relation to wall flashing and other adjacent construction to produce weathertight construction.

3.3 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
 - 1. Testing and inspecting agency will interpret tests and state in each report whether tested work complies with or deviates from requirements.
- B. Testing Services: Testing and inspecting of installed windows shall take place as follows:
 - 1. Testing Methodology: Testing of windows for air infiltration and water resistance shall be performed according to AAMA 502.
 - 2. Air-Infiltration Testing:
 - a. Test Pressure: That required to determine compliance with AAMA/WDMA/CSA 101/I.S.2/A440 performance class indicated.
 - b. Allowable Air-Leakage Rate: 1.5 times the applicable AAMA/WDMA/CSA 101/I.S.2/A440 rate for product type and performance class rounded down to one decimal place.
 - 3. Water-Resistance Testing:
 - a. Test Pressure: Two-thirds times test pressure required to determine compliance with AAMA/WDMA/CSA 101/I.S.2/A440 performance grade indicated.
 - b. Allowable Water Infiltration: No water penetration.
 - 4. Testing Extent: Three windows of each type as selected by Architect and a qualified independent testing and inspecting agency. Windows shall be tested after perimeter sealants have cured.
 - 5. Test Reports: Prepared according to AAMA 502.
- C. Windows will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.4 ADJUSTING, CLEANING, AND PROTECTION

- A. Adjust operating sashes and hardware for a tight fit at contact points and weather stripping for smooth operation and weathertight closure.
- B. Clean exposed surfaces immediately after installing windows. Remove excess sealants, glazing materials, dirt, and other substances.
 - 1. Keep protective films and coverings in place until final cleaning.
- C. Remove and replace sashes if glass has been broken, chipped, cracked, abraded, or damaged during construction period.
- D. Protect window surfaces from contact with contaminating substances resulting from construction operations. If contaminating substances do contact window surfaces, remove contaminants immediately according to manufacturer's written instructions.

END OF SECTION 085200

SECTION 230923 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SCOPE OF WORK SUMMARY

- A. General: The control system shall consist of a high-speed, peer-to-peer network of DDC controllers, a control system server, and a web-based operator interface. The control system shall be seamlessly integrated with the State of Maine Building Control Center (BCC) which provides 24 hours a day, 7 days a week, 365 days a year monitoring of state facilities. The HVAC controls shall be an extension of the existing Honeywell Enterprise Building Integrator (EBI) with host server hardware located in Augusta Maine. The Building Automation System (BAS) shall enable monitoring and control of mechanical systems installed under the scope of this project through the BCC. Integration of HVAC system, panels, associated devices, front-end programming and graphics are proprietary to Honeywell International Inc.
- B. Graphics package shall be 5 star or better graphics to include detailed graphics customized for this building showing all controlled equipment, device and sensor locations, and building floor plans indicating HVAC zones and current temperature and humidity conditions as applicable.
- C. Section Includes, but not necessarily limited to the following:
 - 1. DDC system for monitoring and controlling of HVAC systems.
 - 2. Delivery of selected control devices to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.
 - 3. Integration into existing Honeywell system for State of Maine.
 - 4. Air temperature sensors.
 - 5. Air temperature switches.
 - 6. Combination air temperature sensors and switches.
 - 7. Air temperature RTD transmitters.
- D. Related Requirements: Electrical wiring and installation shall be in accordance with NEC and Division 26 specifications. Specific references include:
 - 1. Section 260553 "Identification for Electrical Systems" for identification requirements for electrical components.

1.3 DEFINITIONS

- A. BACnet Specific Definitions:

1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data over and services over a network.
 2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
 3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
 4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.
 5. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.
- B. COV: Changes of value.
- C. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.
- D. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.
- E. DOCSIS: Data-Over Cable Service Interface Specifications.
- F. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.
- G. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.
- H. LAN: Local area network.
- I. LNS: LonWorks Network Services.
- J. Modbus TCP/IP: An open protocol for exchange of process data.
- K. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.
- L. MTBF: Mean time between failures.
- M. POT: Portable operator's terminal.
- N. PUE: Performance usage effectiveness.

- O. RAM: Random access memory.
- P. RF: Radio frequency.
- Q. Server: Computer used to maintain system configuration, historical and programming database.
- R. TCP/IP: Transport control protocol/Internet protocol.
- S. UPS: Uninterruptible power supply.
- T. USB: Universal Serial Bus.
- U. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.
- V. VAV: Variable air volume.
- W. WLED: White light emitting diode.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.5 ACTION SUBMITTALS

- A. Controls submittal shall be one integrated comprehensive submittal to include the requirements listed in this paragraph.
- B. Multiple Submissions:
 - 1. If multiple submissions are required to execute work within schedule, first submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission.
 - 2. Clearly identify each submittal requirement indicated and in which submission the information will be provided.
 - 3. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.
- C. Product Data: For each type of product include the following:
 - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
 - 3. Product description with complete technical data, performance curves, and product specification sheets.

4. Installation, operation and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
 - a. Gateways.
 - b. Routers.
 - c. Protocol analyzers.
 - d. DDC controllers.
 - e. Enclosures.
 - f. Electrical power devices.
 - g. UPS units.
 - h. Accessories.
 - i. Instruments.
 - j. Control dampers and actuators.
 - k. Control valves and actuators.
6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

D. Software Submittal:

1. Cross-referenced listing of software to be loaded on each operator workstation, server, gateway, and DDC controller.
2. Description and technical data of all software provided, and cross-referenced to products in which software will be installed.
3. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
4. Listing and description of each engineering equation used with reference source.
5. Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.
6. Description of operator interface to alphanumeric and graphic programming.
7. Description of each network communication protocol.
8. Description of system database, including all data included in database, database capacity and limitations to expand database.
9. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies.

E. Shop Drawings:

1. General Requirements:
 - a. Include cover drawing with Project name, location, Owner, Architect, Contractor and issue date with each Shop Drawings submission.
 - b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
2. Include plans, elevations, sections, and mounting details where applicable.

3. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Plan Drawings indicating the following:
 - a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork, and piping.
 - b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
 - c. Each desktop workstation, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
 - d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
 - e. Network communication cable and raceway routing.
 - f. Information, drawn to scale, of 1/4 inch to 1/2 inch.
 - g. Proposed routing of wiring, cabling, conduit, and tubing, coordinated with building services for review before installation.
5. Schematic drawings for each controlled HVAC system indicating the following:
 - a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
 - b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
 - c. A graphic showing location of control I/O in proper relationship to HVAC system.
 - d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
 - e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
 - f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays, and interface to DDC controllers.
 - g. Narrative sequence of operation.
6. Control panel drawings indicating the following:
 - a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
 - b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates, and allocated spare space.
 - c. Front, rear, and side elevations and nameplate legend.
 - d. Unique drawing for each panel.
7. DDC system network riser diagram indicating the following:
 - a. Each device connected to network with unique identification for each.
 - b. Interconnection of each different network in DDC system.
 - c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.

- d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.
8. DDC system electrical power riser diagram indicating the following:
 - a. Each point of connection to field power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
 - b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
 - c. Each product requiring power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
 - d. Power wiring type and size, race type, and size for each.
 9. Monitoring and control signal diagrams indicating the following:
 - a. Control signal cable and wiring between controllers and I/O.
 - b. Point-to-point schematic wiring diagrams for each product.

F. System Description:

1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
2. Complete listing and description of each report, log and trend for format and timing, and events which initiate generation.
3. System and product operation under each potential failure condition including, but not limited to, the following:
 - a. Loss of power.
 - b. Loss of network communication signal.
 - c. Loss of controller signals to inputs and outpoints.
 - d. Operator workstation failure.
 - e. Server failure.
 - f. Gateway failure.
 - g. Network failure
 - h. Controller failure.
 - i. Instrument failure.
 - j. Control damper and valve actuator failure.
4. Complete bibliography of documentation and media to be delivered to Owner.
5. Description of testing plans and procedures.
6. Description of Owner training.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. Systems Provider Qualification Data:

- a. Resume of project manager assigned to Project.
 - b. Resumes of application engineering staff assigned to Project.
 - c. Resumes of installation and programming technicians assigned to Project.
 - d. Resumes of service technicians assigned to Project.
 - e. Brief description of past project including physical address, floor area, number of floors, building system cooling and heating capacity, and building's primary function.
 - f. Description of past project DDC system, noting similarities to Project scope and complexity indicated.
 - g. Names of staff assigned to past project that will also be assigned to execute work of this Project.
- B. Product Test Reports: For each product that requires testing to be performed by manufacturer.
- C. Field quality-control reports.
- D. Sample Warranty: For manufacturer's warranty.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For DDC system to include in emergency, operation, and maintenance manuals.
1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
 - b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
 - c. As-built versions of submittal Product Data.
 - d. Names, addresses, e-mail addresses, and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
 - e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
 - f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
 - g. Engineering, installation, and maintenance manuals that explain how to:
 - 1) Design and install new points, panels, and other hardware.
 - 2) Perform preventive maintenance and calibration.
 - 3) Debug hardware problems.
 - 4) Repair or replace hardware.
 - h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
 - i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.

- j. List of recommended spare parts with part numbers and suppliers.
- k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
- l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
- m. Licenses, guarantees, and warranty documents.
- n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
- o. Owner training materials.

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.9 QUALITY ASSURANCE

- A. DDC System Manufacturer Qualifications:
 - 1. System manufacturer shall be Honeywell and compatible with existing State of Maine BAS controls.
- B. DDC System Provider Qualifications:
 - 1. Authorized representative of, and trained by, DDC system manufacturer.
 - 2. In-place facility located within 50 miles of Project.
 - 3. Demonstrated past experience with installation of DDC system products being installed for period within three consecutive years before time of bid.
 - 4. Each person assigned to Project shall have demonstrated past experience.
 - 5. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
 - 6. Service and maintenance staff assigned to support Project during warranty period.
 - 7. Product parts inventory to support on-going DDC system operation for a period of not less than 5 years after Substantial Completion.

1.10 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.
 - 1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
 - 2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.
 - a. Install updates only after receiving Owner's written authorization.

3. Warranty service shall occur during normal business hours and commence within 24 hours of Owner's warranty service request.
4. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 DDC SYSTEM MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, ~~provide products by one of the following:~~ available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Honeywell International Inc.
2. JCI – Johnson Controls.
3. Trane.
4. Automated logic.
5. Alerton.
6. Other qualified contractors that provide BACnet control systems that meet this specification.

- ~~1.B.~~ Acceptable BAS manufacturers must fully interface with the existing State of Maine Honeywell EBI system.

2. ~~Sensors, actuators, transformers, enclosures, and other control components as selected by Honeywell.~~

2.2 DDC SYSTEM DESCRIPTION

- A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.

1. DDC system shall consist of a peer-to-peer network of distributed DDC controllers, operator interfaces, and software.

- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 WEB ACCESS

- A. DDC system shall be web based.

1. Web-Based Access to DDC System:

- a. DDC system software shall be based on server thin-client architecture, designed around open standards of web technology. DDC system server shall be accessed using a web browser over DDC system network, using Owner's LAN, and remotely over Internet through Owner's LAN.

- b. Intent of thin-client architecture is to provide operators complete access to DDC system via a web browser. No special software other than a web browser shall be required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
- c. Web access shall be password protected.

2.4 PERFORMANCE REQUIREMENTS

A. DDC system shall be designed to satisfy requirements indicated.

1. System Performance Objectives:

- a. DDC system shall manage and control all other HVAC systems other than VRF systems.
- b. DDC system shall interface with VRF system controllers to provide a graphics window into VRF system component status, space temperatures and setpoints, but shall not directly control VRF systems. VRF systems have their own controls that directly control VRF system components.
- c. DDC system control shall operate HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
- d. DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
- e. DDC system shall operate while unattended by an operator and through operator interaction.
- f. DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.

B. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

- 1. Flame-Spread Index: 25 or less.
- 2. Smoke-Developed Index: 50 or less.

C. DDC System Speed:

1. Response Time of Connected I/O:

- a. AI point values connected to DDC system shall be updated at least every two seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
- b. BI point values connected to DDC system shall be updated at least every two seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
- c. AO points connected to DDC system shall begin to respond to controller output commands within one second. Global commands shall also comply with this requirement.
- d. BO point values connected to DDC system shall respond to controller output commands within one second. Global commands shall also comply with this requirement.

2. Display of Connected I/O:
 - a. Analog point COV connected to DDC system shall be updated and displayed at least every five seconds for use by operator.
 - b. Binary point COV connected to DDC system shall be updated and displayed at least every five seconds for use by operator.
 - c. Alarms of analog and digital points connected to DDC system shall be displayed within 30 seconds of activation or change of state.
 - d. Graphic display refresh shall update within four seconds.
 - e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations shall not exceed graphic refresh rate indicated.

- D. Network Bandwidth: Design each network of DDC system to include at least 30 percent available spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions.

- E. DDC System Data Storage:
 1. Include capability to archive not less than 24 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends and other information indicated.
 2. Local Storage:
 - a. Use storage on existing server or workstation. Server(s) shall use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.

- F. DDC Data Access:
 1. When logged into the system, operator shall be able to also interact with any DDC controller connected to DDC system as required for functional operation of DDC system.
 2. System(s) shall be used for application configuration; for archiving, reporting and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.

- G. Input Point Displayed Accuracy: Input point displayed values shall meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.
 1. Energy:
 - a. Electric Power: Within 1 percent of reading.
 - b. Requirements indicated on Drawings for meters not supplied by utility.
 2. Flow:
 - a. Air: Within 5 percent of design flow rate.
 - b. Air (Terminal Units): Within 10 percent of design flow rate.

- c. Water: Within 5 percent of design flow rate.
 - 3. Gas:
 - a. Carbon Dioxide: Within 50 ppm.
 - b. Refrigerant: Within 50 ppm.
 - 4. Moisture (Relative Humidity):
 - a. Air: Within 5 percent RH.
 - b. Space: Within 5 percent RH.
 - c. Outdoor: Within 5 percent RH.
 - 5. Pressure:
 - a. Air, Ducts and Equipment: 1 percent of instrument range.
 - b. Space: Within 1 percent of instrument range.
 - c. Water: Within 1 percent of instrument range.
 - 6. Speed: Within 5 percent of reading.
 - 7. Temperature, Dew Point:
 - a. Air: Within 1 deg F.
 - b. Space: Within 1 deg F.
 - c. Outdoor: Within 2 deg F.
 - 8. Temperature, Dry Bulb:
 - a. Air: Within 1 deg F.
 - b. Space: Within 1 deg F.
 - c. Outdoor: Within 1 deg F.
 - d. Energy Recovery Runaround Liquid: Within 1 deg F.
 - e. Temperature Difference: Within 0.5 deg F.
 - 9. Temperature, Wet Bulb:
 - a. Air: Within 0.5 deg F.
 - b. Space: Within 0.5 deg F.
 - c. Outdoor: Within 1 deg F.
- H. Precision of I/O Reported Values: Values reported in database and displayed shall have following precision:
 - 1. Current:
 - a. Milliamperes: Nearest 1/100th of a milliampere.
 - b. Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.
 - 2. Energy:

- a. Electric Power:
 - 1) Rate (Watts): Nearest 1/10th of a watt through 1000 W.
 - 2) Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
 - 3) Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.
3. Flow:
 - a. Air: Nearest 1/10th of a cfm through 100 cfm; nearest cfm between 100 and 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm.
 - b. Water: Nearest 1/10th gpm through 100 gpm; nearest gpm between 100 and 1000 gpm.
4. Gas:
 - a. Carbon Dioxide (ppm): Nearest ppm.
 - b. Refrigerant (ppm): Nearest ppm.
5. Moisture (Relative Humidity):
 - a. Relative Humidity (Percentage): Nearest 1 percent.
6. Position, Dampers and Valves (Percentage Open): Nearest 1 percent.
7. Pressure:
 - a. Air, Ducts and Equipment: Nearest 1/10th in. w.c..
 - b. Space: Nearest 1/100th in. w.c..
 - c. Water: Nearest 1/10 psig through 100 psig; nearest psig above 100 psig.
8. Temperature:
 - a. Air, Ducts and Equipment: Nearest 1/10th of a degree.
 - b. Outdoor: Nearest degree.
 - c. Space: Nearest 1/10th of a degree.
 - d. Heat Recovery Runaround: Nearest 1/10th of a degree.
9. Voltage: Nearest 1/10 volt up to 100 V; nearest volt above 100 V.
- I. Environmental Conditions for Controllers, Gateways, and Routers:
 1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.
 - a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.

2. Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:
 - a. Outdoors, Protected: Type 3.
 - b. Outdoors, Unprotected: Type 4.
 - c. Indoors: Type 1.
 - d. Mechanical Equipment Rooms:
 - 1) Mechanical Room 008: Type 4.
 - 2) Air-Moving Equipment Rooms: Type 2.
 - e. Localized Areas Exposed to Washdown: Type 4.

J. Electric Power Quality:

1. Power-Line Surges:
 - a. Protect DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.
 - b. Do not use fuses for surge protection.
 - c. Test protection in the normal mode and in the common mode, using the following two waveforms:
 - 1) 10-by-1000-mic.sec. waveform with a peak voltage of 1500 V and a peak current of 60 A.
 - 2) 8-by-20-mic.sec. waveform with a peak voltage of 1000 V and a peak current of 500 A.
2. Power Conditioning:
 - a. Protect DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner shall be as follows:
 - 1) At 85 percent load, output voltage shall not deviate by more than plus or minus 1 percent of nominal when input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.
 - 2) During load changes from zero to full load, output voltage shall not deviate by more than plus or minus 3 percent of nominal.
 - 3) Accomplish full correction of load switching disturbances within five cycles, and 95 percent correction within two cycles of onset of disturbance.
 - 4) Total harmonic distortion shall not exceed 3-1/2 percent at full load.
3. Ground Fault: Protect products from ground fault by providing suitable grounding. Products shall not fail due to ground fault condition.

K. Backup Power Source:

1. HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.

L. UPS:

1. DDC system products powered by UPS units shall include the following:
 - a. DDC controllers.

M. Continuity of Operation after Electric Power Interruption:

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

2.5 SOLENOID VALVES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. ASCO Valve, Inc.

B. Description:

1. Action: Either normally open or normally closed in the event of electrical power failure as required by the application.
2. Size to close against the system pressure.
3. Manual override capable.
4. Heavy-duty assembly.
5. Body: Brass.
6. Seats and Discs: NBR or PTFE.
7. Solenoid Enclosure: NEMA 250, Type 4.

2.6 ELECTRIC AND ELECTRONIC CONTROL DAMPER ACTUATORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following::

1. Belimo Aircontrols (USA), Inc.
2. Honeywell Building Solutions; Honeywell International, Inc.

B. Type: Motor operated, with or without gears, electric and electronic.

C. Voltage:

1. Provide 24 V actuators for dampers less than 36 inch and as possible. Use of 120 V actuators is acceptable for larger dampers with higher power requirements.
2. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
3. Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.

D. Construction:

1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

E. Field Adjustment:

1. Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.
2. Provide external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.

F. Two-Position Actuators: Single direction, spring return.

G. Modulating Actuators:

1. Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:
 - a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position, and other input drives actuator to close position. No signal of either input remains in last position.
 - b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10- or 2- to 10-V dc and 4- to 20-mA signals.

H. Position Feedback:

1. Equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
2. Equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

I. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.

2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

J. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

K. Damper Attachment:

1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.
4. The end of the damper shaft shall be marked with a line indicating the damper blade orientation.

L. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

M. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with a heater and controller where required by application.

N. Stroke Time:

1. Operate damper from fully closed to fully open within 90 seconds.
2. Operate damper from fully open to fully closed within 90 seconds.
3. Move damper to failed position within 90 seconds.
4. Select operating speed to be compatible with equipment and system operation.
5. Actuators operating in smoke control systems comply with governing code and NFPA requirements.

O. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

2.7 SYSTEM ARCHITECTURE

- A. System architecture shall consist of no more than two levels of LANs.
 - 1. Level one LAN shall connect network controllers and operator workstations.
 - 2. Level two LAN shall connect equipment to network controllers.
- B. Minimum Data Transfer and Communication Speed:
 - 1. LAN Level 1: 100 Mbps.
 - 2. LAN Level 2: 38,400 bps.
- C. DDC system shall consist of dedicated LANs that are not shared with other building systems and tenant data and communication networks.
- D. System architecture shall be modular and have inherent ability to expand to not less than two times system size indicated with no impact to performance indicated.
- E. System architecture shall perform modifications without having to remove and replace existing network equipment.
- F. Number of LANs and associated communication shall be transparent to operator. All I/O points residing on any LAN shall be capable of global sharing between all system LANs.
- G. System design shall eliminate dependence on any single device for system alarm reporting and control execution. Each controller shall operate independently by performing its' own control, alarm management and historical data collection.
- H. Special Network Architecture Requirements:
 - 1. Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and VAV terminal units, include a dedicated LAN of application-specific controllers serving VAV terminal units connected directly to controller that is controlling air-handling system air-handling unit(s). Basically, create a DDC system LAN that aligns with air-handling system being controlled.

2.8 DDC SYSTEM OPERATOR INTERFACES

- A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:
 - 1. BCC.
 - 2. Portable operator terminal or workstation with hardwired connection through LAN port.
 - 3. Remote connection through web access.
- B. Access to system, regardless of operator means used, shall be transparent to operator.
- C. Network Ports: For hardwired connection of desktop or portable workstation. Network port shall be easily accessible, properly protected, clearly labeled, and installed at the following locations:

1. Each mechanical equipment room.
2. Attic level in vicinity of VAHU-4.

D. Critical Alarm Reporting:

1. Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.
2. DDC system shall send alarm notification to multiple recipients that are assigned for each alarm.
3. DDC system shall notify recipients by any or all means, including e-mail, text message and prerecorded phone message to mobile and landline phone numbers.

E. Simultaneous Operator Use: Capable of accommodating up to five simultaneous operators that are accessing DDC system through any one of operator interfaces indicated.

2.9 NETWORKS

A. Acceptable networks for connecting workstations, mobile devices, and network controllers include the following:

1. IP.
2. IEEE 8802-3, Ethernet.

B. Acceptable networks for connecting programmable application controllers include the following:

1. IP.
2. IEEE 8802-3, Ethernet.

C. Acceptable networks for connecting application-specific controllers include the following:

1. EIA-485A.
2. IP.
3. IEEE 8802-3, Ethernet.

2.10 NETWORK COMMUNICATION PROTOCOL

A. Network communication protocol(s) used throughout entire DDC system shall be open to Owner and available to other companies for use in making future modifications to DDC system.

B. ASHRAE 135 Protocol:

1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.
2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.

3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
4. Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.

C. Industry Standard Protocols:

1. DDC system shall use any one or a combination of the following industry standard protocols for network communication while complying with other DDC system requirements indicated:
 - a. ASHRAE 135.
 - b. CEA-709.1-C.
 - c. Modbus Application Protocol Specification V1.1b.
2. Operator workstations and network controllers shall communicate through ASHRAE 135 protocol.
3. Portions of DDC system networks using ASHRAE 135 communication protocol shall be an open implementation of network devices complying with ASHRAE 135. Network devices shall be tested and listed by BACnet Testing Laboratories.
4. Portions of DDC system networks using Modbus Application Protocol Specification V1.1b communication protocol shall be an open implementation of network devices and technology complying with Modbus Application Protocol Specification V1.1b.
5. Gateways shall be used to connect networks and network devices using different protocols.

2.11 SERVERS

- A. Server functions shall be provided by the existing permanently installed computers at BCC.

2.12 SYSTEM SOFTWARE

A. System Software Minimum Requirements:

1. Real-time multitasking and multiuser 32- or 64-bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
2. Operating system shall be capable of operating DOS and Microsoft Windows applications.
3. Database management software shall manage all data on an integrated and non-redundant basis. Additions and deletions to database shall be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
4. Network communications software shall manage and control multiple network communications to provide exchange of global information and execution of global programs.

5. Operator interface software shall include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
6. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.

B. Operator Interface Software:

1. Operator interface shall conform to existing operator interface norms used for control of other buildings on the State of Maine Network
2. Minimize operator training through use of English language prorating and English language point identification.
3. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.
4. Operator sign-off shall be a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
5. Automatic sign-off period shall be programmable from one to 60 minutes in one-minute increments on a per operator basis.
6. Operator sign-on and sign-off activity shall be recorded and sent to printer.
7. Security Access:
 - a. Operator access to DDC system shall be under password control.
 - b. An alphanumeric password shall be field assignable to each operator.
 - c. Operators shall be able to access DDC system by entry of proper password.
 - d. Operator password shall be same regardless of which computer or other interface means is used.
 - e. Additions or changes made to passwords shall be updated automatically.
 - f. Each operator shall be assigned an access level to restrict access to data and functions the operator is cable of performing.
 - g. Software shall have at least five access levels.
 - h. Each menu item shall be assigned an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
 - i. Display menu items to operator with those capable of access highlighted. Menu and operator access level assignments shall be online programmable and under password control.
8. Data Segregation:
 - a. Include data segregation for control of specific data routed to a workstation, to an operator or to a specific output device, such as a printer.
 - b. Include at least 32 segregation groups.
 - c. Segregation groups shall be selectable such as "fire points," "fire points on second floor," "space temperature points," "HVAC points," and so on.
 - d. Points shall be assignable to multiple segregation groups. Display and output of data to printer or monitor shall occur where there is a match of operator or peripheral segregation group assignment and point segregations.
 - e. Alarms shall be displayed and printed at each peripheral to which segregation allows, but only those operators assigned to peripheral and having proper authorization level will be allowed to acknowledge alarms.

- f. Operators and peripherals shall be assignable to multiple segregation groups and all assignments are to be online programmable and under password control.
9. Operators shall be able to perform commands including, but not limited to, the following:
 - a. Start or stop selected equipment.
 - b. Adjust set points.
 - c. Add, modify, and delete time programming.
 - d. Enable and disable process execution.
 - e. Lock and unlock alarm reporting for each point.
 - f. Enable and disable totalization for each point.
 - g. Enable and disable trending for each point.
 - h. Override control loop set points.
 - i. Enter temporary override schedules.
 - j. Define holiday schedules.
 - k. Change time and date.
 - l. Enter and modify analog alarm limits.
 - m. Enter and modify analog warning limits.
 - n. View limits.
 10. Reporting:
 - a. Generated automatically and manually.
 - b. Sent to displays, printers and disk files.
 - c. Types of Reporting:
 - 1) General listing of points.
 - 2) List points currently in alarm.
 - 3) List of off-line points.
 - 4) List points currently in override status.
 - 5) List of disabled points.
 - 6) List points currently locked out.
 - 7) List of items defined in a "Follow-Up" file.
 - 8) List weekly schedules.
 - 9) List holiday programming.
 - 10) List of limits and deadbands.
 11. Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.

C. Graphic Interface Software:

1. The graphic interface shall be designed and installed by Honeywell EBI for the BCC system.
2. Graphic interface for the Ray Building shall have a similar look, feel, and operation as other controls in existing State of Maine buildings.
3. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.

4. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface shall use a pointing device with pull-down or penetrating menus, color and animation to facilitate operator understanding of system.
5. Include at least 10 levels of graphic penetration with the hierarchy operator assignable.
6. Descriptors for graphics, points, alarms and such shall be modified through operator's workstation under password control.
7. Graphic displays shall be online user definable and modifiable using the hardware and software provided.
8. Data to be displayed within a graphic shall be assignable regardless of physical hardware address, communication or point type.
9. Graphics are to be online programmable and under password control.
10. Points may be assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
11. Graphics shall also contain software points.
12. Penetration within a graphic hierarchy shall display each graphic name as graphics are selected to facilitate operator understanding.
13. Back-trace feature shall permit operator to move upward in the hierarchy using a pointing device. Back trace shall show all previous penetration levels. Include operator with option of showing each graphic full screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
14. Display operator accessed data on the monitor.
15. Operator shall select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Defined and linked graphic below that selection shall then be displayed.
16. Include operator with means to directly access graphics without going through penetration path.
17. Dynamic data shall be assignable to graphics.
18. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
19. Use color, rotation, or other highly visible means, to denote status and alarm states. Color shall be variable for each class of points, as chosen by operator.
20. Points shall be dynamic with operator adjustable update rates on a per point basis from one second to over a minute.
21. For operators with appropriate privilege, points shall be commanded directly from display using pointing device.
 - a. For an analog command point such as set point, current conditions and limits shall be displayed and operator can position new set point using pointing device.
 - b. For a digital command point such as valve position, valve shall show its current state such as open or closed and operator could select alternative position using pointing device.
 - c. Keyboard equivalent shall be available for those operators with that preference.
22. Operator shall be able to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot and other information on other quadrants on screen. This feature shall allow real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.
23. Help Features:

- a. On-line context-sensitive help utility to facilitate operator training and understanding.
 - b. Bridge to further explanation of selected keywords. Document shall contain text and graphics to clarify system operation.
 - 1) If help feature does not have ability to bridge on keywords for more information, a complete set of user manuals shall be provided in an indexed word-processing program, which shall run concurrently with operating system software.
 - c. Available for Every Menu Item:
 - 1) Index items for each system menu item.
24. Graphic generation software shall allow operator to add, modify, or delete system graphic displays.
- a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols.
 - b. Graphic development package shall use a pointing device in conjunction with a drawing program to allow operator to perform the following:
 - 1) Define background screens.
 - 2) Define connecting lines and curves.
 - 3) Locate, orient and size descriptive text.
 - 4) Define and display colors for all elements.
 - 5) Establish correlation between symbols or text and associated system points or other displays.
- D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:
1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.
 2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:
 - a. Room layouts with room identification and name.
 - b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
 - c. Location and identification of each hardware point being controlled or monitored by DDC system.
 3. Control schematic for each of following, including a graphic system schematic representation with point identification, set point and dynamic value indication, and sequence of operation.
 4. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.
 5. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, gateways, operator workstations, and other network devices.

E. Customizing Software:

1. Modifications to the DDC system graphics is done through the system integrator – Honeywell EBI.

F. Alarm Handling Software:

1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers.
2. Include first in, first out handling of alarms according to alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.
3. Alarm handling shall be active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.
4. Alarms display shall include the following:
 - a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
 - b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."
 - c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."
 - d. Include extended message capability to allow assignment and printing of extended action messages. Capability shall be operator programmable and assignable on a per point basis.
5. Alarms shall be directed to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.
6. Send e-mail alarm messages to designated operators.
7. Send e-mail, page, text and voice messages to designated operators for critical alarms.
8. Alarms shall be categorized and processed by class.
 - a. Class 1:
 - 1) Associated with fire, security and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.
 - 2) Unacknowledged alarms to be placed in unacknowledged alarm buffer.
 - 3) All conditions shall cause an audible sound and shall require individual acknowledgment to silence audible sound.
 - b. Class 2:
 - 1) Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
 - 2) Acknowledgement may be through a multiple alarm acknowledgment.
 - c. Class 3:

- 1) General alarms; printed, displayed and placed in unacknowledged alarm buffer queues.
 - 2) Each new alarm received shall cause an audible sound. Audible sound shall be silenced by "acknowledging" alarm or by pressing a "silence" key.
 - 3) Acknowledgement of queued alarms shall be either on an individual basis or through a multiple alarm acknowledgement.
 - 4) Alarms returning to normal condition shall be printed and not cause an audible sound or require acknowledgment.
- d. Class 4:
- 1) Routine maintenance or other types of warning alarms.
 - 2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.
9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator shall be able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.
10. To ensure that no alarm records are lost, it shall be possible to assign a backup printer to accept alarms in case of failure of primary printer.
- G. Reports and Logs shall be provided via the existing BCC system and shall include the following:
1. All I/O: With current status and values.
 2. Alarm: All current alarms, except those in alarm lockout.
 3. Disabled I/O: All I/O points that are disabled.
 4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
 5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
 6. Logs:
 - a. Alarm history.
 - b. System messages.
 - c. System events.
 - d. Trends.
- H. Standard Trends:
1. Trend all I/O point present values, set points, and other parameters indicated for trending.
 2. Trends shall be associated into groups, and a trend report shall be set up for each group.
 3. Trends shall be stored within DDC controller and uploaded to hard drives automatically on reaching 75 of DDC controller buffer limit, or by operator request, or by archiving time schedule.
 4. Preset trend intervals for each I/O point after review with Owner.
 5. Trend intervals shall be operator selectable from 10 seconds up to 60 minutes. Minimum number of consecutive trend values stored at one time shall be 100 per variable.
 6. When drive storage memory is full, most recent data shall overwrite oldest data.
 7. Archived and real-time trend data shall be available for viewing numerically and graphically by operators.

- I. Custom Trends: Operator shall be able to define a custom trend log for any I/O point in DDC system.
 1. Each trend shall include interval, start time, and stop time.
 2. Data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on workstation hard drives.
 3. Data shall be retrievable for use in spreadsheets and standard database programs.
- J. Programming Software:
 1. Include programming software as required to execute sequences of operation indicated.
- K. Database Management Software:
 1. Where a separate SQL database is used for information storage, DDC system shall include database management software that separates database monitoring and managing functions by supporting multiple separate windows.
 2. Database secure access shall be accomplished using standard SQL authentication including ability to access data for use outside of DDC system applications.
 3. Database management function shall include summarized information on trend, alarm, event, and audit for the following database management actions:
 - a. Backup.
 - b. Purge.
 - c. Restore.
 4. Database management software shall support the following:
 - a. Statistics: Display database server information and trend, alarm, event, and audit information on database.
 - b. Maintenance: Include method of purging records from trend, alarm, event and audit databases by supporting separate screens for creating a backup before purging, selecting database, and allowing for retention of a selected number of day's data.
 - c. Backup: Include means to create a database backup file and select a storage location.
 - d. Restore: Include a restricted means of restoring a database by requiring operator to have proper security level.
 5. Database management software shall include information of current database activity, including the following:
 - a. Ready.
 - b. Purging record from a database.
 - c. Action failed.
 - d. Refreshing statistics.
 - e. Restoring database.
 - f. Shrinking a database.
 - g. Backing up a database.
 - h. Resetting Internet information services.
 - i. Starting network device manager.

- j. Shutting down the network device manager.
 - k. Action successful.
- 6. Database management software monitoring functions shall continuously read database information once operator has logged on.
 - 7. Include operator notification through on-screen pop-up display and e-mail message when database value has exceeded a warning or alarm limit.
 - 8. Monitoring settings window shall have the following sections:
 - a. Allow operator to set and review scan intervals and start times.
 - b. E-mail: Allow operator to create and review e-mail and phone text messages to be delivered when a warning or an alarm is generated.
 - c. Warning: Allow operator to define warning limit parameters, set reminder frequency and link e-mail message.
 - d. Alarm: Allow operator to define alarm limit parameters, set reminder frequency and link e-mail message.
 - e. Database Login: Protect system from unauthorized database manipulation by creating a read access and a write access for each of trend, alarm, event and audit databases as well as operator proper security access to restore a database.
 - 9. Monitoring settings taskbar shall include the following informational icons:
 - a. Normal: Indicates by color and size, or other easily identifiable means that all databases are within their limits.
 - b. Warning: Indicates by color and size, or other easily identifiable means that one or more databases have exceeded their warning limit.
 - c. Alarm: Indicates by color and size, or other easily identifiable means that one or more databases have exceeded their alarm limit.

2.13 ASHRAE 135 GATEWAYS

- A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, outdoor condensing units and variable-speed drives.
- B. Include gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment, only when specifically requested and approved by Owner.
- C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.
- D. Gateway Minimum Requirements:
 - 1. Read and view all readable object properties on non-BACnet network to BACnet network and vice versa where applicable.
 - 2. Write to all writeable object properties on non-BACnet network from BACnet network and vice versa where applicable.

3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet and vice versa.
4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs according to ASHRAE 135.
5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
6. Backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

2.14 ASHRAE 135 PROTOCOL ANALYZER

- A. Analyzer and required cables and fittings for connection to ASHRAE 135 network.
- B. Analyzer shall include the following minimum capabilities:
 1. Capture and store to a file data traffic on all network levels.
 2. Measure bandwidth usage.
 3. Filtering options with ability to ignore select traffic.

2.15 DDC CONTROLLERS

- A. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.
- B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.
- C. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.
- D. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.
- E. Environment Requirements:
 1. Controller hardware shall be suitable for the anticipated ambient conditions.
 2. Controllers located in conditioned space shall be rated for operation at 32 to 120 deg F.
 3. Controllers located outdoors shall be rated for operation at minus 20 to 150 deg F.
- F. Power and Noise Immunity:
 1. Controller shall operate at 90 to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent of nominal voltage.
 2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.
- G. DDC Controller Spare Processing Capacity:

1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:
 - a. Network Controllers: 50 percent.
 - b. Programmable Application Controllers: Not less than 60 percent.
 - c. Application-Specific Controllers: Not less than 70 percent.
 2. Memory shall support DDC controller's operating system and database and shall include the following:
 - a. Monitoring and control.
 - b. Energy management, operation and optimization applications.
 - c. Alarm management.
 - d. Historical trend data of all connected I/O points.
 - e. Maintenance applications.
 - f. Operator interfaces.
 - g. Monitoring of manual overrides.
- H. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:
1. Network Controllers:
 - a. 10 percent of each AI, AO, BI, and BO point connected to controller.
 - b. Minimum Spare I/O Points per Controller:
 - 1) AIs: Three.
 - 2) AOs: Three.
 - 3) BIs: Three.
 - 4) BOs: Five.
 2. Programmable Application Controllers:
 - a. 10 percent of each AI, AO, BI, and BO point connected to controller.
 - b. Minimum Spare I/O Points per Controller:
 - 1) AIs: Two.
 - 2) AOs: Two.
 - 3) BIs: Three.
 - 4) BOs: Three.
 3. Application-Specific Controllers:
 - a. 10 percent of each AI, AO, BI, and BO point connected to controller.
 - b. Minimum Spare I/O Points per Controller:
 - 1) AIs: Two.
 - 2) AOs: Two.
 - 3) BIs: Two.
 - 4) BOs: Two.

- I. Maintenance and Support: Include the following features to facilitate maintenance and support:
 1. Mount microprocessor components on circuit cards for ease of removal and replacement.
 2. Means to quickly and easily disconnect controller from network.
 3. Means to quickly and easily access connect to field test equipment.
 4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

2.16 NETWORK CONTROLLERS

A. General Network Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. System shall consist of one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
3. Controller shall have enough memory to support its operating system, database, and programming requirements.
4. Data shall be shared between networked controllers and other network devices.
5. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
6. Controllers that perform scheduling shall have a real-time clock.
7. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
8. Controllers shall be fully programmable.

B. Communication:

1. Network controllers shall communicate with other devices on DDC system Level one network.
2. Network controller also shall perform routing if connected to a network of programmable application and application-specific controllers.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 96 hours.

2.17 PROGRAMMABLE APPLICATION CONTROLLERS

A. General Programmable Application Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. Controller shall have enough memory to support its operating system, database, and programming requirements.
3. Capable of standalone operation and shall continue to include control functions with being connected to network.
4. Data shall be shared between networked controllers and other network devices.
5. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
6. Controllers that perform scheduling shall have a real-time clock.
7. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
8. Controllers shall be fully programmable.

B. Communication:

1. Programmable application controllers shall communicate with other devices on network.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.18 APPLICATION-SPECIFIC CONTROLLERS

A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.

1. Capable of standalone operation and shall continue to include control functions without being connected to network.
2. Data shall be shared between networked controllers and other network devices.

B. Communication: Application-specific controllers shall communicate with other application-specific controller and devices on network, and to programmable application and network controllers.

- C. Operator Interface: Controller shall be equipped with a service communications port for connection to a portable operator's workstation.
- D. Serviceability:
 - 1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
 - 2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
 - 3. Controller shall use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.19 CONTROLLER SOFTWARE

- A. General Controller Software Requirements:
 - 1. Software applications shall reside and operate in controllers. Editing of applications shall occur at operator workstations.
 - 2. I/O points shall be identified by up to 30-character point name and up to 16-character point descriptor. Same names shall be used at operator workstations.
 - 3. Control functions shall be executed within controllers using DDC algorithms.
 - 4. Controllers shall be configured to use stored default values to ensure fail-safe operation. Default values shall be used when there is a failure of a connected input instrument or loss of communication of a global point value.
- B. Security:
 - 1. Operator access shall be secured using individual security passwords and user names.
 - 2. Passwords shall restrict operator to points, applications, and system functions as assigned by system manager.
 - 3. Operator log-on and log-off attempts shall be recorded.
 - 4. System shall protect itself from unauthorized use by automatically logging off after last keystroke. The delay time shall be operator-definable.
- C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule shall consist of the following:
 - 1. Weekly Schedule:
 - a. Include separate schedules for each day of week.
 - b. Each schedule should include the capability for start, stop, optimal start, optimal stop, and night economizer.
 - c. Each schedule may consist of up to 10 events.
 - d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.
 - 2. Exception Schedules:
 - a. Include ability for operator to designate any day of the year as an exception schedule.

- b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.
 3. Holiday Schedules:
 - a. Include capability for operator to define up to 99 special or holiday schedules.
 - b. Schedules may be placed on scheduling calendar and will be repeated each year.
 - c. Operator shall be able to define length of each holiday period.
- D. System Coordination:
1. Include standard application for proper coordination of equipment.
 2. Application shall include operator with a method of grouping together equipment based on function and location.
 3. Group may then be used for scheduling and other applications.
- E. Binary Alarms:
1. Each binary point shall be set to alarm based on operator-specified state.
 2. Include capability to automatically and manually disable alarming.
- F. Analog Alarms:
1. Each analog object shall have both high and low alarm limits.
 2. Alarming shall be able to be automatically and manually disabled.
- G. Alarm Reporting:
1. Operator shall be able to determine action to be taken in event of an alarm.
 2. Alarms shall be routed to appropriate operator workstations based on time and other conditions.
 3. Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.
- H. Maintenance Management: System shall monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.
- I. Sequencing: Include application software based on sequences of operation indicated to properly sequence ERVs, VAHUs, and other applicable HVAC equipment.
- J. Control Loops:
1. Support any of the following control loops, as applicable to control required:
 - a. Two-position (on/off, open/close, slow/fast) control.
 - b. Proportional control.
 - c. Proportional plus integral (PI) control.
 - d. Proportional plus integral plus derivative (PID) control.
 - 1) Include PID algorithms with direct or reverse action and anti-windup.

- 2) Algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs.
 - 3) Controlled variable, set point, and PID gains shall be operator-selectable.
- e. Adaptive (automatic tuning).
- K. Staggered Start: Application shall prevent all controlled equipment from simultaneously restarting after a power outage. Order which equipment (or groups of equipment) is started, along with the time delay between starts, shall be operator-selectable.
- L. Anti-Short Cycling:
1. BO points shall be protected from short cycling.
 2. Feature shall allow minimum on-time and off-time to be selected.
- M. On and Off Control with Differential:
1. Include an algorithm that allows a BO to be cycled based on a controlled variable and set point.
 2. Algorithm shall be direct- or reverse-acting and incorporate an adjustable differential.
- N. Run-Time Totalization:
1. Include software to totalize run-times for all BI and BO points.
 2. A high run-time alarm shall be assigned, if required, by operator.

2.20 ENCLOSURES

- A. General Enclosure Requirements:
1. House each controller and associated control accessories in a single enclosure. Enclosure shall serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies and transformers.
 2. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
- B. Internal Arrangement:
1. Arrange layout to group similar products together.
 2. Include a barrier between line-voltage and low-voltage electrical and electronic products.
 3. Factory or shop install products, tubing, cabling and wiring complying with requirements and standards indicated.
 4. Terminate field cable and wire using heavy-duty terminal blocks.
 5. Include spare terminals, equal to not less than 10 percent of used terminals.
 6. Include spade lugs for stranded cable and wire.
 7. Install a maximum of two wires on each side of a terminal.
 8. Include enclosure field power supply with a toggle-type switch located at entrance inside enclosure to disconnect power.

9. Include enclosure with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.
10. Mount products within enclosure on removable internal panel(s).
11. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). The nameplates shall have at least 1/4-inch-high lettering.
12. Route tubing cable and wire located inside enclosure within a raceway with a continuous removable cover.
13. Label each end of cable, wire and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
14. Size enclosure internal panel to include at least 25 percent spare area on face of panel.

C. Wall-Mounted, NEMA 250, Type 1:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Hoffman; brand of nVent Electrical plc.
2. Enclosure shall be NRTL listed according to UL 50 or UL 50E.
3. Construct enclosure of steel, not less than:
 - a. Enclosure size less than 24 in.: 0.053 in. thick.
 - b. Enclosure size 24 in. and larger: 0.067 in. thick.
4. Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Exterior color shall be manufacturer's standard.
 - b. Interior color shall be manufacturer's standard.
5. Hinged door full size of front face of enclosure and supported using:
 - a. Enclosures sizes less than 36 in. tall: Multiple butt hinges.
 - b. Enclosures sizes 36 in. tall and larger: Continuous piano hinges.
6. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Size less than 24 in.: Solid or Perforated steel, 0.053 in. thick.
 - b. Size 24 in. and larger: Solid steel, 0.093 in. thick.
7. Internal panel mounting hardware, grounding hardware and sealing washers.
8. Grounding stud on enclosure body.
9. Thermoplastic pocket on inside of door for record Drawings and Product Data.

D. Wall Mounted NEMA 250, Types 4 and 12:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Hoffman; brand of nVent Electrical plc.
2. Enclosure shall be NRTL listed according to UL 508A.
3. Seam and joints are continuously welded and ground smooth.
4. Where recessed enclosures are indicated, include enclosures with face flange for flush mounting.
5. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
6. Single-door enclosure sizes up to 60 inches tall by 36 inches wide.
7. Double-door enclosure sizes up to 36 inches tall by 60 inches wide.
8. Construct enclosure of steel, not less than the following:
 - a. Size Less Than 24 Inches: 0.053 inch thick.
 - b. Size 24 Inches and Larger: 0.067 inch thick.
9. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Exterior color shall be manufacturer's standard.
 - b. Interior color shall be manufacturer's standard.
10. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.
 - a. Sizes through 24 Inches Tall: Two hinges.
 - b. Sizes between 24 Inches through 48 Inches Tall: Three hinges.
 - c. Sizes Larger 48 Inches Tall: Four hinges.
11. Double-door enclosures with overlapping door design to include unobstructed full-width access.
 - a. Single-door enclosures 48 inches and taller, and all double-door enclosures, with three-point (top, middle and bottom) latch system.
12. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Size Less Than 24 Inches: Solid or perforated steel, 0.053 inch thick.
 - b. Size 24 Inches and Larger: Solid steel, 0.093 inch thick.
13. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
14. Grounding stud on enclosure body.
15. Thermoplastic pocket on inside of door for record Drawings and Product Data.

2.21 RELAYS

A. General-Purpose Relays:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Siemens Industry, Inc., Building Technologies Division.
 - b. Functional Devices, Inc.
2. Relays shall be heavy duty and rated for at least 10 A at 250-V ac and 60 Hz.
3. Relays shall be either double pole double throw (DPDT) or three-pole double throw, depending on the control application.
4. Use a plug-in-style relay with an eight-pin octal plug for DPDT relays and an 11-pin octal plug for three-pole double-throw relays.
5. Construct the contacts of either silver cadmium oxide or gold.
6. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
7. Relays shall have LED indication and a manual reset and push-to-test button.
8. Performance:
 - a. Mechanical Life: At least 10 million cycles.
 - b. Electrical Life: At least 100,000 cycles at rated load.
 - c. Pickup Time: 15 ms or less.
 - d. Dropout Time: 10 ms or less.
 - e. Pull-in Voltage: 85 percent of rated voltage.
 - f. Dropout Voltage: 50 percent of nominal rated voltage.
 - g. Power Consumption: 2 VA.
 - h. Ambient Operating Temperatures: Minus 40 to 115 deg F.
9. Equip relays with coil transient suppression to limit transients to non-damaging levels.
10. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
11. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

B. Current Sensing Relay (Current Transformer – CT):

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Veris.
 - b. Square D; Schneider Electric USA.
 - c. Flex Core.
 - d. Eaton.
2. Monitors ac current.
3. Independent adjustable controls for pickup and dropout current.
4. Energized when supply voltage is present and current is above pickup setting.
5. De-energizes when monitored current is below dropout current.

6. Dropout current is adjustable from 50 to 95 percent of pickup current.
7. Include a current transformer, if required for application.

C. Combination On-Off Status Sensor and On-Off Relay:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Functional Devices Inc.
2. Description:
 - a. On-off control and status indication in a single device.
 - b. LED status indication of activated relay and current trigger.
 - c. Closed-Open-Auto override switch located on the load side of the relay.
3. Performance:
 - a. Ambient Temperature: Minus 30 to 140 deg F.
 - b. Voltage Rating: Single-phase loads rated for 300-V ac. Three-phase loads rated for 600-V ac.
4. Status Indication:
 - a. Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.
 - b. Current Sensor Range: As required by application.
 - c. Current Set Point: Adjustable.
 - d. Current Sensor Output:
 - 1) Solid-state, single-pole double-throw contact rated for 30-V ac and dc and for 0.4 A.
 - 2) Solid-state, single-pole double-throw contact rated for 120-V ac and 1.0 A.
 - 3) Analog, zero- to 5- or 10-V dc.
 - 4) Analog, 4 to 20 mA, loop powered.
5. Relay: Single-pole double-throw, continuous-duty coil; rated for 10-million mechanical cycles.
6. Enclosure: NEMA 250, Type 1 enclosure.

2.22 ELECTRICAL POWER DEVICES

A. Transformers:

1. Transformer shall be sized for the total connected load, plus an additional 25 percent of connected load.
2. Transformer shall be at least 40 VA.
3. Transformer shall have both primary and secondary fuses.

B. Transient Voltage Suppression and High-Frequency Noise Filter Unit:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Current Technology Inc.
2. The maximum continuous operating voltage shall be at least 125 percent.
3. The operating frequency range shall be 47 to 63 Hz.
4. Protection modes according to NEMA LS-1.
5. The rated single-pulse surge current capacity, for each mode of protection, shall be no less than the following:
 - a. Line to Neutral: 45,000 A.
 - b. Neutral to Ground: 45,000 A.
 - c. Line to Ground: 45,000 A.
 - d. Per Phase: 90,000 A.
6. Clamping voltages shall be in compliance with test and evaluation procedures defined in NEMA LS-1. Maximum clamping voltage shall be as follows:
 - a. Line to Neutral: 360 V.
 - b. Line to Ground: 360 V.
 - c. Neutral to Ground: 360 V.
7. Electromagnetic interference and RF interference noise rejection or attenuation values shall comply with test and evaluation procedures defined in NEMA LS-1.
 - a. Line to Neutral:
 - 1) 100 kHz: 42 dB.
 - 2) 1 MHz: 25 dB.
 - 3) 10 MHz: 21 dB.
 - 4) 100 MHz: 36 dB.
 - b. Line to Ground:
 - 1) 100 kHz: 16 dB.
 - 2) 1 MHz: 55 dB.
 - 3) 10 MHz: 81 dB.
 - 4) 100 MHz: 80 dB.
8. Unit shall have LED status indicator that extinguishes to indicate a failure.
9. Unit shall be listed by an NRTL as a transient voltage surge suppressor per UL 1449, and as an electromagnetic interference filter per UL 1283.
10. Unit shall not generate any appreciable magnetic field.
11. Unit shall not generate an audible noise.

C. DC Power Supply:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Acopian Technical Company.
2. Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.
3. Enclose circuitry in a housing.
4. Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.
5. Performance:
 - a. Output voltage nominally 25-V dc within 5 percent.
 - b. Output current up to 100 mA.
 - c. Input voltage nominally 120-V ac, 60 Hz.
 - d. Load regulation within 0.5 percent from zero- to 100-mA load.
 - e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
 - f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

2.23 CONTROL WIRE AND CABLE

A. Wire: Single conductor control wiring above 24 V.

1. Wire size shall be at least No. 18 AWG.
2. Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inch lay.
3. Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C according to UL 83.
4. Conductor colors shall be black (hot), white (neutral), and green (ground).
5. Furnish wire on spools.

B. Single Twisted Shielded Instrumentation Cable above 24 V:

1. Wire size shall be a minimum No. 18 AWG.
2. Conductors shall be a twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch lay.
3. Conductor insulation shall have a Type THHN/THWN or Type TFN rating.
4. Shielding shall be 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 600-V, 90-deg C rating and shall be Type TC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

C. Single Twisted Shielded Instrumentation Cable 24 V and Less:

1. Wire size shall be a minimum No. 18 AWG.
2. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
3. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.

4. Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
 5. Outer jacket insulation shall have a 300-V, 105-deg C rating and shall be Type PLTC cable.
 6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
 7. Furnish wire on spools.
- D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.
1. Cable shall be balanced twisted pair.

2.24 RACEWAYS

- A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.
- B. Comply with requirements in Section 270528 "Pathways for Communications Systems" for raceways for balanced twisted pair cables.

2.25 ACCESSORIES

A. Pressure Electric Switches:

1. Diaphragm-operated snap acting switch.
2. Set point adjustable from 3 to 20 psig.
3. Differential adjustable from 2 to 6 psig.
4. Rated for resistance loads at 120-V ac.
5. Body and switch housing shall be metal.

B. Damper Blade Limit Switches:

1. Sense positive open and/or closed position of the damper blades.
2. NEMA 250, Type 13, oil-tight construction.
3. Arrange for the mounting application.
4. Additional waterproof enclosure when required by its environment.
5. Arrange to prevent "over-center" operation.

C. Instrument Enclosures:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Hoffman; a brand of nVent.
2. Include instrument enclosure for secondary protection to comply with requirements indicated in "Performance Requirements" Article.

3. NRTL listed and labeled to UL 50.
4. Sized to include at least 25 percent spare area on subpanel.
5. Instrument(s) mounted within enclosure on internal subpanel(s).
6. Enclosure face with engraved, laminated phenolic nameplate for each instrument within enclosure.
7. Enclosures housing multiple instruments shall route tubing and wiring within enclosure in a raceway having a continuous removable cover.
8. Enclosures larger than 12 inches shall have a hinged full-size face cover.
9. Equip enclosure with lock and common key.

D. Thermal Resistors (Thermistors): Common Requirements:

1. 10,000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:
 - a. Range: Typical Minus 50 to 275 deg F, or as modified for specific application.
 - b. Interchangeable Accuracy: At 77 deg F within 0.5 deg F.
 - c. Repeatability: Within 0.5 deg F.
 - d. Drift: Within 0.5 deg F over 10 years.
 - e. Self-Heating: Negligible.
4. Transmitter optional, contingent on compliance with end-to-end control accuracy.

E. Thermistor, Single-Point Duct Air Temperature Sensors:

1. Products: Subject to compliance with requirements, offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Minco; TS400 Series TB.
 - b. Honeywell.
2. Temperature Range: Minus 50 to 250 deg F
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches.
5. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
6. Gasket for attachment to duct or equipment to seal penetration airtight.
7. Conduit Connection: 1/2- inch trade size.

F. Thermistor Averaging Air Temperature Sensors:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Minco; TS400 Series TB.
 - b. Honeywell.
2. Temperature Range: Minus 40 to 250 deg F
3. Multiple sensors to provide average temperature across entire length of sensor.

4. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
5. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.
6. Length: As required by application to cover entire cross section of air tunnel.
7. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
8. Gasket for attachment to duct or equipment to seal penetration airtight.
9. Conduit Connection: 1/2-inch trade size.

G. Thermistor Outdoor Air Temperature Sensors:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Minco; TS400 Series TB.
 - b. Honeywell.
2. Temperature Range: Minus 50 to 275 deg F
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Solar Shield: Stainless steel.
5. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
6. Conduit Connection: 1/2-inch trade size.

H. Thermistor Space Air Temperature Sensors:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Honeywell
 - b. Minco; TS400 Series TB.
2. Temperature Range: Minus 4 to 122 deg F
3. Sensor assembly shall include a temperature sensing element mounted under a bright white, non-yellowing, plastic cover.
4. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
5. Concealed wiring connection.
6. Provide digital display of sensed temperature and setpoint.
7. Provide sensor with local controls.
 - a. Local override to turn HVAC on.
 - b. Local adjustment of temperature set point.
 - c. Both features shall be capable of manual override through control system operator.

I. Humidity Sensors:

1. Description:

- a. Factory package consisting of humidity sensor, sensing probe, installation hardware, interconnecting sensor cabling, installation instructions, and operating manual.
 - b. Each sensor shall be individually calibrated and provided with NIST traceable calibration certifications.
2. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
- a. Honeywell
 - b. Minco
3. Humidity Sensor:
- a. Relative Humidity Measurement Range: Zero to 100 percent.
 - b. Thin film capacitance technology resistant to damage from condensation
 - c. Response time in still air within 40 seconds.
 - d. Accuracy including non-linearity, hysteresis, and repeatability:
 - 1) For Temperature between 59 and 77 Deg F and Relative Humidity between Zero and 90 Percent: Within 2 percent.
 - 2) For Temperature between Minus 4 and 104 Deg F: Within 3 percent.
 - e. Sintered, stainless steel filter, protecting sensor.
4. Electronics Enclosure:
- a. Integral to sensors for wall (room) mounted applications and remote from temperature and humidity sensors for duct and equipment applications.
 - b. Labeled terminal strip for field wiring connections.
5. Programming:
- a. Transmitter parameters to be field programmable.
 - b. Programmed parameters to be stored in nonvolatile EEPROM.
6. Output Signals:
- a. 4 to 20 mA or 0 to 10-V dc for each output.
7. Power Supply:
- a. Field Power: 24-V ac, 60 Hz powered from controller.
- J. Combination Humidity and Temperature Sensor and Transmitter with Display:
1. Description:
 - a. Factory package consisting of humidity and temperature sensor, digital display, keypad user interface, installation hardware, interconnecting sensor cabling, installation instructions, and operating manual.

- b. Each transmitter to be individually calibrated and provided with NIST traceable calibration certifications.
2. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Honeywell
 - b. Minco
3. Display:
 - a. Alphanumeric display of the following on the face of the enclosure:
 - 1) Percent relative humidity.
 - 2) Dry-bulb temperature.
 - 3) Dew point temperature.
4. Electronics Enclosure:
 - a. Integral to sensors for wall (room) mounted applications and remote from temperature and humidity sensors for duct and equipment applications.
 - b. Labeled terminal strip for field wiring connections.
5. Programming:
 - a. Transmitter parameters to be field programmable through keypad on the face of the enclosure.
 - b. Programmed parameters to be stored in nonvolatile EEPROM.
6. Output Signals:
 - a. Three Analog Outputs: 4 to 20 mA or 0 to 10-V dc for each output.
7. Temperature Sensor:
 - a. Thermistor Space Air Temperature Sensors:
 - b. Temperature range matched to application, but not less than minus 4 to 122 deg F
 - c. Within 0.5 deg F accuracy over the temperature range of 50 to 100 deg F and within 1 deg F over the remainder of the range.
8. Humidity Sensor:
 - a. Relative Humidity Measurement Range: Zero to 100 percent.
 - b. Thin film capacitance technology resistant to damage from condensation
 - c. Response time in still air within 40 seconds.
 - d. Accuracy including non-linearity, hysteresis, and repeatability:
 - 1) For Temperature between 59 and 77 Deg F and Relative Humidity between Zero and 90 Percent: Within 1 percent.
 - 2) For Temperature between 59 and 77 Deg F and Relative Humidity between 90 and 100 Percent: Within 1.7 percent.

- 3) For Temperature between Minus 4 and 104 Deg F: Within 1 percent plus 0.008 times relative humidity reading.
- e. Sintered, stainless steel filter, protecting sensor.
9. Power Supply:
 - a. Field Power: 24-V ac, 60 Hz powered from controller.
- K. Carbon Dioxide Sensor
 1. Description:
 - a. Factory package consisting of carbon dioxide (CO₂) sensor, digital display, keypad user interface, installation hardware, interconnecting sensor cabling, installation instructions, and operating manual.
 - b. Each sensor to be individually calibrated and provided with NIST traceable calibration certifications.
 2. Display:
 - a. Alphanumeric display of the following on the face of the enclosure:
 - 1) Carbon Dioxide Concentration in PPM.
 3. Electronics Enclosure:
 - a. Integral to sensors for wall (room) mounted applications and remote from CO₂ sensors for duct and equipment applications.
 - b. White plastic or painted metal enclosure.
 - c. Labeled terminal strip for field wiring connections.
 4. Programming:
 - a. Sensor parameters and calibration shall be field programmable.
 - b. Programmed parameters to be stored in nonvolatile EEPROM.
 - c. Sensor shall be calibratable in the field. Provide calibration gas, connectors, and instructions for field calibrations.
 5. Output Signals:
 - a. One Analog Output: 4 to 20 mA or 0 to 10-V dc.
 6. CO₂ Sensor:
 - a. Non-dispersive infrared (NDIR) type sensor.
 - b. Response time in still air within 5 minutes.
 - c. Accuracy including non-linearity, hysteresis, and repeatability:
 - 1) Range: 0 – 2000 PPM.
 - 2) Accuracy: ±75 PPM.
 - 3) Operating Range: 32 -122°F and 0-95% RH non-condensing.

- d. Drift: No more than 25 PPM per year.
- 7. Power Supply:
 - a. Field Power: 12-24-V dc or 18-24 V ac.

2.26 IDENTIFICATION

A. Control Equipment, Instruments, and Control Devices:

- 1. Self-adhesive label bearing unique identification.
 - a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.
- 2. Letter size shall be at least 0.5 inch or larger as needed to be read from the floor.
- 3. Legend shall consist of black lettering on white background.
- 4. Laminated acrylic or melamine plastic sign shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded black with contrasting white center exposed by engraving through outer layer and shall be fastened with drive pins.
- 5. Instruments, control devices, and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require additional identification.

B. Valve Tags:

- 1. Brass tags and brass chains attached to valve.
- 2. Tags shall be at least 1.5 inches in diameter.
- 3. Include tag with unique valve identification indicating control influence such as flow, level, pressure, or temperature; followed by location of valve, and followed by three-digit sequential number. For example: TV-1.001.
- 4. Valves with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

C. Raceway and Boxes:

- 1. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- 2. Paint cover plates on junction boxes and conduit same color as the tape banding for conduits. After painting, label cover plate "HVAC Controls," using an engraved phenolic tag.

D. Equipment Warning Labels:

- 1. Self-adhesive label with pressure-sensitive adhesive back and peel-off protective jacket.
- 2. Lettering size shall be at least 14-point type with white lettering on red background.

3. Warning label shall read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
4. Lettering shall be enclosed in a white line border. Edge of label shall extend at least 0.25 inch beyond white border.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 1. Verify compatibility with and suitability of substrates.
- B. Examine roughing-in for products to verify actual locations of connections before installation.
 1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
 2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
 3. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed. Notify Architect of any conditions detrimental to performance of the Work are found.
 4. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

- A. Communication Interface to Equipment with Integral Controls:
 1. DDC system shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.
 2. Equipment to Be Connected:
 - a. Air-terminal units specified in Section 233600 "Air Terminal Units."
 - b. Dedicated Outdoor Air Units specified in Section 233743 "Dedicated Outdoor-Air Units."
 - c. Variable-refrigerant-flow HVAC systems specified in Section 238129 "Variable-Refrigerant-Flow HVAC Systems."
 - d. Fan-coil units specified in Section 238219 "Fan Coil Units."
 - e. Refrigerant monitoring.
- B. Communication Interface to Other Building Systems:
 1. Systems to Be Connected:
 - a. Honeywell system operated by State of Maine.
 - b. Phoenix Controls in Lab area.

3.3 DDC SYSTEM INTERFACE WITH EXISTING SYSTEMS

A. Interface with Existing Systems:

1. Existing electronic controls shall be completely demolished.
2. DDC systems shall interface existing systems to achieve integration.

B. Integration with Existing Enterprise System:

1. DDC system shall interface with an existing BCC building control center enterprise system to adhere to Owner standards already in-place and to achieve integration.
2. Owner's control system integrator will provide the following services:
 - a. Enterprise system expansion and development of graphics, logs, reports, trends and other operational capabilities of enterprise system for I/O being added to DDC control system for use by enterprise system operators.
 - b. Limited assistance during commissioning to extent of DDC system integration with existing enterprise system.
 - c. Prepare on-site demonstration mockup of integration of DDC system to be installed with existing system before installing DDC system.
3. Engage Owner's control system integrator to provide the following services:
 - a. Enterprise system expansion and development of graphics, logs, reports, trends and other operational capabilities of enterprise system for I/O being added to DDC control system for use by enterprise system operators.
 - b. Limited assistance during commissioning to extent of DDC system integration with existing enterprise system.
 - c. Prepare on-site demonstration mockup of integration of DDC system to be installed with existing system before installing DDC system.
4. Control System Integrator Contact Information:
 - a. Company: Honeywell Building Technologies.
 - b. Company Street Address: <Insert address>915 Holt Avenue, Unit 7, Manchester, NH 03109.
 - c. Company Contact: <Insert name>Thomas Smith.
 - d. Phone Number: <Insert phone number>(603) 530-2064.
 - e. E-mail Address: <Insert e-mail address>Thomas.smith2@honeywell.com.
5. Attend meetings with control system integrator to integrate DDC system.

3.4 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

- A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.
- B. Deliver the following to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.

1. Airflow sensors and switches, which are specified in this specification section.
 2. Instruments are specified in this specification section.
- C. Deliver the following to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.
1. Pipe-mounted sensors, switches, and transmitters.
 2. Liquid temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
 3. Pipe- and tank-mounted thermowells.

3.5 GENERAL INSTALLATION REQUIREMENTS

- A. Install products to satisfy more stringent of all requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Support products, tubing, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break.
- D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.
- E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- F. Firestop Penetrations Made in Fire-Rated Assemblies: Comply with requirements in Section 078413 "Penetration Firestopping."
- G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 079200 "Joint Sealants."
- H. Fastening Hardware:
 1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.
- I. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.
- J. Corrosive Environments:
 1. Avoid or limit use of materials in corrosive airstreams and environments, including, but not limited to, the following:

- a. Laboratory hood exhaust-air streams.

3.6 GATEWAY INSTALLATION

- A. Install gateways if required for DDC system communication interface requirements indicated.
- B. Test gateway to verify that communication interface functions properly.

3.7 ROUTER INSTALLATION

- A. Install routers if required for DDC system communication interface requirements indicated.
- B. Test router to verify that communication interface functions properly.

3.8 CONTROLLER INSTALLATION

- A. Install controllers in enclosures to comply with indicated requirements.
- B. Connect controllers to field power supply.
- C. Install controller with latest version of applicable software and configure to execute requirements indicated.
- D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.
- E. Installation of Network Controllers:
 - 1. Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
 - 2. Install controllers in a protected location that is easily accessible by operators.
 - 3. Top of controller shall be within 84 inches of finished floor.
- F. Installation of Programmable Application Controllers:
 - 1. Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
 - 2. Install controllers in a protected location that is easily accessible by operators.
 - 3. Top of controller shall be within 84 inches of finished floor.
- G. Application-Specific Controllers:
 - 1. Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
 - 2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.9 ENCLOSURES INSTALLATION

- A. Install the following items in enclosures, to comply with indicated requirements:
 - 1. Gateways.
 - 2. Routers.
 - 3. Controllers.
 - 4. Electrical power devices.
 - 5. UPS units.
 - 6. Relays.
 - 7. Accessories.
- B. Attach wall-mounted enclosures to wall using the following types of steel struts:
 - 1. For NEMA 250, Type 1 Enclosures: Use galvanized-steel strut and hardware.
 - 2. For NEMA 250, Type 4 Enclosures and Enclosures Located Outdoors: Use stainless steel strut and hardware.
 - 3. Install plastic caps on exposed cut edges of strut.
- C. Align top of adjacent enclosures.
- D. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireway used for application shall have protection equal to NEMA 250 rating of connected enclosures.

3.10 ELECTRIC POWER CONNECTIONS

- A. Connect electrical power to DDC system products requiring electrical power connections.
- B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade. Work shall comply with NFPA 70 and other requirements indicated.
- C. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.
- D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.
- E. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

3.11 TEMPERATURE INSTRUMENT INSTALLATIONS

- A. Mounting Location:
 - 1. Roughing In:
 - a. Outline instrument mounting locations before setting instruments and routing cable, wiring, and conduit to final location.

- b. Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.
 - 1) Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.
 - 2) Do not begin installation without submittal approval of mounting location.
 - c. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.
2. Install switches and transmitters for air and liquid temperature associated with individual air-handling units and associated connected ductwork and piping near air-handling units co-located in air-handling unit system control panel to provide service personnel a single and convenient location for inspection and service.
 3. Install liquid and steam temperature transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
 4. Install air temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
 5. Mount switches and transmitters on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
- B. Special Mounting Requirements:
1. Protect products installed outdoors from solar radiation, building and wind effect with stand-offs and shields constructed of Type 316 stainless.
 2. Temperature instruments having performance impacted by temperature of mounting substrate shall be isolated with an insulating barrier located between instrument and substrate to eliminate effect. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.
- C. Mounting Height:
1. Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
 2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.
 - a. Make every effort to mount at 60 inches.
- D. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.
- E. Space Temperature Sensor Installation:

1. Conceal assembly in an electrical junction box of sufficient size to house sensor and transmitter, if provided.
2. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.
3. In finished areas, recess electrical box within wall.
4. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.
5. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.

F. Outdoor Air Temperature Sensor Installation:

1. Mount sensor in a discrete location facing north.
2. Protect installed sensor from solar radiation and other influences that could impact performance.

G. Single-Point Duct Temperature Sensor Installation:

1. Install single-point-type, duct-mounted, supply- and return-air temperature sensors. Install sensors in ducts with sensitive portion of the element installed in center of duct cross section and located to sense near average temperature. Do not exceed 24 inches in sensor length.
2. Install return-air sensor in location that senses return-air temperature without influence from outdoor or mixed air.
3. Rigidly support sensor to duct and seal penetration airtight.

H. Averaging Duct Temperature Sensor Installation:

1. Install averaging-type air temperature sensor for temperature sensors located within air-handling units, similar equipment, and large ducts with air tunnel cross-sectional area of 20 sq. ft. and larger.
2. Install sensor length to maintain coverage over entire cross-sectional area. Install multiple sensors where required to maintain the minimum coverage.
3. Fasten and support sensor with manufacturer-furnished clips to keep sensor taut throughout entire length.

I. Low-Limit Air Temperature Switch Installation:

1. Install multiple low-limit switches to maintain coverage over entire cross-sectional area of air tunnel.
2. Fasten and support sensing element with manufacturer-furnished clips to keep element taut throughout entire length.
3. Mount switches outside of airstream at a location and mounting height to provide easy access for switch set-point adjustment and manual reset.
4. Install on leaving side of heating coil unless otherwise indicated on Drawings.

3.12 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.
- B. Wash and shine glazing.
- C. Polish glossy surfaces to a clean shine.

3.13 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification products and installation.
- B. Install unique instrument identification on face of each instrument connected to a DDC controller.
- C. Install unique identification on face of each control damper actuator connected to a DDC controller.
- D. Where product is installed above accessible tile ceiling, also install matching identification on face of ceiling grid located directly below.
- E. Where product is installed above an inaccessible ceiling, also install identification on face of access door directly below.
- F. Warning Labels and Signs:
 - 1. Shall be permanently attached to equipment that can be automatically started by DDC control system.
 - 2. Shall be located in highly visible location near power service entry points.

3.14 NETWORK INSTALLATION

- A. Install Category 6 communication cable for IP networks or balanced twisted pair cable for MS/TP networks.
- B. Install cable in continuous raceway.
 - 1. Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit.

3.15 NETWORK NAMING AND NUMBERING

- A. Coordinate with Owner and provide unique naming and addressing for networks and devices.
- B. ASHRAE 135 Networks:

1. MAC Address:
 - a. Every network device shall have an assigned and documented MAC address unique to its network.
 - b. Ethernet Networks: Document MAC address assigned at its creation.
 - c. ARCNET or MS/TP networks: Assign from 00 to 64.
2. Network Numbering:
 - a. Assign unique numbers to each new network.
 - b. Provide ability for changing network number through device switches or operator interface.
 - c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.
3. Device Object Identifier Property Number:
 - a. Assign unique device object identifier property numbers or device instances for each device network.
 - b. Provide for future modification of device instance number by device switches or operator interface.
 - c. LAN shall support up to 4,194,302 unique devices.
4. Device Object Name Property Text:
 - a. Device object name property field shall support 32 minimum printable characters.
 - b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.
 - 1) Example 1: Device object name for device controlling boiler plant at Building 1000 would be "HW System B1000."
 - 2) Example 2: Device object name for a VAV terminal unit controller could be "VAV unit 102".

3.16 INSTRUMENTATION INSTALLATION, GENERAL

- A. Install products level, plumb, parallel, and perpendicular with building construction.
- B. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway.
- C. Fastening Hardware:
 1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

- D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.17 CONTROL WIRE, CABLE AND RACEWAYS INSTALLATION

- A. Comply with NECA 1.

- B. Wire and Cable Installation:

- 1. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.
 - a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.
- 2. Terminate wiring in a junction box.
 - a. Clamp cable over jacket in junction box.
 - b. Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.
- 3. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
- 4. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.
- 5. Use shielded cable to transmitters.
- 6. Use shielded cable to temperature sensors.
- 7. Perform continuity and meager testing on wire and cable after installation.

- C. Conduit Installation:

- 1. Comply with Section 260533 "Raceways and Boxes for Electrical Systems" for control-voltage conductors.

3.18 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative as needed:

- 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

- B. Testing:

- 1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.

2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. As a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.
3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.
4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by DDC system manufacturer. Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.
5. Test Equipment: Use an optical fiber time domain reflectometer for testing of length and optical connectivity.
6. Test Results: Record test results and submit copy of test results for Project record.

3.19 DDC SYSTEM I/O CHECKOUT PROCEDURES

- A. Check installed products before continuity tests, leak tests and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
- D. Control Damper Checkout:
 1. Verify that control dampers are installed correctly for flow direction.
 2. Verify that proper blade alignment, either parallel or opposed, has been provided.
 3. Verify that damper frame attachment is properly secured and sealed.
 4. Verify that damper actuator and linkage attachment is secure.
 5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
 6. Verify that damper blade travel is unobstructed.
- E. Instrument Checkout:
 1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
 2. Verify that attachment is properly secured and sealed.
 3. Verify that conduit connections are properly secured and sealed.
 4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
 5. Inspect instrument tag against approved submittal.
 6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
 7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
 8. For temperature instruments:

- a. Verify sensing element type and proper material.
- b. Verify length and insertion.

3.20 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:

- A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
- B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
- C. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
- D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.
- E. Provide diagnostic and test equipment for calibration and adjustment.
- F. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
- G. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
- H. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
- I. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.
- J. Analog Signals:
 1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
 2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
 3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.
- K. Digital Signals:
 1. Check digital signals using a jumper wire.
 2. Check digital signals using an ohmmeter to test for contact making or breaking.
- L. Control Dampers:
 1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.

2. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

N. Switches: Calibrate switches to make or break contact at set points indicated.

3.21 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.

1. Verify voltage, phase and hertz.
2. Verify that protection from power surges is installed and functioning.
3. Verify that ground fault protection is installed.
4. If applicable, verify if connected to UPS unit.
5. If applicable, verify if connected to a backup power source.
6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.

B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

3.22 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:

1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2. Test every I/O point throughout its full operating range.
3. Test every control loop to verify operation is stable and accurate.
4. Adjust control loop proportional, integral and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:
 - a. Upper quarter of range.
 - b. Lower quarter of range.
 - c. At midpoint of range.

8. Exercise each binary point.
9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller and at field instrument shall match.
10. Prepare and submit a report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desired results.

3.23 DDC SYSTEM VALIDATION TESTS

- A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.
- B. After approval of Test Plan, execute all tests and procedures indicated in plan.
- C. After testing is complete, submit completed test checklist.
- D. Pretest Checklist: Submit the following list with items checked off once verified:
 1. Detailed explanation for any items that are not completed or verified.
 2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.
 3. HVAC equipment motors operate below full-load amperage ratings.
 4. Required DDC system components, wiring, and accessories are installed.
 5. Installed DDC system architecture matches approved Drawings.
 6. Control electric power circuits operate at proper voltage and are free from faults.
 7. Required surge protection is installed.
 8. DDC system network communications function properly, including uploading and downloading programming changes.
 9. Using BACnet protocol analyzer, verify that communications are error free.
 10. Each controller's programming is backed up.
 11. Equipment, products, tubing, wiring cable, and conduits are properly labeled.
 12. All I/O points are programmed into controllers.
 13. Testing, adjusting, and balancing work affecting controls is complete.
 14. Dampers and actuators zero and span adjustments are set properly.
 15. Each control damper and actuator goes to failed position on loss of power.
 16. Valves and actuators zero and span adjustments are set properly.
 17. Each control valve and actuator goes to failed position on loss of power.
 18. Meter, sensor and transmitter readings are accurate and calibrated.
 19. Control loops are tuned for smooth and stable operation.
 20. View trend data where applicable.
 21. Each controller works properly in standalone mode.
 22. Safety controls and devices function properly.
 23. Interfaces with fire-alarm system function properly.
 24. Electrical interlocks function properly.
 25. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphics are created.
 26. Record Drawings are completed.
- E. Test Plan:

1. Prepare and submit a validation test plan including test procedures for performance validation tests.
2. Test plan shall address all specified functions of DDC system and sequences of operation.
3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
5. Include a test checklist to be used to check and initial that each test has been successfully completed.
6. Submit test plan documentation 20 business days before start of tests.

F. Validation Test:

1. Verify operating performance of each I/O point in DDC system.
 - a. Verify analog I/O points at operating value.
 - b. Make adjustments to out-of-tolerance I/O points.
 - 1) Identify I/O points for future reference.
 - 2) Simulate abnormal conditions to demonstrate proper function of safety devices.
 - 3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.
2. Simulate conditions to demonstrate proper sequence of control.
3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.
4. After 24 Hours following Initial Validation Test:
 - a. Re-check I/O points that required corrections during initial test.
 - b. Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.
5. After 24 Hours of Second Validation Test:
 - a. Re-check I/O points that required corrections during second test.
 - b. Continue validation testing until I/O point is normal on two consecutive tests.
6. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
7. After validation testing is complete, prepare and submit a report indicating all I/O points that required correction and how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

G. DDC System Response Time Test:

1. Simulate HLC.
 - a. Heavy load shall be an occurrence of 50 percent of total connected binary COV, one-half of which represent an "alarm" condition, and 50 percent of total

connected analog COV, one-half of which represent an "alarm" condition, that are initiated simultaneously on a one-time basis.

2. Initiate 10 successive occurrences of HLC and measure response time to typical alarms and status changes.
3. Measure with a timer having at least 0.1-second resolution and 0.01 percent accuracy.
4. Purpose of test is to demonstrate DDC system, as follows:
 - a. Reaction to COV and alarm conditions during HLC.
 - b. Ability to update DDC system database during HLC.
5. Passing test is contingent on the following:
 - a. Alarm reporting at BCC beginning no more than 10 seconds after the initiation (time zero) of HLC.
 - b. All alarms, both binary and analog, are reported and printed; none are lost.
 - c. Compliance with response times specified.
6. Prepare and submit a report documenting HLC tested and results of test including time stamp and print out of all alarms.

H. DDC System Network Bandwidth Test:

1. Test network bandwidth usage on all DDC system networks to demonstrate bandwidth usage under DDC system normal operating conditions and under simulated HLC.
2. To pass, none of DDC system networks shall use more than 70 percent of available bandwidth under normal and HLC operation.

3.24 FINAL REVIEW

- A. Submit written request to Architect and Construction Manager when DDC system is ready for final review. Written request shall state the following:
 1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
 2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
 3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
 4. DDC system is complete and ready for final review.
- B. Review by Architect and Construction Manager shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.
- C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

- D. Should more than two reviews be required, DDC system manufacturer and Installer shall compensate entity performing review for total costs, labor and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review.
- E. Prepare and submit closeout submittals when no deficiencies are reported.
- F. A part of DDC system final review shall include a demonstration to parties participating in final review.
 - 1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
 - 2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
 - 3. Demonstration shall include, but not be limited to, the following:
 - a. Accuracy and calibration of 20 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
 - b. HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to 10 I/O points shall be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.
 - c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.
 - d. Operation of randomly selected dampers and valves in normal-on, normal-off and failed positions.
 - e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.
 - f. Trends, summaries, logs and reports set-up for Project.
 - g. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.
 - h. Software's ability to communicate with controllers and BCC.
 - i. Data entry to show Project-specific customizing capability including parameter changes.
 - j. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
 - k. Execution of digital and analog commands in graphic mode.
 - l. Online user guide and help functions.
 - m. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.
 - n. System speed of response compared to requirements indicated.
 - o. For Each Network and Programmable Application Controller:

- 1) Memory: Programmed data, parameters, trend and alarm history collected during normal operation is not lost during power failure.
 - 2) Operator Interface: Ability to connect directly to each type of digital controller with a portable workstation and mobile device. Show that maintenance personnel interface tools perform as indicated in manufacturer's technical literature.
 - 3) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.
 - 4) Electric Power: Ability to disconnect any controller safely from its power source.
 - 5) Wiring Labels: Match control drawings.
 - 6) Network Communication: Ability to locate a controller's location on network and communication architecture matches Shop Drawings.
 - 7) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators, and devices.
- p. Communications and Interoperability: Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management. Use ASHRAE 135 protocol analyzer to help identify devices, view network traffic, and verify interoperability. Requirements must be met even if only one manufacturer's equipment is installed.
- 1) Data Presentation: On each operator workstation, demonstrate graphic display capabilities.
 - 2) Reading of Any Property: Demonstrate ability to read and display any used readable object property of any device on network.
 - 3) Set Point and Parameter Modifications: Show ability to modify set points and tuning parameters indicated.
 - 4) Peer-to-Peer Data Exchange: Network devices are installed and configured to perform without need for operator intervention to implement Project sequence of operation and to share global data.
 - 5) Alarm and Event Management: Alarms and events are installed and prioritized according to Owner. Demonstrate that time delays and other logic are set up to avoid nuisance tripping. Show that operators with sufficient privileges are permitted.
 - 6) Schedule Lists: Schedules are configured for start and stop, mode change, occupant overrides, and night setback as defined in sequence of operations.
 - 7) Schedule Display and Modification: Ability to display any schedule with start and stop times for calendar year. Show that all calendar entries and schedules are modifiable from any connected operator workstation by an operator with sufficient privilege.
 - 8) Archival Storage of Data: Data archiving is handled by operator workstation and server and local trend archiving and display is accomplished.
 - 9) Modification of Trend Log Object Parameters: Operator with sufficient privilege can change logged data points, sampling rate, and trend duration.
 - 10) Device and Network Management:
 - a) Display of network device status.
 - b) Display of BACnet Object Information.
 - c) Silencing devices transmitting erroneous data.

- d) Time synchronization.
- e) Remote device re-initialization.
- f) Backup and restore network device programming and master database(s).
- g) Configuration management of routers.

3.25 EXTENDED OPERATION TEST

- A. Extended operation test is intended to simulate normal operation of DDC system by Owner.
- B. Operate DDC system for an operating period of 14 consecutive calendar days following Substantial Completion. Coordinate exact start date of testing with Owner.
- C. Provide an operator familiar with DDC system installed to man an operator workstation during eight hours of each normal business day occurring during operating period.
- D. During operating period, DDC system shall demonstrate correct operation and accuracy of monitored and controlled points as well as operation capabilities of sequences, logs, trends, reports, specialized control algorithms, diagnostics, and other software indicated.
 - 1. Correct defects of hardware and software when it occurs.
- E. Definition of Failures and Downtime during Operating Period:
 - 1. Failed I/O point constituting downtime is an I/O point failing to perform its intended function consistently and a point physically failed due to hardware and software.
 - 2. Downtime is when any I/O point in DDC system is unable to fulfill its' required function.
 - 3. Downtime shall be calculated as elapsed time between a detected point failure as confirmed by an operator and time point is restored to service.
 - 4. Maximum time interval allowed between DDC system detection of failure occurrence and operator confirmation shall be 0.5 hours.
 - 5. Downtime shall be logged in hours to nearest 0.1 hour.
 - 6. Power outages shall not count as downtime, but shall suspend test hours unless systems are provided with UPS and served through a backup power source.
 - 7. Hardware or software failures caused by power outages shall count as downtime.
- F. During operating period, log downtime and operational problems are encountered.
 - 1. Identify source of problem.
 - 2. Provide written description of corrective action taken.
 - 3. Record duration of downtime.
 - 4. Maintain log showing the following:
 - a. Time of occurrence.
 - b. Description of each occurrence and pertinent written comments for reviewer to understand scope and extent of occurrence.
 - c. Downtime for each failed I/O point.
 - d. Running total of downtime and total time of I/O point after each problem has been restored.

5. Log shall be available to Owner for review at any time.
- G. For DDC system to pass extended operation test, total downtime shall not exceed 1 percent of total point-hours during operating period.
1. Failure to comply with minimum requirements of passing at end of operating period indicated shall require that operating period be extended one consecutive day at a time until DDC system passes requirement.
- H. Evaluation of DDC system passing test shall be based on the following calculation:
1. Downtime shall be counted on a point-hour basis where total number of DDC system point-hours is equal to total number of I/O points in DDC system multiplied by total number of hours during operating period.
 2. One point-hour of downtime is one I/O point down for one hour. Three points down for five hours is a total of 15 point-hours of downtime. Four points down for one-half hour is 2 point-hours of downtime.
 3. Example Calculation: Maximum allowable downtime for 30-day test when DDC system has 1000 total I/O points (combined analog and binary) and has passing score of 1 percent downtime is computed by 30 days x 24 h/day x 1000 points x 1 percent equals 7200 point-hours of maximum allowable downtime.
- I. Prepare test and inspection reports.

3.26 SYSTEM ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.27 DEMONSTRATION

- A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.
- B. Extent of Training:
1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
 2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
 3. Minimum Training Requirements:
 - a. Provide not less than five days of training total.
 - b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.

- c. Total days of training shall be broken into not more than four separate training classes.
- d. Each training class shall be not less than one consecutive day.

C. Training Schedule:

1. Schedule training with Owner 20 business days before expected Substantial Completion.
2. Schedule training to provide Owner with at least 10 business days of notice in advance of training.
3. Training shall occur within normal business hours at a mutually agreed on time. Unless otherwise agreed to, training shall occur Monday through Friday, except on U.S. Federal holidays, with two morning sessions and two afternoon sessions. Each morning session and afternoon session shall be split in half with 15-minute break between sessions. Morning and afternoon sessions shall be separated by 60-minute lunch period. Training, including breaks and excluding lunch period, shall not exceed eight hours per day.
4. Provide staggered training schedule as requested by Owner.

D. Training Attendee List and Sign-in Sheet:

1. Request from Owner in advance of training a proposed attendee list with name, phone number and e-mail address.
2. Provide a preprinted sign-in sheet for each training session with proposed attendees listed and no fewer than six blank spaces to add additional attendees.
3. Preprinted sign-in sheet shall include training session number, date and time, instructor name, phone number and e-mail address, and brief description of content to be covered during session. List attendees with columns for name, phone number, e-mail address and a column for attendee signature or initials.
4. Circulate sign-in sheet at beginning of each session and solicit attendees to sign or initial in applicable location.
5. At end of each training day, send Owner an e-mail with an attachment of scanned copy (PDF) of circulated sign-in sheet for each session.

E. Training Attendee Headcount:

1. Plan in advance of training for five attendees.
2. Make allowance for Owner to add up to one attendee at time of training.
3. Headcount may vary depending on training content covered in session. Attendee access may be restricted to some training content for purposes of maintaining system security.

F. Training Attendee Prior Knowledge: For guidance in planning required training and instruction, assume attendees have the following:

1. High school and technical school education and degree.
2. Basic user knowledge of computers and office applications.
3. Intermediate knowledge of HVAC systems.
4. Intermediate knowledge of DDC systems.
5. Intermediate knowledge of DDC system and products installed.

G. Attendee Training Manuals:

1. Provide each attendee with a color hard copy of all training materials and visual presentations.
 2. Hard-copy materials shall be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
 3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of all hard-copy materials.
- H. Instructor Requirements:
1. One or multiple qualified instructors, as required, to provide training.
 2. Instructors shall have not less than five years of providing instructional training on not less than five past projects with similar DDC system scope and complexity to DDC system installed.
- I. Organization of Training Sessions:
1. Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate the following three levels of operators:
 - a. Daily operators.
 - b. Advanced operators.
 - c. System managers and administrators.
 2. Plan and organize training sessions to group training content to protect DDC system security. Some attendees may be restricted to some training sessions that cover restricted content for purposes of maintaining DDC system security.
- J. Training Outline:
1. Submit training outline for Owner review at least 10 business day before scheduling training.
 2. Outline shall include a detailed agenda for each training day that is broken down into each of four training sessions that day, training objectives for each training session and synopses for each lesson planned.
- K. On-Site Training:
1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power and data connectivity for instructor and each attendee.
 2. Instructor shall provide training materials, projector and other audiovisual equipment used in training.
 3. Provide as much of training located on-site as deemed feasible and practical by Owner.
 4. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration and service requirements.
 5. Operator workstation provided with DDC system shall be used in training. If operator workstation is not indicated, provide a temporary workstation to convey training content.

L. Training Content for Daily Operators:

1. Basic operation of system.
2. Understanding DDC system architecture and configuration.
3. Understanding each unique product type installed including performance and service requirements for each.
4. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm and each unique optimization routine.
5. Operating operator workstations, printers and other peripherals.
6. Logging on and off system.
7. Accessing graphics, reports and alarms.
8. Adjusting and changing set points and time schedules.
9. Recognizing DDC system malfunctions.
10. Understanding content of operation and maintenance manuals including control drawings.
11. Understanding physical location and placement of DDC controllers and I/O hardware.
12. Accessing data from DDC controllers.
13. Review of DDC testing results to establish basic understanding of DDC system operating performance and HVAC system limitations as of Substantial Completion.
14. Running each specified report and log.
15. Stepping through graphics penetration tree, displaying all graphics, demonstrating dynamic updating, and direct access to graphics.
16. Executing digital and analog commands in graphic mode.
17. Demonstrating control loop precision and stability via trend logs of I/O for not less than 10 percent of I/O installed.
18. Demonstrating DDC system performance through trend logs and command tracing.
19. Demonstrating scan, update, and alarm responsiveness.
20. Demonstrating on-line user guide, and help function and mail facility.
21. Demonstrating multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
22. Demonstrating the following for HVAC systems and equipment controlled by DDC system:
 - a. Operation of HVAC equipment in normal-off, -on and failed conditions while observing individual equipment, dampers and valves for correct position under each condition.
 - b. For HVAC equipment with factory-installed software, show that integration into DDC system is able to communicate with DDC controllers or gateways, as applicable.
 - c. Using graphed trends, show that sequence of operation is executed in correct manner, and HVAC systems operate properly through complete sequence of operation including seasonal change, occupied and unoccupied modes, warm-up and cool-down cycles and other modes of operation indicated.
 - d. Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.
 - e. Reporting of alarm conditions for each alarm, and confirm that alarms are received at assigned locations, including operator workstations.
 - f. Each control loop responds to set point adjustment and stabilizes within time period indicated.

- g. Sharing of previously graphed trends of all control loops to demonstrate that each control loop is stable and set points are being maintained.

M. Video of Training Sessions:

1. Provide a digital video and audio recording of each training session. Create a separate recording file for each session.
2. Stamp each recording file with training session number, session name and date.
3. Provide Owner with two copies of digital files on DVDs or flash drives for later reference and for use in future training.
4. Owner retains right to make additional copies for intended training purposes without having to pay royalties.

END OF SECTION 230923

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.
7. Insulated flexible ducts.

- B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: A single set of plans or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."
- C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
- D. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
 - 1. Construct ducts of galvanized sheet steel unless otherwise indicated.
- B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
 - 2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.
- C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." All longitudinal seams shall be Pittsburgh lock seams unless otherwise specified for specific application.
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SINGLE-WALL ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
1. Construct ducts of galvanized sheet steel unless otherwise indicated.
 2. For ducts exposed to weather, construct of Type 304 stainless steel indicated by manufacturer to be suitable for outdoor installation.
 3. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Elgen Manufacturing.
 - b. GSI; a DMI Company.
 - c. Linx Industries; a DMI company (formerly Lindab).
 - d. McGill AirFlow LLC.
 - e. MKT Metal Manufacturing.
 - f. Nordfab Ducting.
 - g. SEMCO, LLC; part of FlaktGroup.
 - h. Set Duct Manufacturing.
 - i. Sheet Metal Connectors, Inc.
 - j. Spiral Manufacturing Co., Inc.
 - k. Stamped Fittings Inc.
- B. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

- B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
 - 1. Galvanized Coating Designation: G90.
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.
 - 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- D. Tie Rods: Galvanized steel, 1/4-inch-minimum diameter for lengths 36 inches or less; 3/8-inch-minimum diameter for lengths longer than 36 inches.

2.5 DUCT LINER

- A. Fiberglass-Free Duct Liner: Made from partially recycled cotton or polyester products and containing no fiberglass. Airstream surface overlaid with fire-resistant facing to prevent surface erosion by airstream, complying with NFPA 90A or NFPA 90B. Treat natural-fiber products with antimicrobial coating.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Acoustical Surfaces, Inc.
 - b. Ductmate Industries, Inc; a DMI company.
 - 2. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature when tested in accordance with ASTM C518.
 - 3. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with ASTM E84; certified by an NRTL.
 - 4. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
- B. Insulation Pins and Washers:
 - 1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 - 2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel; with beveled edge sized as required to hold insulation securely in place, but not less than 1-1/2 inches in diameter.
- C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm or greater.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 - a. Fan discharges.
 - b. Intervals of lined duct preceding unlined duct.
 - c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

~~9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.~~

~~a. Sheet Metal Inner Duct Perforations: 3/32 inch diameter, with an overall open area of 23 percent.~~

10.9. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.6 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
- B. Water-Based Joint and Seam Sealant:
 1. Application Method: Brush on.
 2. Solids Content: Minimum 65 percent.
 3. Shore A Hardness: Minimum 20.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. VOC: Maximum 75 g/L (less water).

7. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

C. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

E. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.7 ASSEMBLY DESCRIPTION

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- C. Comply with the Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-RI."
- D. Comply with ASTM E96/E96M, "Test Methods for Water Vapor Transmission of Materials."

2.8 FLEXIBLE DUCT CONNECTORS

- A. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

2.9 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.
- E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A492.
- F. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. Trapeze and Riser Supports:
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - 2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
 - 3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.
- B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install ducts in maximum practical lengths with fewest possible joints.
- D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

- I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
- J. Install fire dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.
- K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."
- M. Elbows: Use long-radius elbows wherever they fit.
 - 1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
 - 2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.
- N. Branch Connections: Use lateral or conical branch connections.

3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- D. Repair or replace damaged sections and finished work that does not comply with these requirements.
- E. Install flexible ducts according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- F. Install in indoor applications only. Flexible ductwork should not be exposed to UV lighting.
- G. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.
- H. Connect diffusers or light troffer boots to ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.

I. Install duct test holes where required for testing and balancing purposes.

J. Installation:

1. Install ducts fully extended.
2. Do not bend ducts across sharp corners.
3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
5. Install flexible ducts in a direct line, without sags, twists, or turns.

K. Supporting Flexible Ducts:

1. Suspend flexible ducts with bands 1-1/2 inches wide or wider and spaced a maximum of 48 inches apart. Maximum centerline sag between supports shall not exceed 1/2 inch per 12 inches.
2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches o.c.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR LABORATORY EXHAUST AND FUME HOOD EXHAUST DUCTS

- A. Install ducts in accordance with NFPA 45, "Fire Protection for Laboratories Using Chemicals."
- B. Install exhaust ducts without dips and traps that may hold water. Slope ducts a minimum of 2 percent back to hood or inlet. Where indicated on Drawings, install trapped drain piping.
- C. Connect duct to fan, fume hood, and other equipment indicated on Drawings.

3.4 DUCTWORK EXPOSED TO WEATHER

- A. All external joints are to have secure watertight mechanical connections. Seal all openings to provide weatherproof construction.
- B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather. Provide necessary supporting structures.
- C. Single Wall:
 1. Ductwork shall be Type 304 stainless steel.
 2. Ductwork shall be galvanized steel.
 - a. If duct outer surface is uninsulated, protect outer surface with suitable paint. Paint materials and application requirements are specified in Section 099113 "Exterior Painting."

3. Where ducts have external insulation, provide weatherproof aluminum jacket. See Section 230713 "Duct Insulation."

3.5 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 2. Outdoor, Supply-Air Ducts: Seal Class A.
 3. Outdoor, Exhaust Ducts: Seal Class C.
 4. Outdoor, Return-Air Ducts: Seal Class C.
 5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
 6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
 7. Unconditioned Space, Exhaust Ducts: Seal Class C.
 8. Unconditioned Space, Return-Air Ducts: Seal Class B.
 9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
 10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
 11. Conditioned Space, Exhaust Ducts: Seal Class B.
 12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 1. Where practical, install concrete inserts before placing concrete.
 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.7 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.8 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Duct System Cleanliness Tests:
 - 1. Visually inspect duct system to ensure that no visible contaminants are present.
 - 2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
 - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
- C. Duct system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.10 DUCT CLEANING

- A. Clean new duct system(s) before testing, adjusting, and balancing.
- B. Use service openings for entry and inspection.

1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.11 STARTUP

- A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.12 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
 - 1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.
- B. Supply Ducts:
 - 1. Pressure Class: Positive 2-inch wg.
 - 2. Minimum SMACNA Seal Class: B.
- C. Return Ducts:
 - 1. Pressure Class: Positive or negative 1-inch wg.
 - 2. Minimum SMACNA Seal Class: B.
- D. Exhaust Ducts:
 - 1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
 - a. Pressure Class: Negative 2-inch wg.
 - b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.
 - 2. Ducts Connected to Fans Exhausting Fume Hood, Laboratory, and Process (ASHRAE 62.1, Class 3 and Class 4) Air:
 - a. Type 316, stainless-steel sheet.
 - 1) Exposed to View: No. 4 finish.
 - 2) Concealed: No. 2B finish.
 - b. Pressure Class: Positive or negative 3-inch wg.
 - c. Minimum SMACNA Seal Class A.
 - d. SMACNA Leakage Class 2.
- E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
 - 1. Ducts Connected to VAHU-3, VAHU-4, and Hood Exhaust Bypass:
 - a. Pressure Class: Positive or negative 1-inch wg.
 - b. Minimum SMACNA Seal Class: C.
- F. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.
 2. Stainless-Steel Ducts:
 - a. Exposed to Airstream: Match duct material.
 - b. Not Exposed to Airstream: Match duct material.
- G. Liner (where indicated on Drawings):
1. Supply-Air Ducts: Natural fiber, 1 inch thick.
 2. Return-Air Ducts: Natural fiber, 1 inch thick.
 3. Exhaust-Air Ducts: Natural fiber, 1 inch thick.
 4. Transfer Ducts: Natural fiber, 1 inch thick.
- H. Elbow Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - 4) Radius-to Diameter Ratio: 1.5.
 - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam or welded.
- I. Branch Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Conical spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm: Conical tap.
 - c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

- 1. Manual volume dampers.
- 2. Control dampers.
- 3. Fire dampers.
- 4. Duct silencers.
- 5. Turning vanes.
- 6. Duct-mounted access doors.
- 7. Flexible connectors.
- 8. Duct accessory hardware.
- ~~8-9.~~ Insulated flexible ducts.

- B. Related Requirements:

- 1. Section 284621.11 "Addressable Fire-Alarm Systems" for duct-mounted fire and smoke detectors.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, or BIM model, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from installers of the items involved.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with NFPA 90A and NFPA 90B.
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 ASSEMBLY DESCRIPTION

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- C. Comply with the Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1."
- D. Comply with ASTM E96/E96M, "Test Methods for Water Vapor Transmission of Materials."

2.2.3 MANUAL VOLUME DAMPERS

- A. Standard, Steel, Manual Volume Dampers:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Air Balance; a division of MESTEK, Inc.
 - b. Aire Technologies, Inc.; a DMI company.
 - c. American Warming and Ventilating; a Mestek Architectural Group company.
 - d. Arrow United Industries.
 - e. Cesco Products; a division of MESTEK, Inc.
 - f. Greenheck Fan Corporation.
 - g. Lloyd Industries, Inc.
 - h. McGill AirFlow LLC.
 - i. Nailor Industries Inc.
 - j. Pottorff.
 - k. Ruskin Company.
 - l. Safe Air - Dowco Products.
 - m. United Enertech.
 - n. Vent Products Co., Inc.

2. Performance:
 - a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. against 1-inch wg differential static pressure.
3. Construction:
 - a. Linkage out of airstream.
 - b. Suitable for horizontal or vertical airflow applications.
4. Frames:
 - a. Hat-shaped, 16-gauge-thick, galvanized sheet steel.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized steel; 16 gauge thick.
6. Blade Axles: Galvanized steel.
7. Bearings:
 - a. Oil-impregnated bronze.
 - b. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.
8. Tie Bars and Brackets: Galvanized steel.
9. Locking device to hold damper blades in a fixed position without vibration.

2.32.4 CONTROL DAMPERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. American Warming and Ventilating; a Mestek Architectural Group company.
 2. Arrow United Industries.
 3. Carnes Company.
 4. Cesco Products; a division of MESTEK, Inc.
 5. Greenheck Fan Corporation.
 6. Lloyd Industries, Inc.
 7. McGill AirFlow LLC.
 8. Metal Form Manufacturing, Inc.
 9. Nailor Industries Inc.
 10. NCA Manufacturing, Inc.
 11. Pottorff.
 12. Ruskin Company.

13. Safe Air - Dowco Products.
14. United Enertech.
15. Vent Products Co., Inc.
16. Young Regulator Company.

B. General Requirements:

1. Unless otherwise indicated, use parallel-blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed-blade configuration.
2. Factory or field assemble multiple damper sections to provide a single damper assembly of size required by the application.

C. Construction:

1. Linkage out of airstream.
2. Suitable for horizontal or vertical airflow applications.
3. Blades:
 - a. Multiple blade with maximum blade width of 6 inches.
 - b. Parallel or opposed-blade design.
 - c. Galvanized steel.
 - d. 16-gauge-thick single skin.
4. Blade Axles: 1/2-inch diameter; galvanized steel.
5. Blade-Linkage Hardware: Zinc-plated steel and brass; ends sealed against blade bearings. Linkage mounted out of air stream.
6. Bearings:
 - a. Oil-impregnated bronze.
 - b. Dampers mounted with vertical blades to have thrust bearings at each end of every blade.

D. Damper Actuator - Electric:

1. Electric - 120 V ac or 24 V ac.
2. UL 873, plenum rated.
3. Two position with fail-safe spring return.
 - a. Sufficient motor torque and spring torque to drive damper fully open and fully closed with adequate force to achieve required damper seal.
 - b. Minimum 90-degree drive rotation.
4. Clockwise or counterclockwise drive rotation as required for application.
5. Environmental Operating Range:
 - a. Temperature: Minus 40 to plus 130 deg F.
 - b. Humidity: 5 to 95 percent relative humidity noncondensing.
6. Environmental enclosure: NEMA 2.
7. Actuator to be factory mounted and provided with a single-point wiring connection.

- E. Controllers, Electrical Devices, and Wiring:
 - 1. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

2.42.5 FIRE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Air Balance; a division of MESTEK, Inc.
 - 2. Aire Technologies, Inc.; a DMI company.
 - 3. Arrow United Industries.
 - 4. Cesco Products; a division of MESTEK, Inc.
 - 5. CL WARD & Family Inc.
 - 6. Greenheck Fan Corporation.
 - 7. NCA Manufacturing, Inc.
 - 8. Pottorff.
 - 9. Prefco.
 - 10. Ruskin Company.
 - 11. Safe Air - Dowco Products.
 - 12. United Enertech.
 - 13. Vent Products Co., Inc.
- B. Type: Static and dynamic; rated and labeled in accordance with UL 555 by an NRTL.
- C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000 fpm velocity.
- D. Fire Rating: 1-1/2 hours.
- E. Frame: Curtain type with blades inside airstream; fabricated with roll-formed galvanized steel; with mitered and interlocking corners; gauge in accordance with UL listing.
- F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel; gauge in accordance with UL listing.
- G. Mounting Orientation: Vertical or horizontal as indicated.
- H. Blades: Roll-formed galvanized sheet steel, interlocking. Material gauge is to be in accordance with UL listing.
- I. Horizontal Dampers: Include blade lock and stainless steel closure spring.
- J. Heat-Responsive Device:
 - 1. Replaceable, 165 deg F rated, fusible links.

2.52.6 DUCT SILENCERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Flexmaster U.S.A., Inc.
 2. FläktGroup.
 3. IAC Acoustics.
 4. McGill AirFlow LLC.
 5. Metal Form Manufacturing LLC; United Eneritech Corp.
 6. Pottorff.
 7. Price Industries Limited (Basis of Design).
 8. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
 9. Vibro-Acoustics.
- B. General Requirements:
1. Factory fabricated.
 2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.
 3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 4. Bearing AMCA's Certified Ratings Seal for prefabricated silencer sound and air performance.
- C. Shape:
1. Rectangular straight with splitters or baffles.
 2. Rectangular elbow with splitters or baffles.
 3. Rectangular transitional with splitters or baffles.
- D. Construction:
1. Cross Talk silencers shall be constructed in accordance with ASHRAE and SMACNA Standards for the pressure and velocity classification specified for the air distribution system in which it is installed.
 2. Cross Talk silencers shall be constructed of:
 - a. 22 gauge solid steel casing.
 - b. 26 gauge solid steel internal noses at inlet and outlet.
 - c. 3/4-inch dual density absorptive fiberglass media.
 3. Cross Talk silencers shall be fastened with the use of button lock, Pittsburgh lock, and welds. Screws and other types of mechanical fasteners shall not be acceptable.
 4. Acoustic Media:
 - a. Acoustic media shall be shot-free inorganic glass fiber with long, resilient fibers, bonded with thermosetting resin.
 - b. Glass fiber shall be in accordance with erosion requirements of UL 181, and shall conform to the physical properties and requirements of ASTM C1071.

- E. Capacities and Characteristics: See schedule on Drawing.

2.62.7 TURNING VANES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Aero-Dyne Sound Control Co.
 - 2. CL WARD & Family Inc.
 - 3. Ductmate Industries, Inc; a DMI company.
 - 4. Duro Dyne Inc.
 - 5. DynAir; a Carlisle Company.
 - 6. Elgen Manufacturing.
 - 7. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Manufactured Turning Vanes for Metal Ducts: Fabricate curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
 - 1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
- C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
- E. Vane Construction:
 - 1. Single wall.

2.72.8 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Aire Technologies, Inc.; a DMI company.
 - 2. Arrow United Industries.
 - 3. Cesco Products; a division of MESTEK, Inc.
 - 4. CL WARD & Family Inc.
 - 5. Ductmate Industries, Inc; a DMI company.
 - 6. Duro Dyne Inc.
 - 7. Elgen Manufacturing.
 - 8. Flexmaster U.S.A., Inc.
 - 9. McGill AirFlow LLC.
 - 10. Ruskin Company.

11. United Enertech.
 12. Ventfabrics, Inc.
 13. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Duct-Mounted Access Doors: Fabricate access panels in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 7-2 (7-2M), "Duct Access Doors and Panels," and Figure 7-3, "Access Doors - Round Duct."
1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. 24-gauge-thick galvanized steel door panel.
 - d. Vision panel.
 - e. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - f. Fabricate doors airtight and suitable for duct pressure class.
 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.

2.82.9 FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. CL WARD & Family Inc.
 2. Ductmate Industries, Inc; a DMI company.
 3. Duro Dyne Inc.
 4. DynAir; a Carlisle Company.
 5. Elgen Manufacturing.
 6. Ventfabrics, Inc.
 7. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Fire-Performance Characteristics: Adhesives, sealants, fabric materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.
- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Materials: Flame-retardant or noncombustible fabrics.
- E. Coatings and Adhesives: Comply with UL 181, Class 1.
- F. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd..
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

2.92.10 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.11 INSULATED FLEXIBLE DUCTS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Flexmaster U.S.A., Inc.
 2. JP Lamborn Co.
 3. McGill AirFlow LLC.
 4. Thermaflex; a Flex-Tek Group company.
 5. Ward Industries; a brand of Hart & Cooley, LLC.
 6. Buckley Associates. Inc.
- B. Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
 2. Maximum Air Velocity: 4000 fpm.
 3. Temperature Range: Minus 20 to plus 175 deg F.
 4. Insulation R-Value: R6.
- B.—

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories in accordance with applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116 for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless steel accessories in stainless steel ducts, and aluminum accessories in aluminum ducts.

- C. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - 1. Install steel volume dampers in steel ducts.
 - 2. Install aluminum volume dampers in aluminum ducts.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install test holes at fan inlets and outlets and elsewhere as indicated and as needed for testing and balancing.
- G. Install fire dampers in accordance with UL listing.
- H. Install duct silencers with open end facing up. Do not connect to supply or return ductwork. Use duct silencers to connect spaces shown on Drawings, in order to comply with ASHRAE 15.
- I. Install access doors with swing against duct static pressure.
- J. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 8 by 5 inches.
 - 2. Two-Hand Access: 12 by 6 inches.
 - 3. Head and Hand Access: 18 by 10 inches.
- K. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- L. Install flexible connectors to connect ducts to equipment.
- M. Install duct test holes where required for testing and balancing purposes.
- N. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.
- O. Install flexible ducts according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- P. Install in indoor applications only. Flexible ductwork should not be exposed to UV lighting.
- Q. Connect diffusers or light troffer boots to ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.
- R. Connect flexible ducts to metal ducts with draw bands.
- S. Install duct test holes where required for testing and balancing purposes.

T. Installation:

1. Install ducts fully extended.
2. Do not bend ducts across sharp corners.
3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
5. Install flexible ducts in a direct line, without sags, twists, or turns.

U. Supporting Flexible Ducts:

1. Suspend flexible ducts with bands 1-1/2 inches wide or wider and spaced a maximum of 48 inches apart. Maximum centerline sag between supports shall not exceed 1/2 inch per 12 inches.
2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.

N.V. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches o.c.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors, and verify that size and location of access doors are adequate to perform required operation.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation, and verify that vanes do not move or rattle.

END OF SECTION 233300

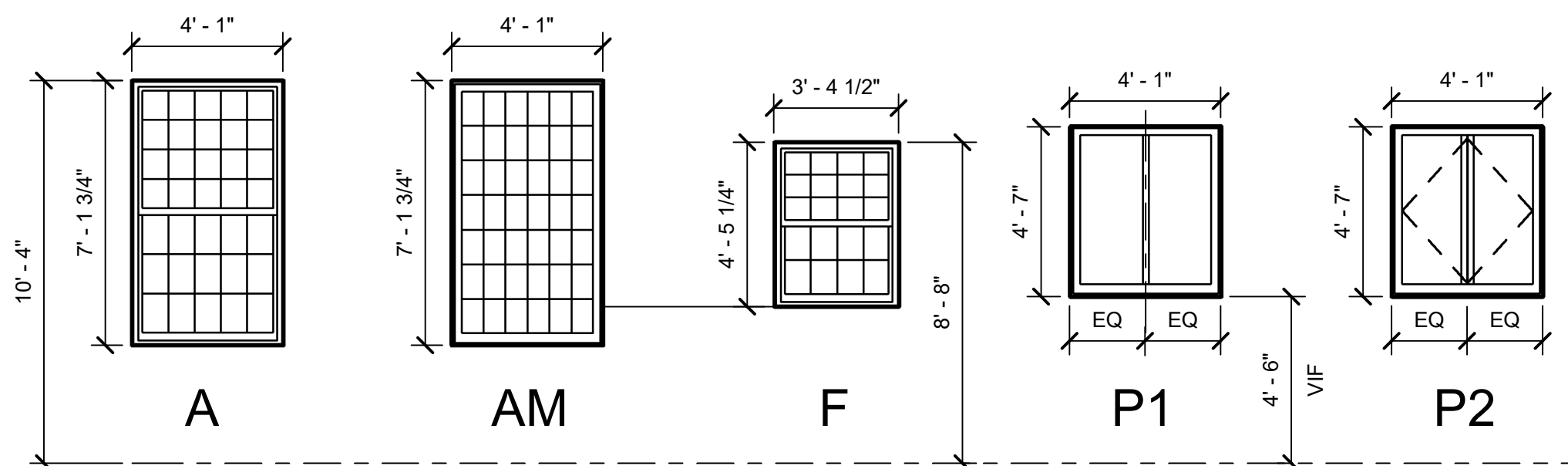
DOOR SCHEDULE														
NO.	DOOR WIDTH	HT	DOOR			STC	FIRE RATING	HWS	FRAME				SILL	COMMENTS
			THK	TYPE	MATL				HEAD	JAMB	JAMB			
001	2'-6"	7'-0"	VIF	1 3/4"	FL	WD		08	HM-1	HM	H1	J1		VERIFY EXISTING OPENING
002	2'-6"	7'-0"	VIF	1 3/4"	FL	WD		08	HM-1	HM	H1	J1		VERIFY EXISTING OPENING
004	3'-0"	7'-0"	1 3/4"	FL	WD		1 HR	8A	HM-1	HM	H1	J1		
005	3'-0"	7'-0"	1 3/4"	FL	WD			07	HM-1	HM	H1	J1		
006	3'-0"	7'-0"	1 3/4"	HG	WD			05	HM-1	HM	H1	J1		
007	3'-0"	7'-0"	1 3/4"	FL	WD			09	HM-1	HM	H1	J1		ACCESS CONTROL - COORDINATE WITH OWNER
010	3'-0"	7'-0"	1 3/4"	FL	WD			09	HM-1	HM	H1	J1		ACCESS CONTROL - COORDINATE WITH OWNER
010A	3'-0"	7'-0"	1 3/4"	FL	WD			09	HM-1	HM	H1	J1		ACCESS CONTROL - COORDINATE WITH OWNER
012	3'-0"	7'-0"	1 3/4"	HG	WD			09	HM-1	HM	H1	J1		ACCESS CONTROL - COORDINATE WITH OWNER
015	3'-0"	7'-0"	1 3/4"	FL	WD			1A	HM-1	HM	H2	J2		
016A	3'-0"	7'-0"	1 3/4"	FL	WD			1A	HM-1	HM	H2	J2		
016B	3'-0"	7'-0"	1 3/4"	FL	WD		1 HR	8A	HM-1	HM	H1	J1		
018A	3'-0"	7'-0"	1 3/4"	FL	WD			05	HM-1	HM	H1	J1		
018B	3'-0"	7'-0"	1 3/4"	FL	WD			05	HM-1	HM	H1	J1		
025	3'-0"	7'-0"	1 3/4"	SFG	AL	40		5A	AL-2B	AL	D6	C6	A6	
026	3'-0"	7'-0"	1 3/4"	SFG	AL	40		5A	AL-2A	AL	D6	C6	A6	
027	3'-0"	7'-0"	1 3/4"	SFG	AL	34		06	SL-1	AL	D1	C1	A1	
030	3'-0"	7'-0"	1 3/4"	FL	WD			09	HM-1	HM	H1	J1		ACCESS CONTROL - COORDINATE WITH OWNER
030C	3'-0"	7'-0"	1 3/4"	FL	WD			09	HM-1	HM	H1	J1		ACCESS CONTROL - COORDINATE WITH OWNER
031	3'-0"	7'-0"	1 3/4"	FL	WD			09	HM-1	HM	H1	J1		ACCESS CONTROL - COORDINATE WITH OWNER
034B	2'-0"	5'-8"	1 3/4"	FL2	HM			3B	HM-1	HM	H1	J1		2'-0" PAIR
035	3'-0"	7'-0"	1 3/4"	FL	WD			04	HM-1	HM	H1	J1		
036	3'-0"	7'-0"	1 3/4"	FL	WD			1B	HM-1	HM	H1	J1		
037	3'-0"	7'-0"	1 3/4"	FL	WD			04	HM-1	HM	H1	J1		
038	3'-0"	7'-0"	1 3/4"	FL	WD			04	HM-1	HM	H1	J1		
039	3'-0"	7'-0"	1 3/4"	FL	WD			04	HM-1	HM	H1	J1		
041	2'-6"	7'-0"	1 3/4"	FL	WD			08	HM-1	HM	H1	J1		
042A	3'-0"	7'-0"	1 3/4"	FL	WD			4A	HM-1	HM	H1	J1		
042B	3'-0"	7'-0"	1 3/4"	FL	WD		1 HR	8A	HM-1	HM	H1	J1		
042C	3'-0"	7'-0"	1 3/4"	FL	WD			4A	HM-1	HM	H1	J1		
044	5'-0"	7'-0"	1 3/4"	NL2	WD		1 HR	03	HM-2	HM	H2	J2		2' x 3' DOOR, 3' LEAF ON THE RIGHT
045	3'-0"	7'-0"	1 3/4"	SFG	AL	34		6A	SL-2	AL	D1	C1	A1	
046	7'-0"	7'-0"	1 3/4"	FL	WD	34		6B	SL-2	AL	D1	C1	A1	
101	3'-6"	7'-0"	1 3/4"	HG	HM			9A	HM-1	HM	H1	J1		ACCESS CONTROL - COORDINATE WITH OWNER
102A	3'-0"	7'-0"	1 3/4"	NL	WD		1 HR	2A	HM-1	HM	H1	J1		ACCESS CONTROL - COORDINATE WITH OWNER
102B	3'-0"	7'-0"	1 3/4"	HG	HM			9B	HM-1	HM	H1	J1		
103	3'-0"	7'-0"	1 3/4"	FL	WD		1 HR	2A	HM-1	HM	H1	J1		
103A	3'-0"	7'-0"	1 3/4"	FL	WD		1 HR	2B	HM-1	HM	H1	J1		
107	3'-0"	7'-0"	1 3/4"	FL	HM			07	HM-1	HM	H1	J1		
111	3'-0"	7'-0"	1 3/4"	HG	WD			3A	HM-2	HM	H1	J1		
113A	3'-0"	7'-0"	1 3/4"	HG	WD			05	HM-1	HM	H1	J1		
113B	3'-0"	7'-0"	1 3/4"	HG	WD			05	HM-1	HM	H1	J1		
115	3'-0"	7'-0"	1 3/4"	SFG	AL	40		6B	AL-4	AL	D6	C6	A6	
116	3'-0"	7'-0"	1 3/4"	SFG	AL	40		5B	AL-4	AL	D6	C6	A6	
117	3'-0"	7'-0"	1 3/4"	SFG	AL	34		6A	SL-4	AL	D1	C1	A1	
118	3'-0"	7'-0"	1 3/4"	SFG	AL	34		6A	SL-4	AL	D1	C1	A1	
119	3'-0"	7'-0"	1 3/4"	HG	WD			6A	SL-4	AL	D1	C1	A1	
120	3'-0"	7'-0"	1 3/4"	SFG	AL	34		06	SL-1	AL	D1	C1	A1	
120A	2'-0"	7'-0"	1 3/4"	DF	WD			8B	HM-2	HM	H1	J1		2'-0" PAIR
122	3'-0"	7'-0"	1 3/4"	FL	WD			01	HM-1	HM	H1	J1		
123	3'-0"	7'-0"	1 3/4"	FL	WD			1A	HM-1	HM	H1	J1		
126	3'-0"	7'-0"	1 3/4"	FL	WD			08	HM-1	HM	H1	J1		
127	3'-0"	7'-0"	1 3/4"	SFG	AL	40		5A	AL-1	AL	D6	C6	A6	
128	3'-0"	7'-0"	1 3/4"	FL	WD			08	HM-1	HM	H1	J1		
130	3'-0"	7'-0"	1 3/4"	SFG	AL	40		5A	AL-3	AL	D6	C6	A6	
135	3'-0"	7'-0"	1 3/4"	SFG	AL	34		06	SL-2	AL	D1	C1	A1	
137	3'-0"	7'-0"	1 3/4"	FL	WD			8B	HM-2	HM	H1	J1		3'-0" PAIR
139	3'-0"	7'-0"	1 3/4"	SFG	AL	34		6A	SL-3	AL	D1	C1	A1	
140	3'-0"	7'-0"	1 3/4"	SFG	AL	34		6A	SL-3	AL	D1	C1	A1	
141	3'-0"	7'-0"	1 3/4"	SFG	AL	34		6A	SL-1	AL	D1	C1	A1	
142	3'-0"	7'-0"	1 3/4"	SFG	AL	34		06	SL-1	AL	D1	C1	A1	
144	3'-0"	7'-0"	1 3/4"	FL	WD			08	HM-1	HM	H1	J1		
145	3'-0"	7'-0"	1 3/4"	SFG	AL	40		5A	AL-1	AL	D6	C6	A6	
146	3'-0"	7'-0"	1 3/4"	FL	WD			08	HM-1	HM	H1	J1		
149	3'-0"	7'-0"	1 3/4"	FL	WD			01	HM-1	HM	H1	J1		
150	3'-0"	7'-0"	1 3/4"	FL	WD			01	HM-1	HM	H1	J1		
151	2'-4"	7'-0"	1 3/4"	FL	WD			08	HM-1	HM	H1	J1		
152	3'-0"	7'-0"	1 3/4"	FL2	WD			8B	HM-2	HM	H1	J1		3'-0" PAIR
153	3'-0"	7'-0"	1 3/4"	SFG	AL	45		5C	AL-4	AL	D6	C6	A6	
201	3'-0"	7'-0"	1 3/4"	FL	WD		1 HR	02	HM-2	HM	H2	J2		ACCESS CONTROL - COORDINATE WITH OWNER
201A	3'-0"	7'-0"	1 3/4"	FL	WD		1 HR	02	HM-2	HM	H2	J2		ACCESS CONTROL - COORDINATE WITH OWNER
209	3'-0"	7'-0"	1 3/4"	SFG	AL	34		6A	SL-2	AL	D1	C1	A1	
210	3'-0"	7'-0"	1 3/4"	SFG	AL	34		6A	SL-2	AL	D1	C1	A1	
211	3'-0"	7'-0"	1 3/4"	FL	WD			01	HM-1	HM	H1	J1		
212	3'-0"	7'-0"	1 3/4"	FL	WD			01	HM-1	HM	H1	J1		
217	3'-0"	7'-0"	1 3/4"	SFG	AL	40		5A	AL-2B	AL	D6	C6	A6	
218	3'-0"	7'-0"	1 3/4"	SFG	AL	40		5A	AL-5b	AL	D6	C6	A6	
221	3'-0"	7'-0"	1 3/4"	FL2	WD			8B	HM-2	HM	H1	J1		3'-0" PAIR
222	3'-0"	7'-0"	1 3/4"	FL	WD			08	HM-1	HM	H1	J1		
223	3'-0"	7'-0"	1 3/4"	FL	WD			08	HM-1	HM	H1	J1		
224	3'-0"	7'-0"	1 3/4"	FL	WD			4A	HM-1	HM	H1	J1		
226	3'-0"	7'-0"	1 3/4"	SFG	AL	34		06	SL-3	AL	D1	C1	A1	
227	3'-0"	7'-0"	1 3/4"	SFG	AL	34		6A	SL-3	AL	D1	C1	A1	

DOOR SCHEDULE														
NO.	DOOR WIDTH	HT	DOOR			STC	FIRE RATING	HWS	FRAME				SILL	COMMENTS
			THK	TYPE	MATL				HEAD	JAMB	JAMB			
229	3'-0"	7'-0"	1 3/4"	SFG	AL	34		06	SL-1	AL	D1	C1	A1	
232	3'-0"	7'-0"	1 3/4"	FL	WD			01	HM-1	HM	H1	J1		
233	3'-0"	7'-0"	1 3/4"	FL	WD			01	HM-1	HM	H1	J1		
234	3'-0"	7'-0"	1 3/4"	SFG	AL	40		5A	AL-1	AL	D6	C6	A6	
235	3'-0"	7'-0"	1 3/4"	SFG	AL	40		5A	AL-1	AL	D6	C6	A6	
300A	3'-0"	7'-0"	1 3/4"	FL	WD		1 HR	02	HM-2	HM	H2	J2		
300B	3'-0"	7'-0"	1 3/4"	FL	WD		1 HR	02	HM-2	HM	H2	J2		
303	2'-4"	7'-0"	1 3/4"	FL	WD			08	HM-1	HM	H1	J1		
306A	3'-0"	7'-0"	1 3/4"	FL	WD			08	HM-1	HM	H1	J1		
307	3'-0"	7'-0"	1 3/4"	SFG	AL	34		06	SL-2	AL	D1	C1	A1	
308	3'-0"	7'-0"	1 3/4"	SFG	AL	34		6A	SL-2	AL	D1	C1	A1	
310	3'-0"	7'-0"	1 3/4"	SFG	AL	34		6A	SL-2	AL	D1	C1	A1	
311	3'-0"	7'-0"	1 3/4"	SFG	AL	34		6A	SL-2	AL	D1	C1	A1	
313	3'-0"	7'-0"	1 3/4"	SFG	AL	34		6A	SL-2	AL	D1	C1	A1	
314	3'-0"	7'-0"	1 3/4"	SFG	AL	34		6A	SL-2	AL	D1	C1	A1	
315	3'-0"	7'-0"	1 3/4"	FL	WD			1A	HM-1	HM	H2	J2		
316	3'-0"	7'-0"	1 3/4"	FL	WD			01	HM-1	HM	H2	J2		
317A	3'-0"	7'-0"	1 3/4"	FL	HM		1 HR	7A	HM-1	HM	H1	J1		
320	3'-0"	7'-0"	1 3/4"	SFG	AL	40		05	HM-1	HM	H1	J1		
321	3'-0"	7'-0"	1 3/4"	FL	WD			05	HM-2	HM	H2	J2		
323	3'-0"	7'-0"	1 3/4"	FL2	WD			8B	HM-2	HM	H2	J2		3'-0" PAIR
324	3'-0"	7'-0"	1 3/4"	FL	WD			08	HM-1	HM	H1	J1		
325	3'-0"	7'-0"	1 3/4"	FL	WD			4A	HM-1	HM	H1	J1		
326	3'-0"	7'-0"	1 3/4"	FL	WD			06	HM-1	HM	H1	J1		
327	3'-0"	7'-0"	1 3/4"	SFG										
331	3'-0"	7'-0"	1 3/4"	FL	HM	40	1 HR	7A	HM-1	HM	H1	J1		
332	3'-0"	7'-0"	1 3/4"	FL	WD			01	HM-1	HM	H1	J1		
333	3'-0"	7'-0"	1 3/4"	FL	WD			01	HM-1	HM	H1	J1		
334	3'-0"	7'-0"	1 3/4"	SFG	AL	40		5A	AL-6	AL	D6	C6	A6	
335	3'-0"	7'-0"	1 3/4"	SFG	AL	40		5A	AL-6	AL	D6	C6	A6	
E001A	3'-0"	7'-0"	1 3/4"	HG	EXIST			11			EXIST	EXIST	EXIST	ACCESS CONTROL - COORDINATE WITH OWNER
E003A	3'-0"	7'-0"	1 3/4"	FL	EXIST		1 HR	11						

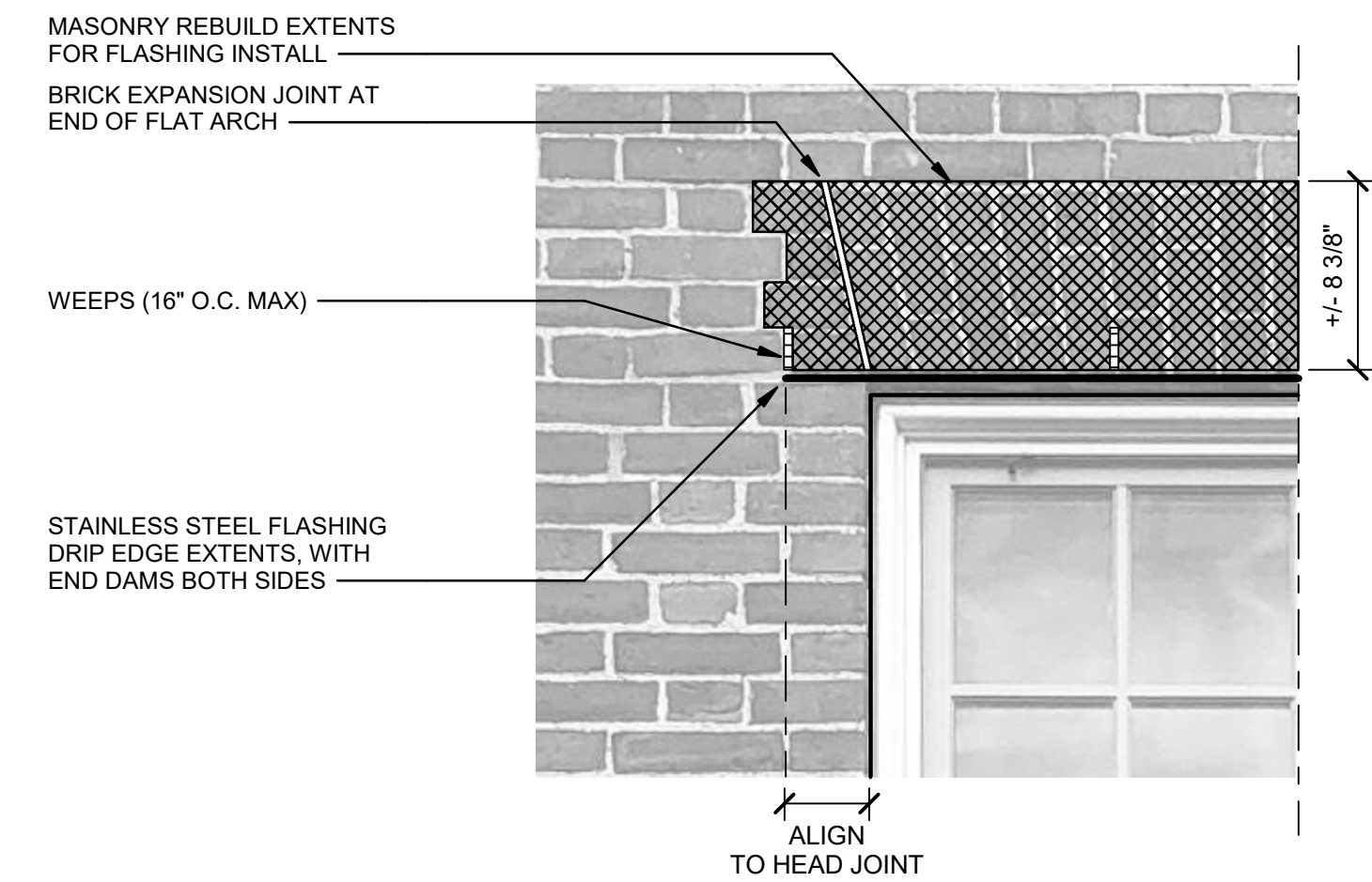
WINDOW SCHEDULE											
TYPE	R.O. HEIGHT	R.O. WIDTH	FINISH	GLAZING THICKNESS	GLAZING TYPE	HEAD DETAIL	SILL DETAIL	JAMB DETAIL	TYPE	OPERABLE	COMMENTS
A	7'-1 3/4"	4'-1"	ALUM CLAD WOOD	7/8" IGU		C1/AE621 OR D3/AE621	C1/AE621	A1/AE621	DOUBLE HUNG		
AM	7'-1 3/4"	4'-1"	ALUM CLAD WOOD	7/8" IGU		B3/AE621	B3/AE621	A3/AE621	FIXED		
F	4'-6"	3'-4 1/2"	ALUM CLAD WOOD	7/8" IGU		C1/AE621 OR D3/AE621	C1/AE621	A1/AE621	DOUBLE HUNG		
P1	4'-7"	4'-0"	ALUM CLAD WOOD	7/8" IGU	TEMPERED	E3/AE622	E3/AE622	C3/AE622	FAUX CASEMENT		
P2	4'-7"	4'-0"	ALUM CLAD WOOD	7/8" IGU	TEMPERED	E3/AE622	E3/AE622	C3/AE622	OPERABLE CASEMENT	INWARD SWINGING	

WINDOW SCHEDULE NOTES

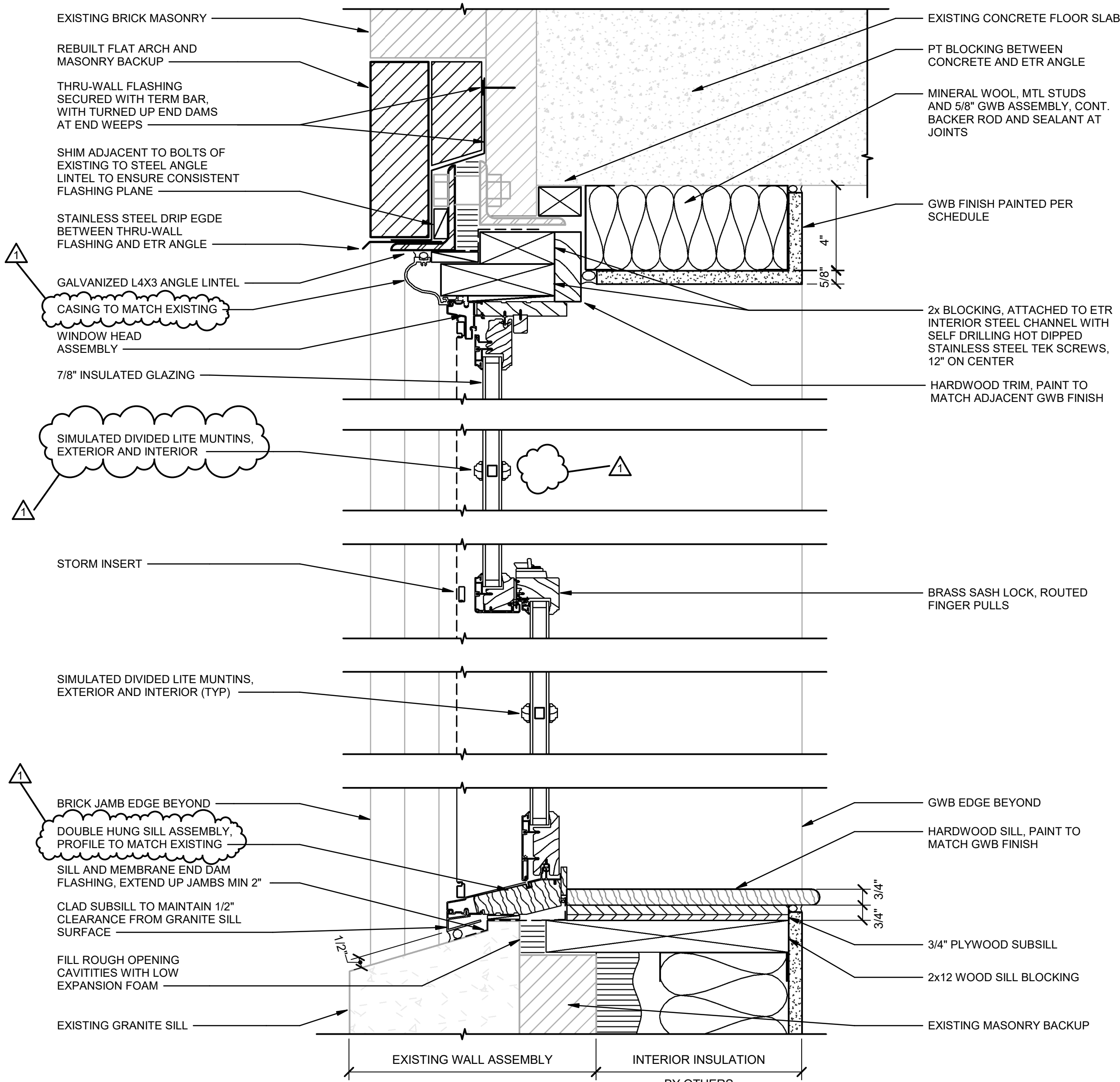
- BASIS OF DESIGN WINDOW MANUFACTURER TO BE MARVIN
 - 7/8" LOW-E ARGON INSULATING GLASS
 - WHITE SIMULATED DIVIDED LITE MUNTIONS ON BOTH EXTERIOR AND INTERIOR SIDES, WITH SPACER BARS, MATCHING EXISTING PROFILE(S)
 - APPLY CUSTOM EXTERIOR CASING AT JAMBS AND HEAD, WITH 2" JAMB EXTENSION
 - SASH MEETING RAILS AND JAMB PROFILE TO MATCH EXISTING
- PROVIDE PRESSURE TREATED BLOCKING IN THE DIMENSIONS REQUIRED TO SHIM WINDOWS PLUMB
 - FOAM SHIM SPACES WITH NON EXPANDING FOAM TO LIMIT THERMAL BRIDGING



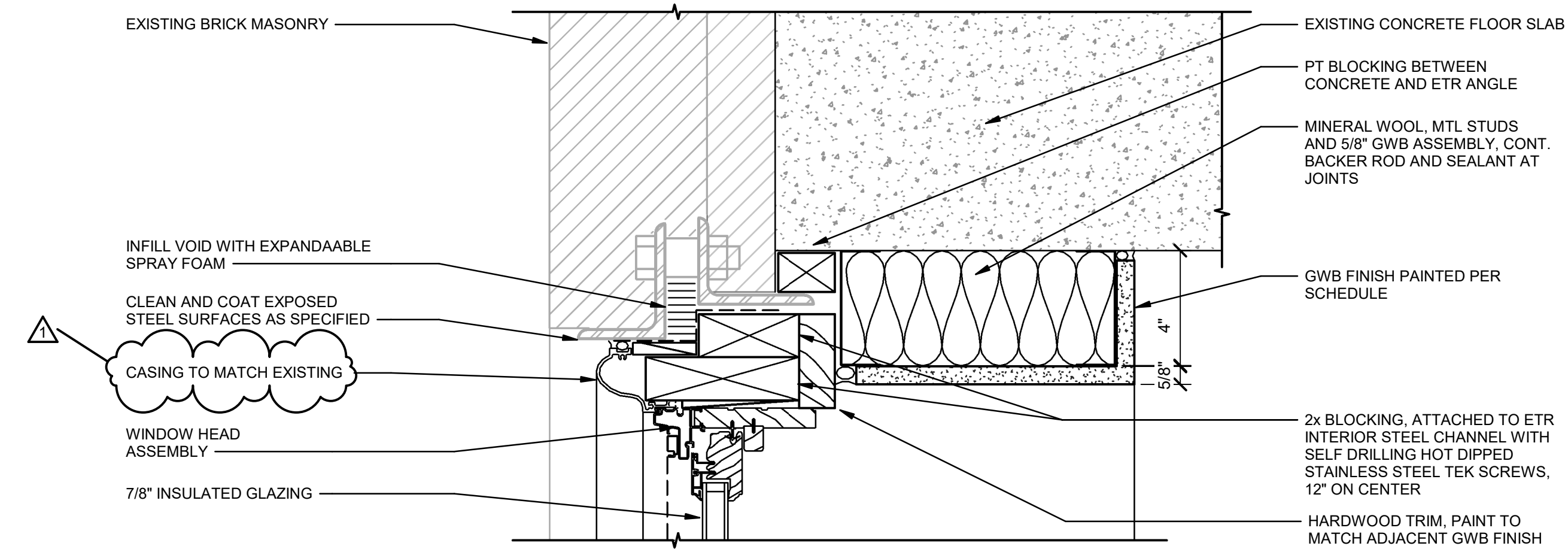
F3 WINDOW LEGEND
1/4" = 1'-0"



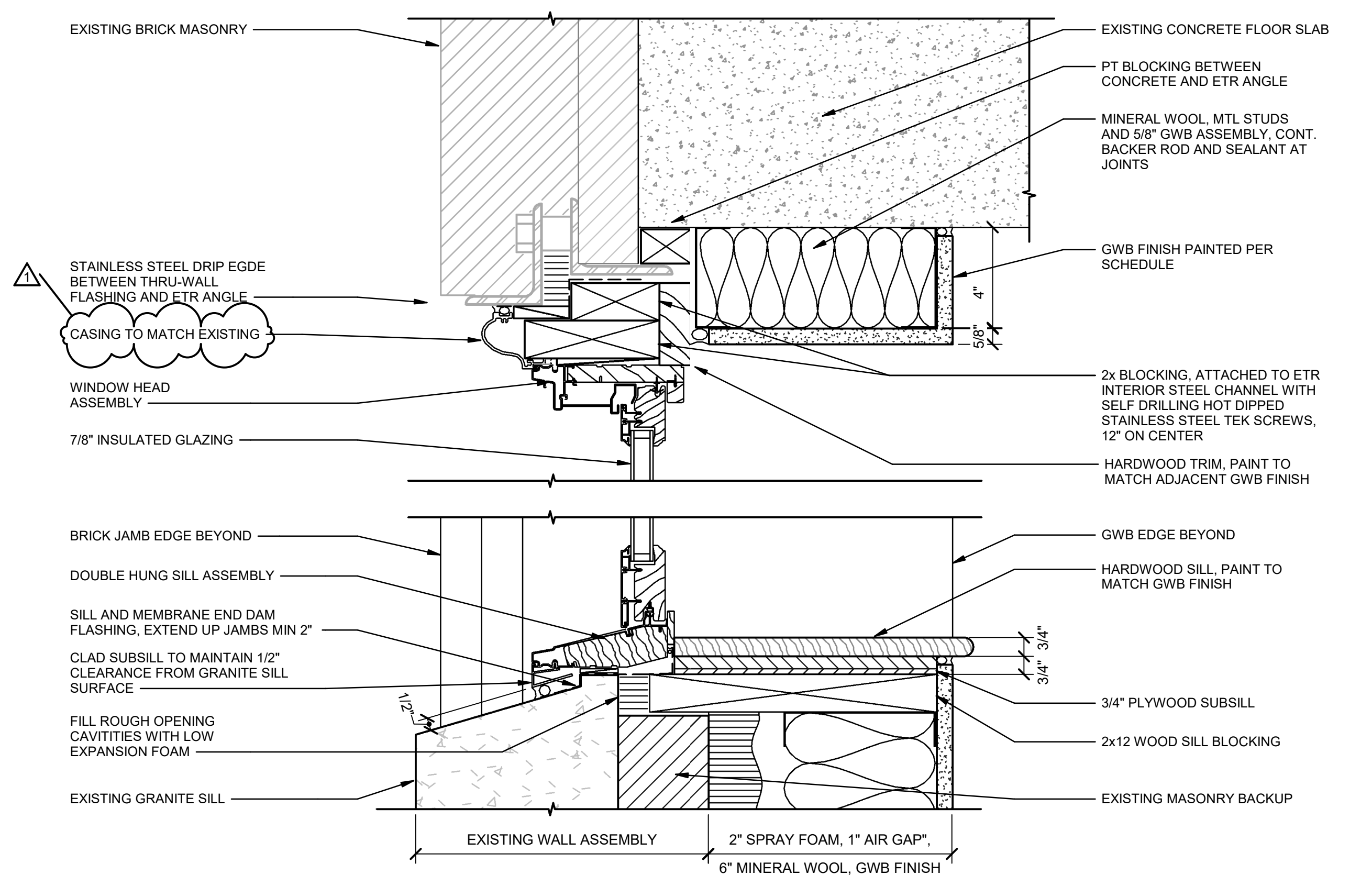
E6 WINDOW LINTEL REBUILD EXTENTS
1 1/2" = 1'-0"



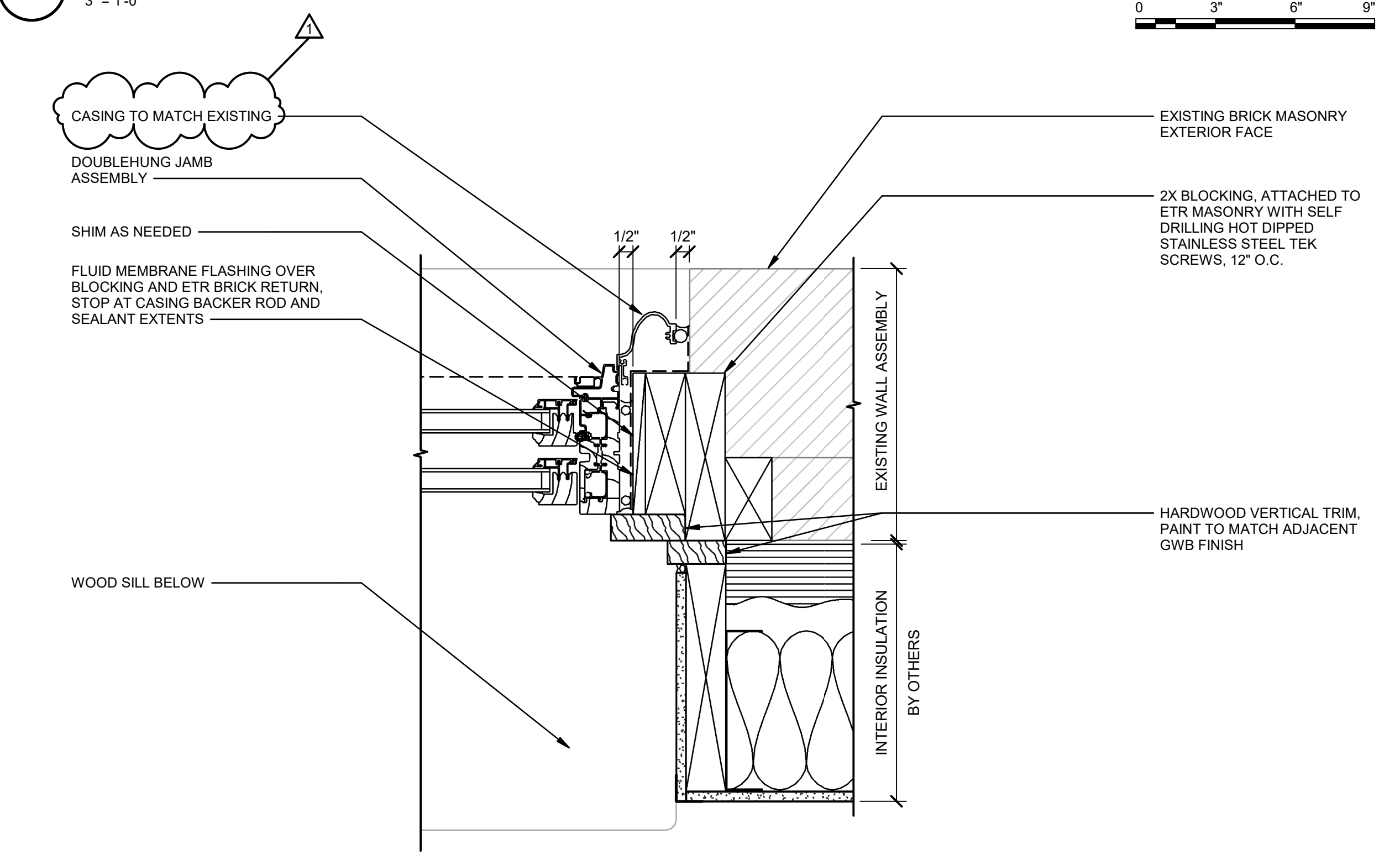
C1 A & F - DOUBLEHUNG HEAD AND SILL DETAILS (LINTEL REBUILD)
3" = 1'-0"



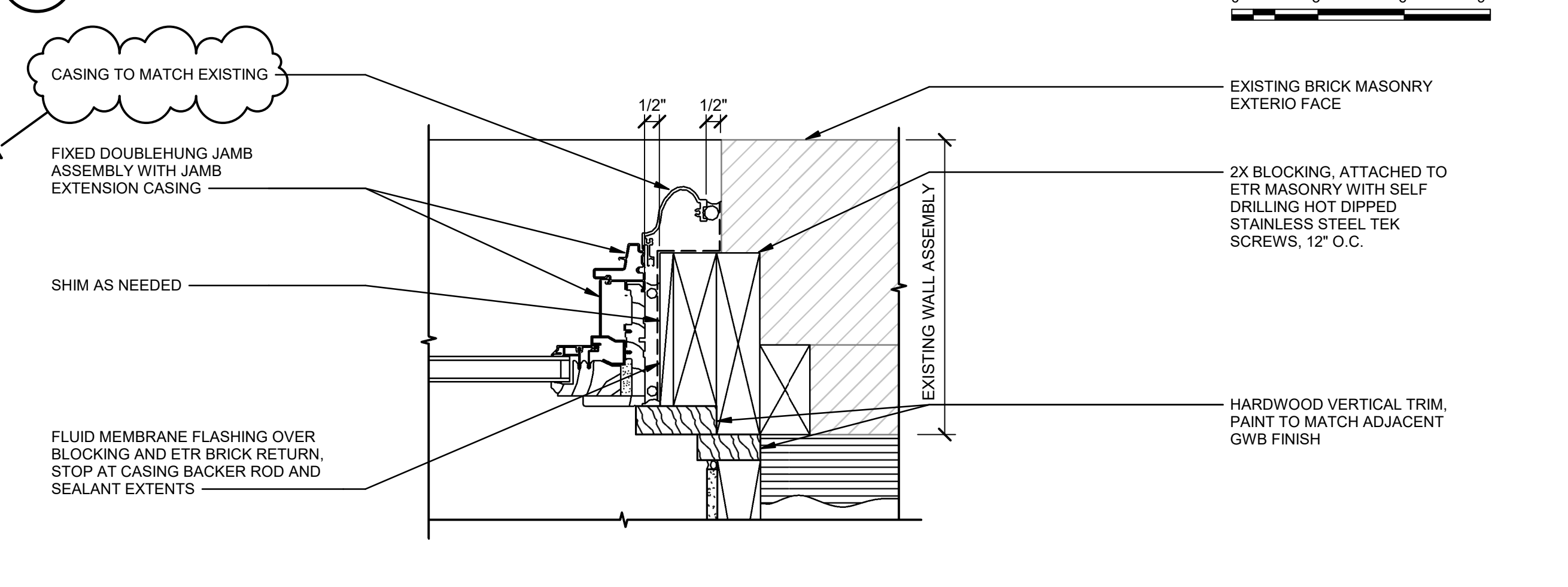
D3 A & F - DOUBLEHUNG HEAD (NON LINTEL REBUILD)
3" = 1'-0"



B3 AM - DOUBLEHUNG PICTURE WINDOW
3" = 1'-0"



A1 A & F - DOUBLEHUNG JAMB DETAIL
3" = 1'-0"



A3 AM - DOUBLEHUNG JAMB DETAIL
3" = 1'-0"

wood.
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LeMessurier.

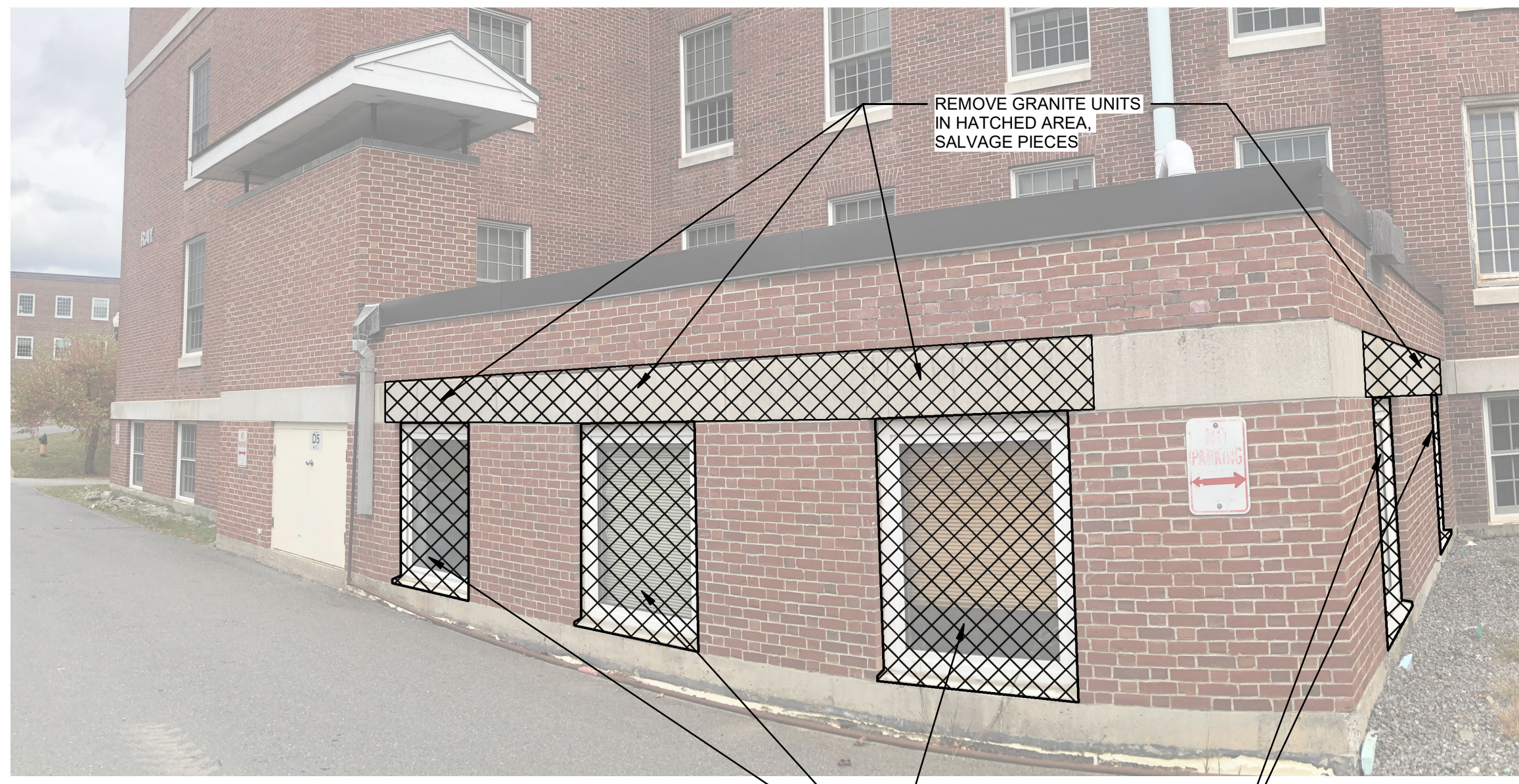
STATE OF MAINE
BUREAU OF GENERAL SERVICES
111 SEWALL STREET, 4TH FLOOR
AUGUSTA, MAINE 04333-0077
(207) 624-314



ISSUED FOR BID
MARCH 31, 2022
RAY BUILDING RENOVATION
28 TYSON DRIVE, AUGUSTA, MAINE

REV	DATE	ISSUED FOR BID	REVISION ISSUE DESCRIPTION
1	04-26-2022		ADDENDUM NO. 2
0	03-31-2022		ISSUED FOR BID

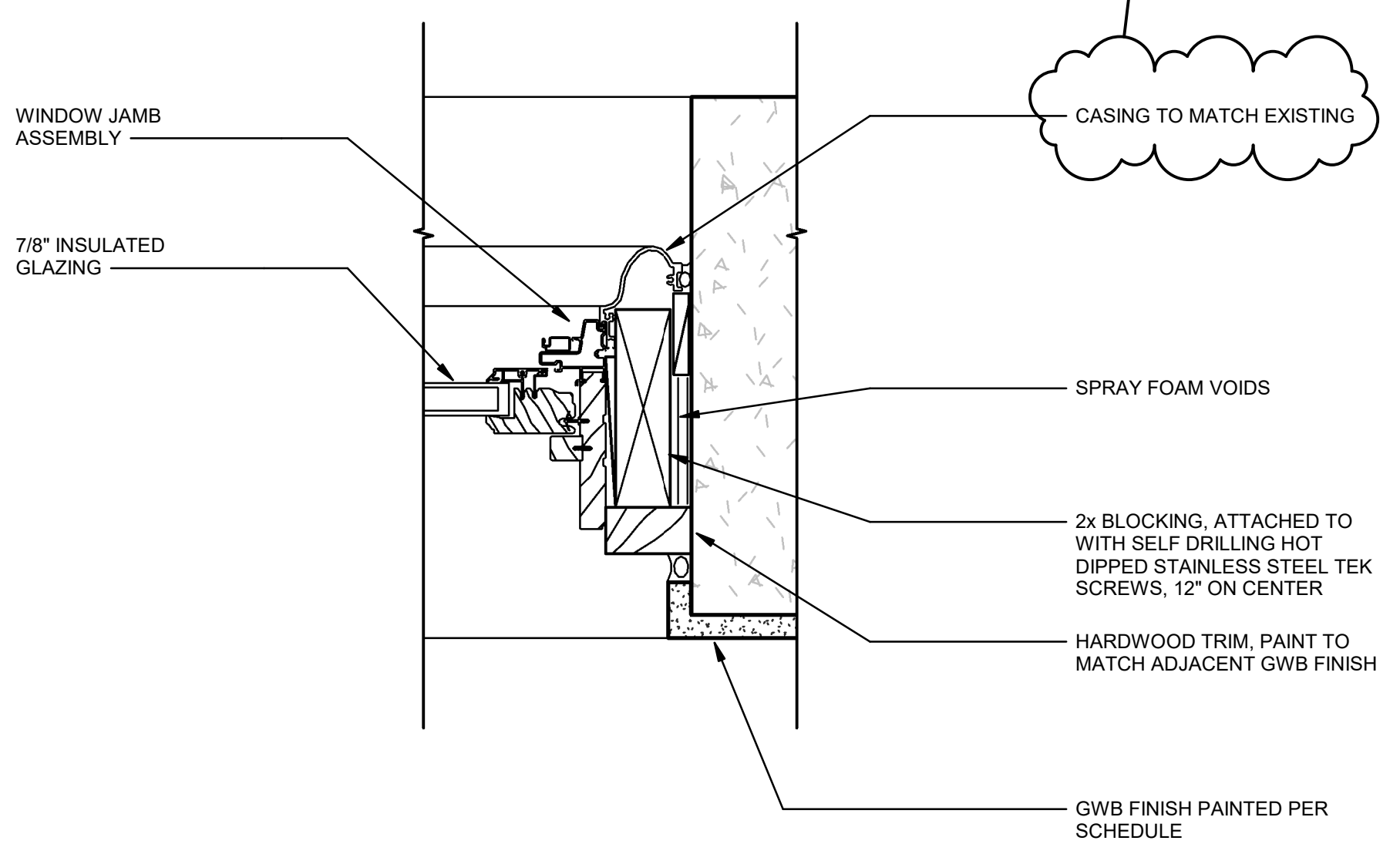
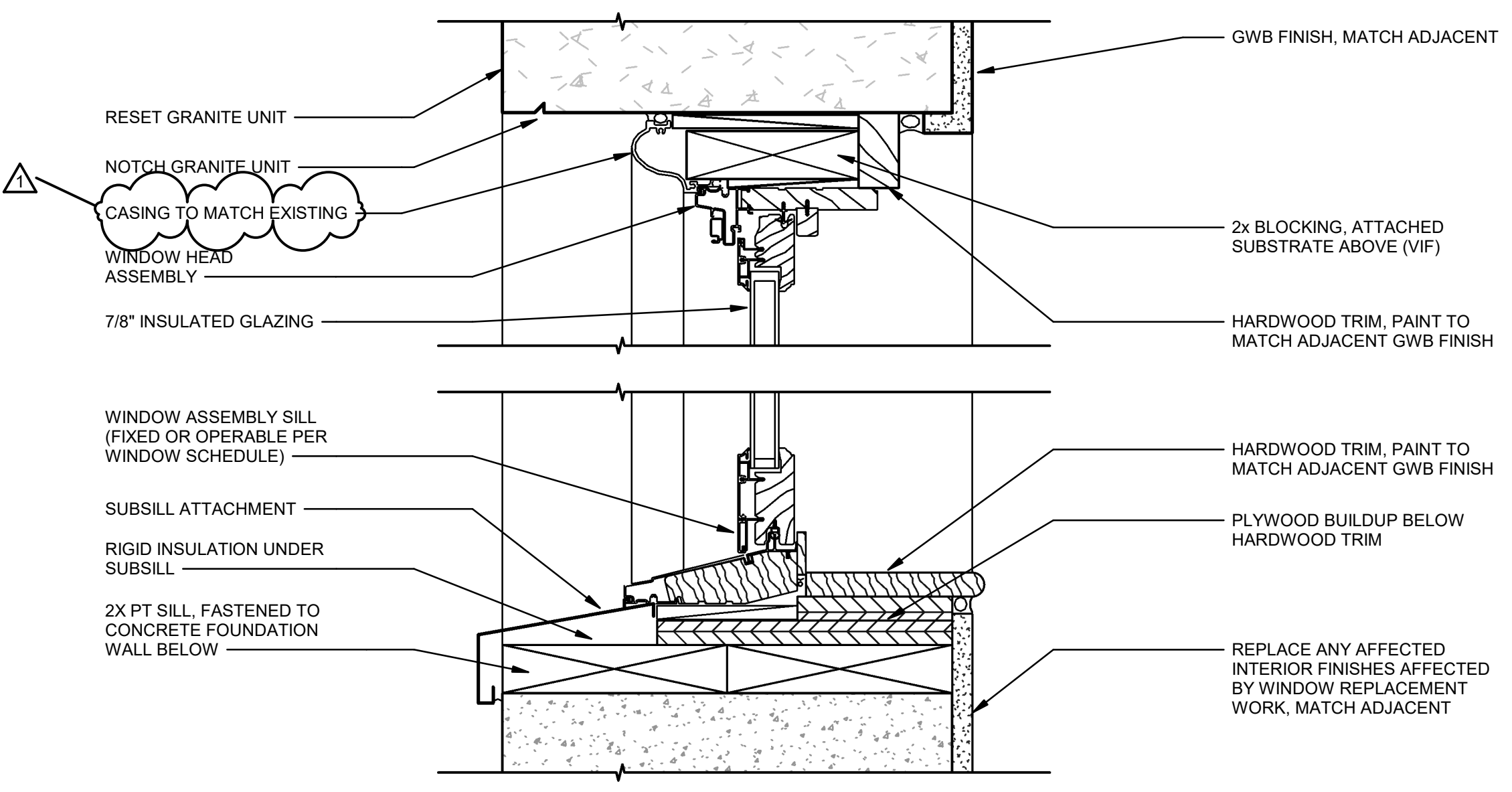
PROJECT NO: 3616206102
PROJECT MANAGER: KFM
A/E OF RECORD: DCM
DESIGNED BY: GJN
DRAWN BY: GJN
SHEET TITLE:
WINDOW SCHEDULE AND DETAILS
SHEET ID:
AE621



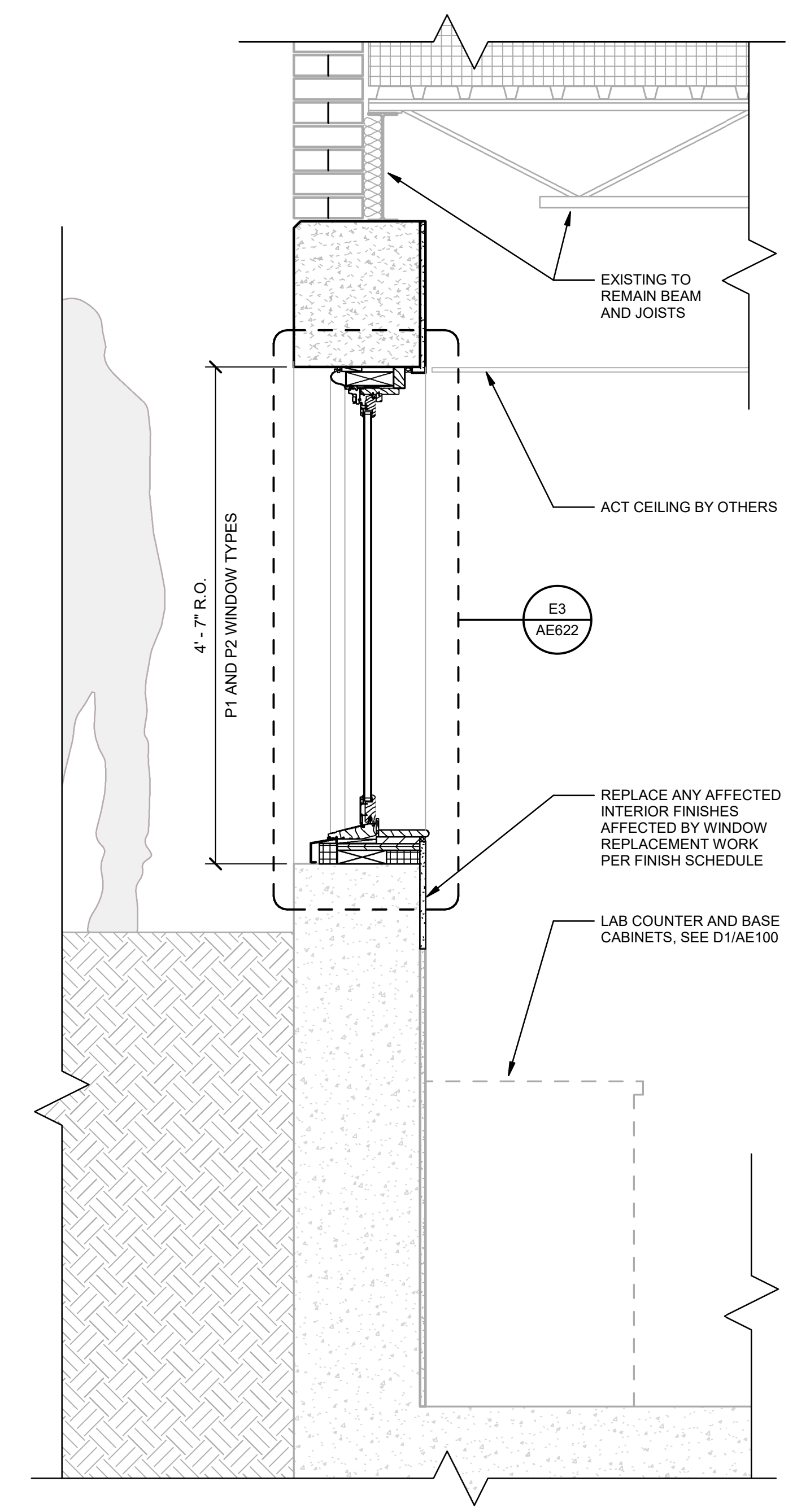
REMOVE GRANITE UNITS IN HATCHED AREA. SALVAGE PIECES.

REMOVE (5) LAB AREA FIXED WINDOW ASSEMBLY TO ROUGH OPENING EXTENTS

E1 LAB AREA WINDOWS
12" = 1'-0"

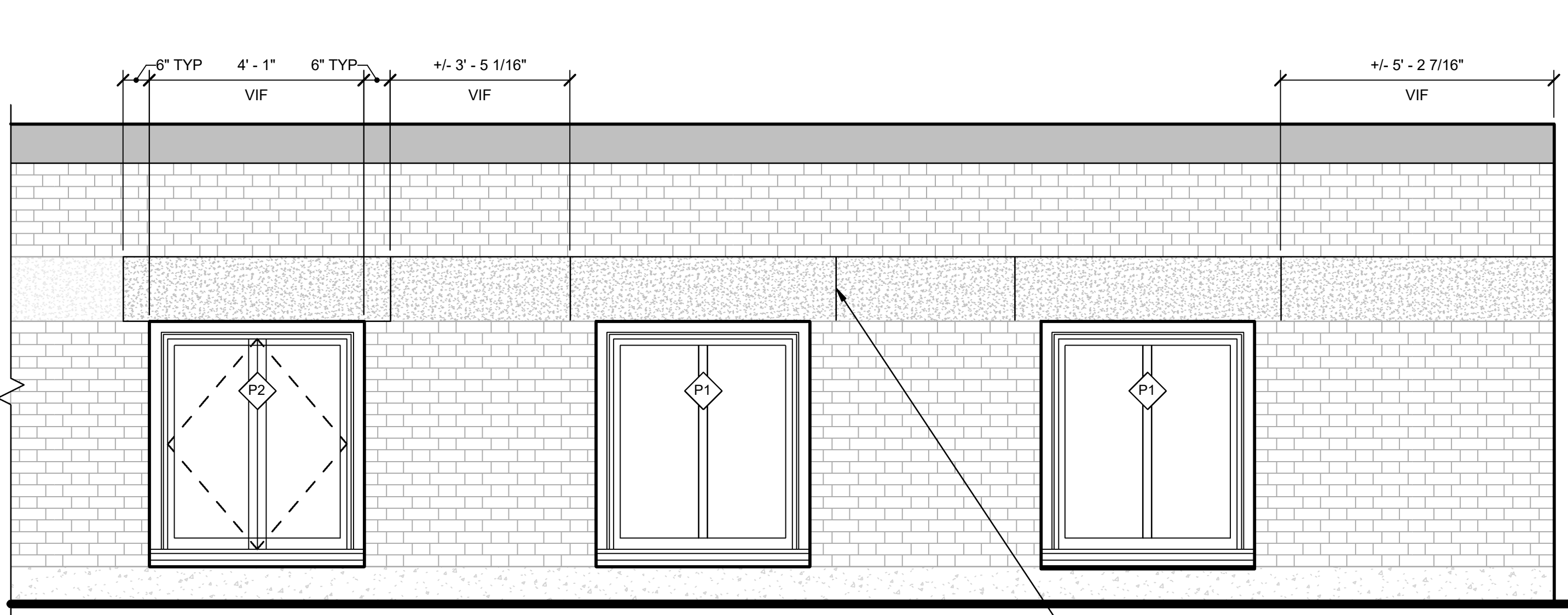


C3 P1 AND P2 HEAD AND JAMB DETAIL
3" = 1'-0"

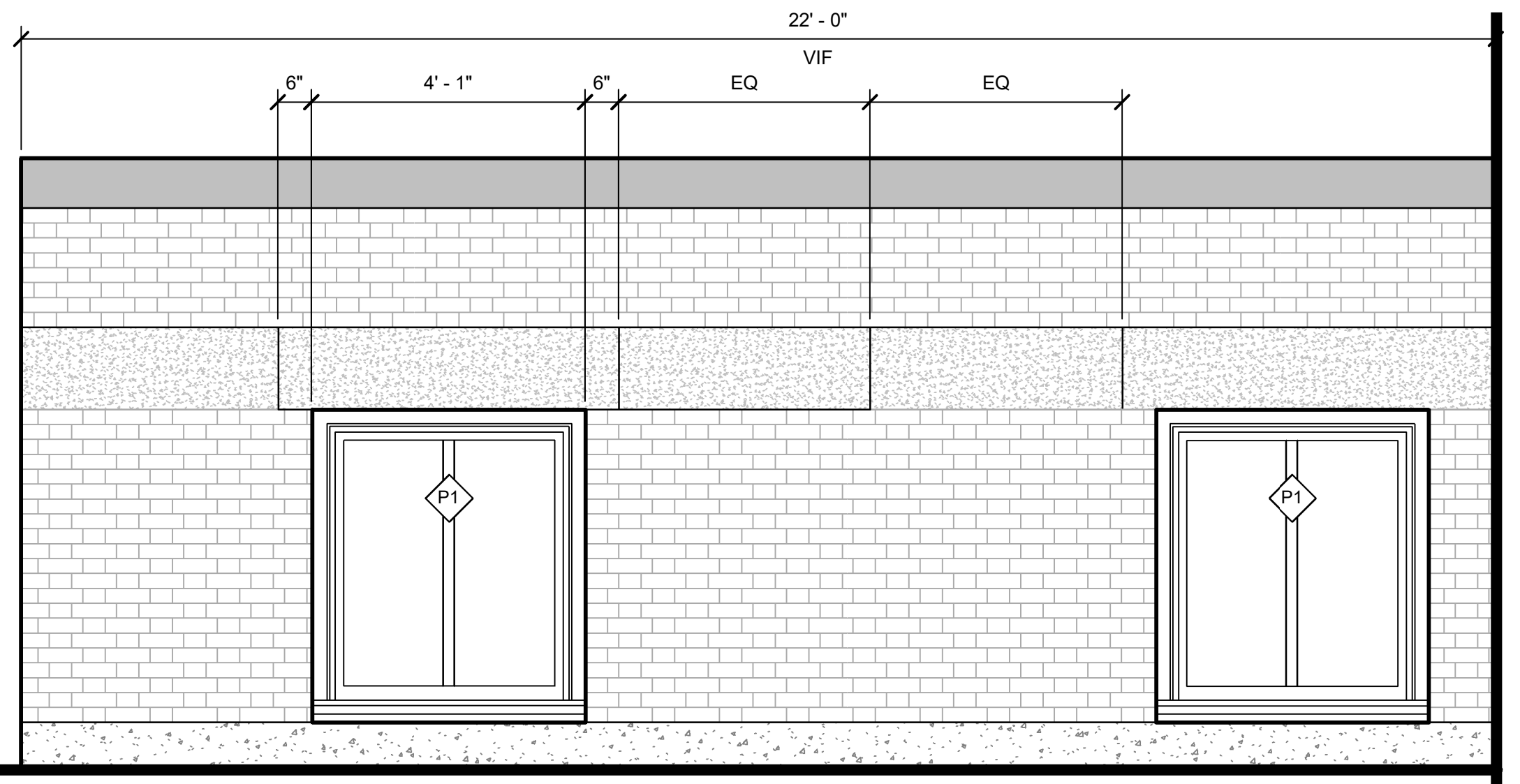


C5 LAB WALL SECTION (TYP)
1" = 1'-0"
NOTE: ALL NEW GLAZING WITHIN NEW WINDOWS OF LAB SPACE ARE TO BE TEMPERED.

E3 P1 AND P2 HEAD AND SILL DETAILS
3" = 1'-0"



WEST ELEVATION



SOUTH ELEVATION

DRILL AND EPOXY (2) THREADED RODS OR REBAR INTO EXISTING GRANITE HEADERS, ALIGN BAR LOCATIONS WITH ADJACENT HEADERS, V.I.F. 6" EMBEDMENT OF RODS MIN.

A1 LAB AREA EXTERIOR ELEVATIONS
1/2" = 1'-0"

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MARCH 31, 2022
RAY BUILDING RENOVATION
28 TYSON DRIVE, AUGUSTA, MAINE

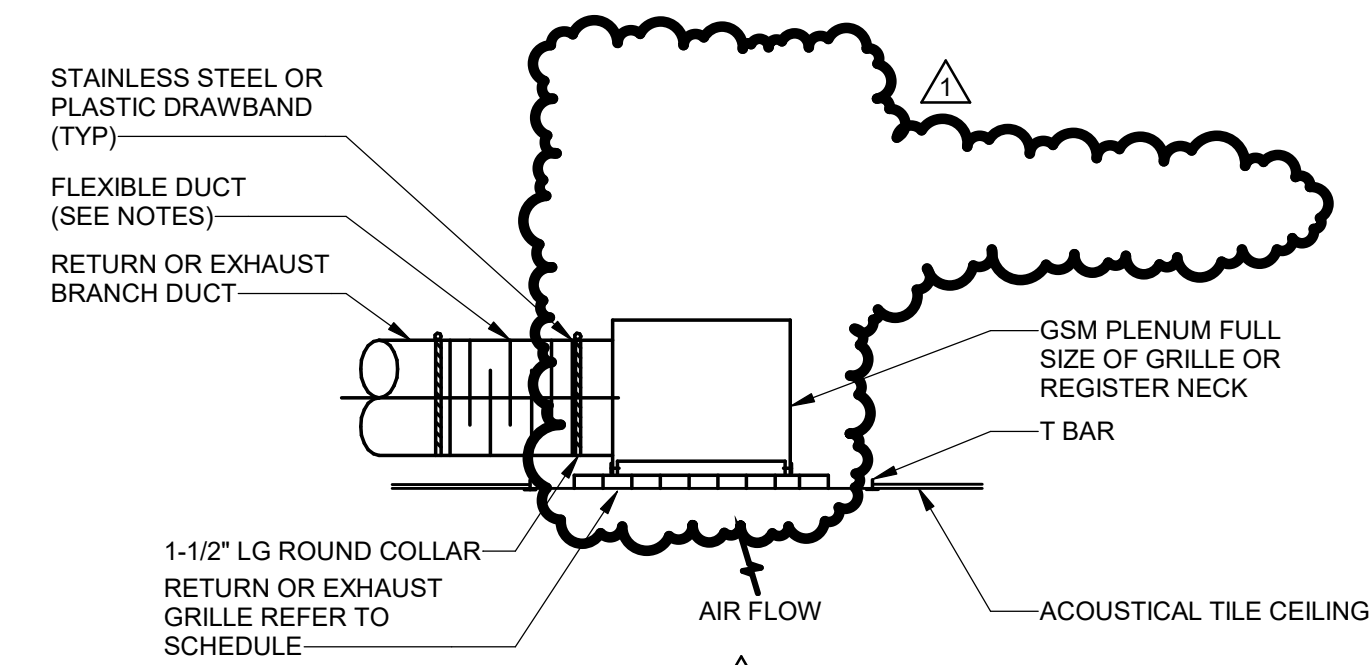
PROJECT NO.	3616206102
PROJECT MANAGER:	KFM
A/E OF RECORD:	EAI
DESIGNED BY:	JRB
DRAWN BY:	GJN
SHEET TITLE:	LAB AREA WINDOW ELEVATIONS AND DETAILS
SHEET ID:	AE622

1 ADDENDUM NO. 2
0 ISSUED FOR BID
REV REVISION ISSUE DESCRIPTION DATE
04-26-2022
03-31-2022

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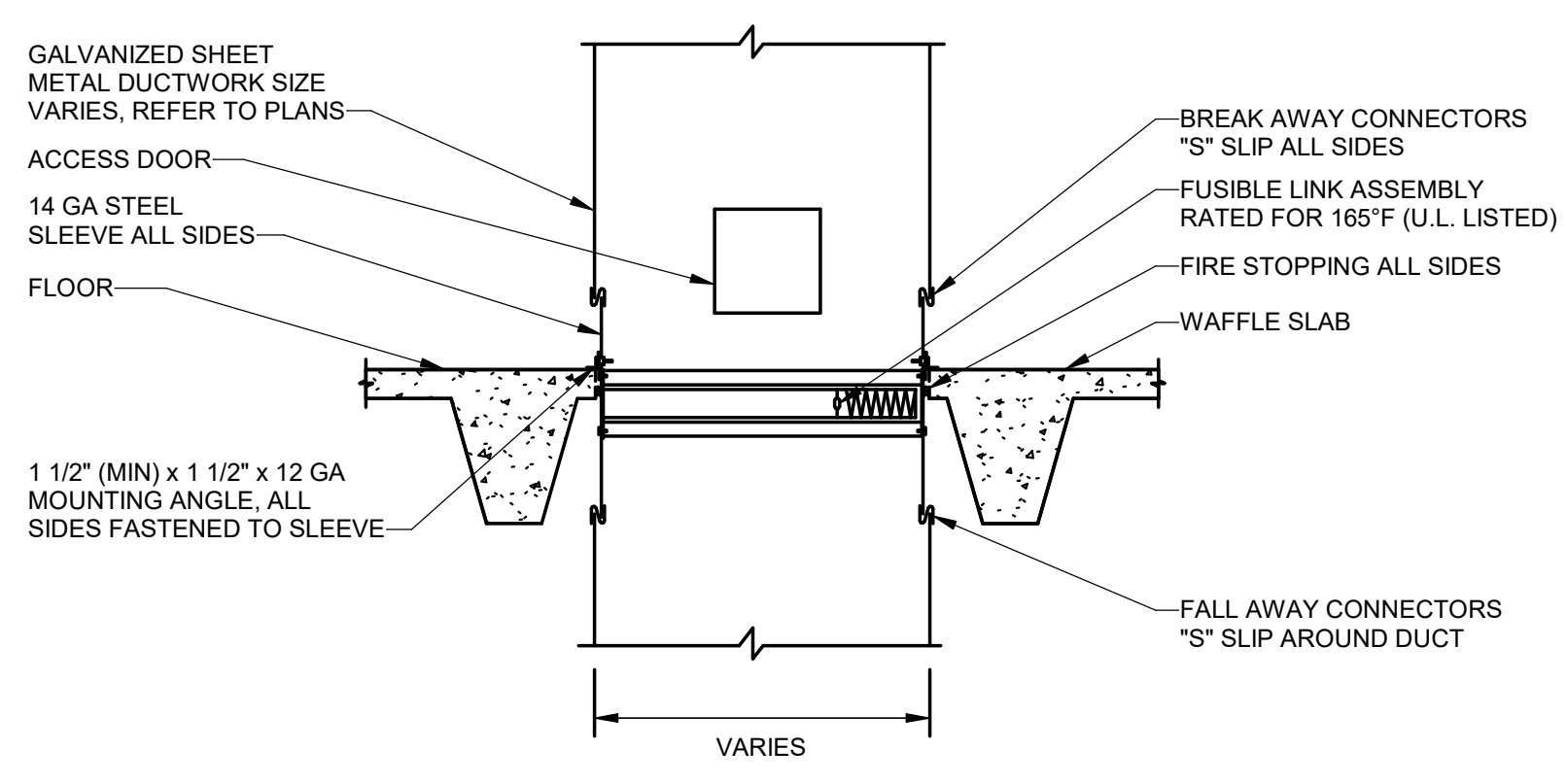
NOTES

1. SEE SHEET M-001 FOR LEGEND, ABBREVIATIONS AND GENERAL NOTES.

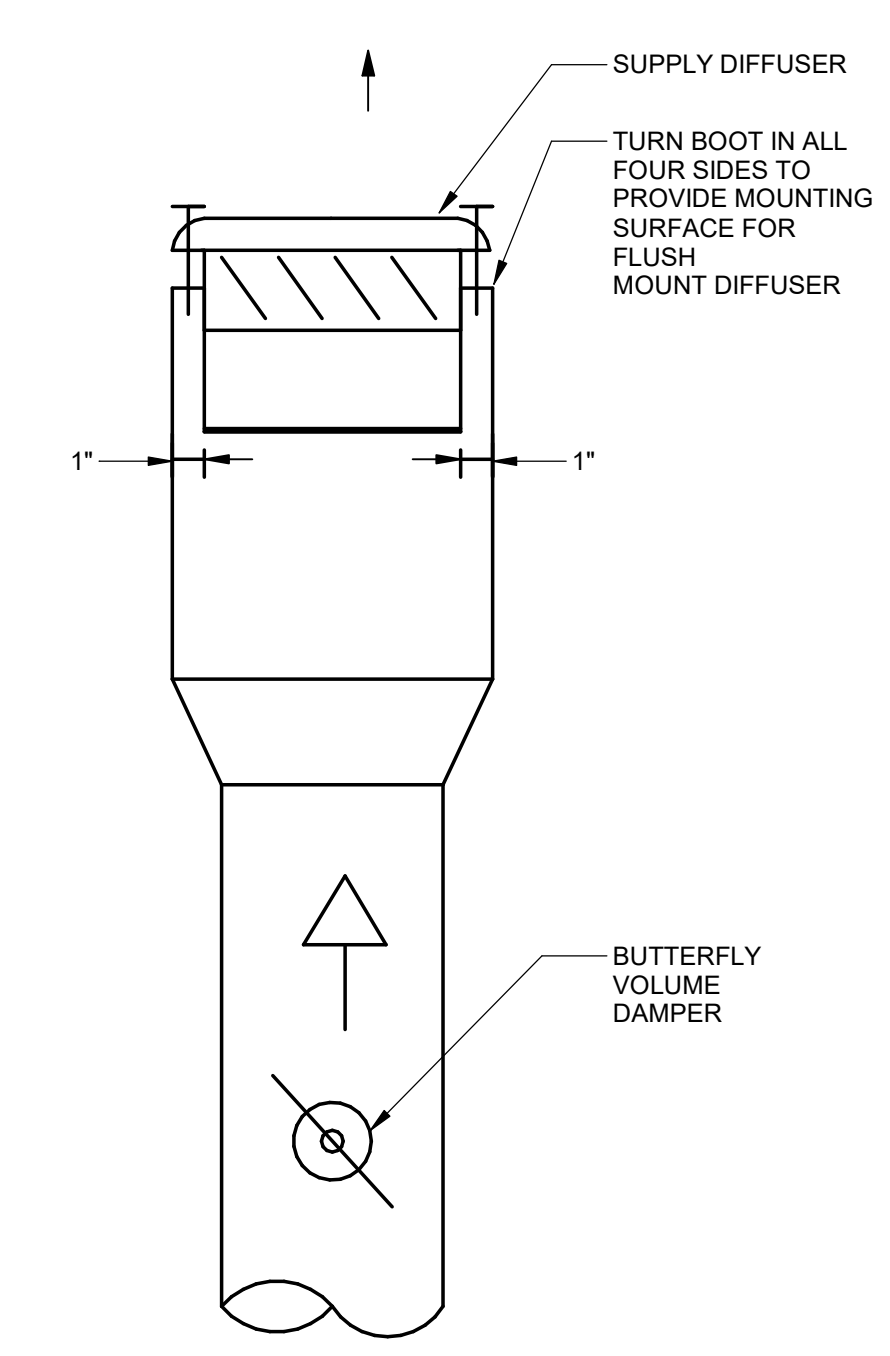


- NOTES:**
1. FLEXIBLE DUCT LENGTH SHALL NOT EXCEED 10'
 2. PROVIDE INSULATION AS REQUIRED PER THE SPECIFICATIONS.
 3. BRANCH DUCT CONNECTION TO PLENUM MAY BE FROM TOP OR SIDES.

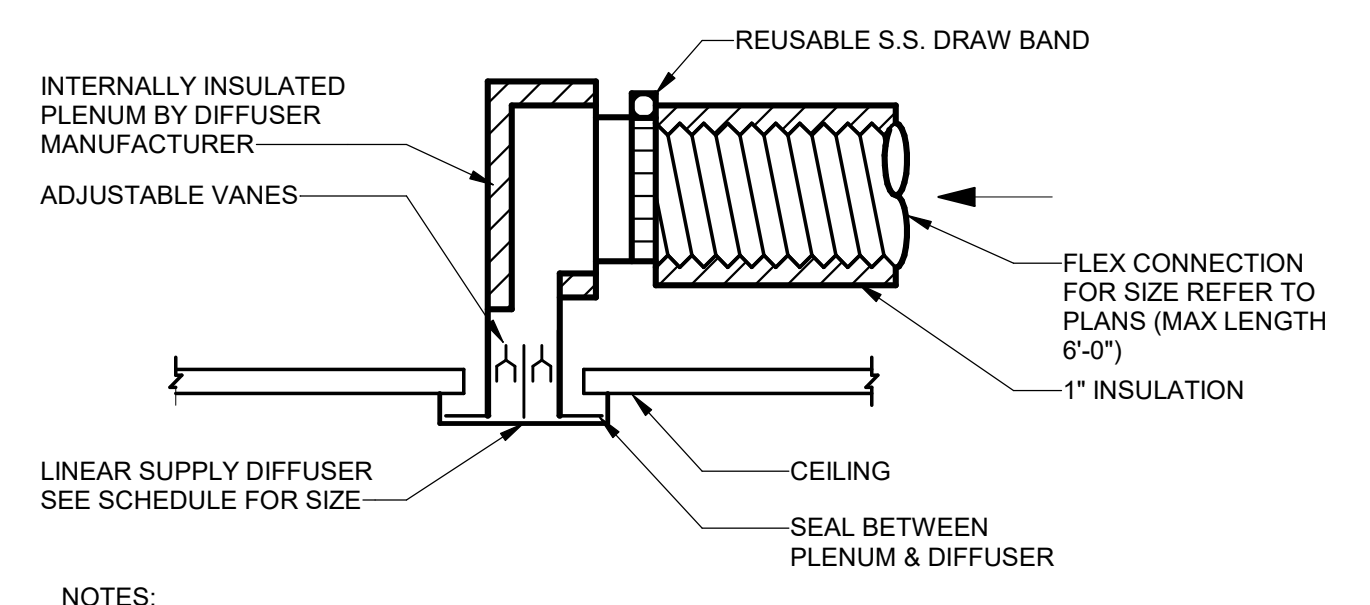
E1 RETURN/EXHAUST GRILLE DUCT CONNECTION DETAIL
NOT TO SCALE



E3 FIRE DAMPER THROUGH WAFFLE SLAB DETAIL
NOT TO SCALE

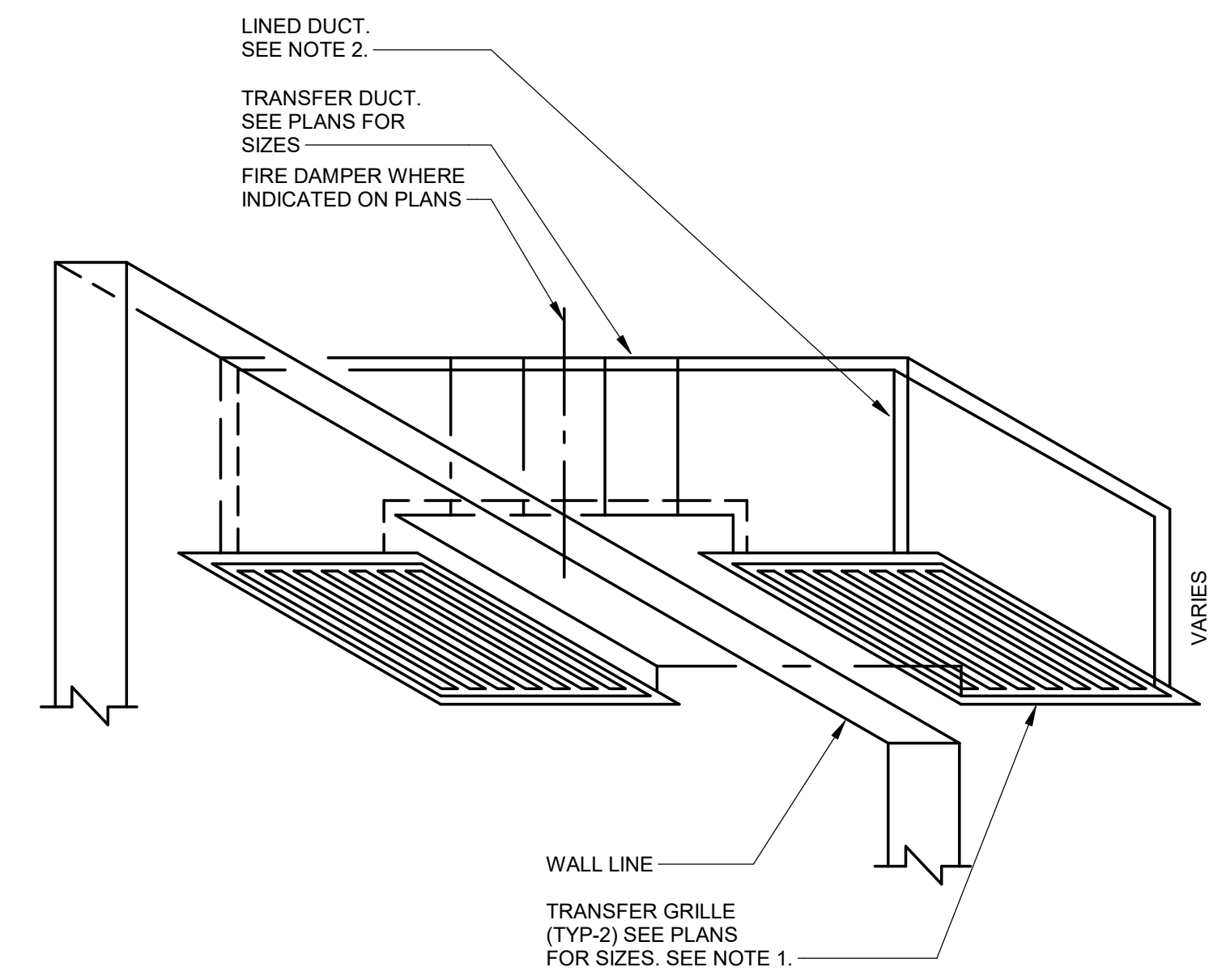


E5 DUCT BOOT DETAIL
NOT TO SCALE



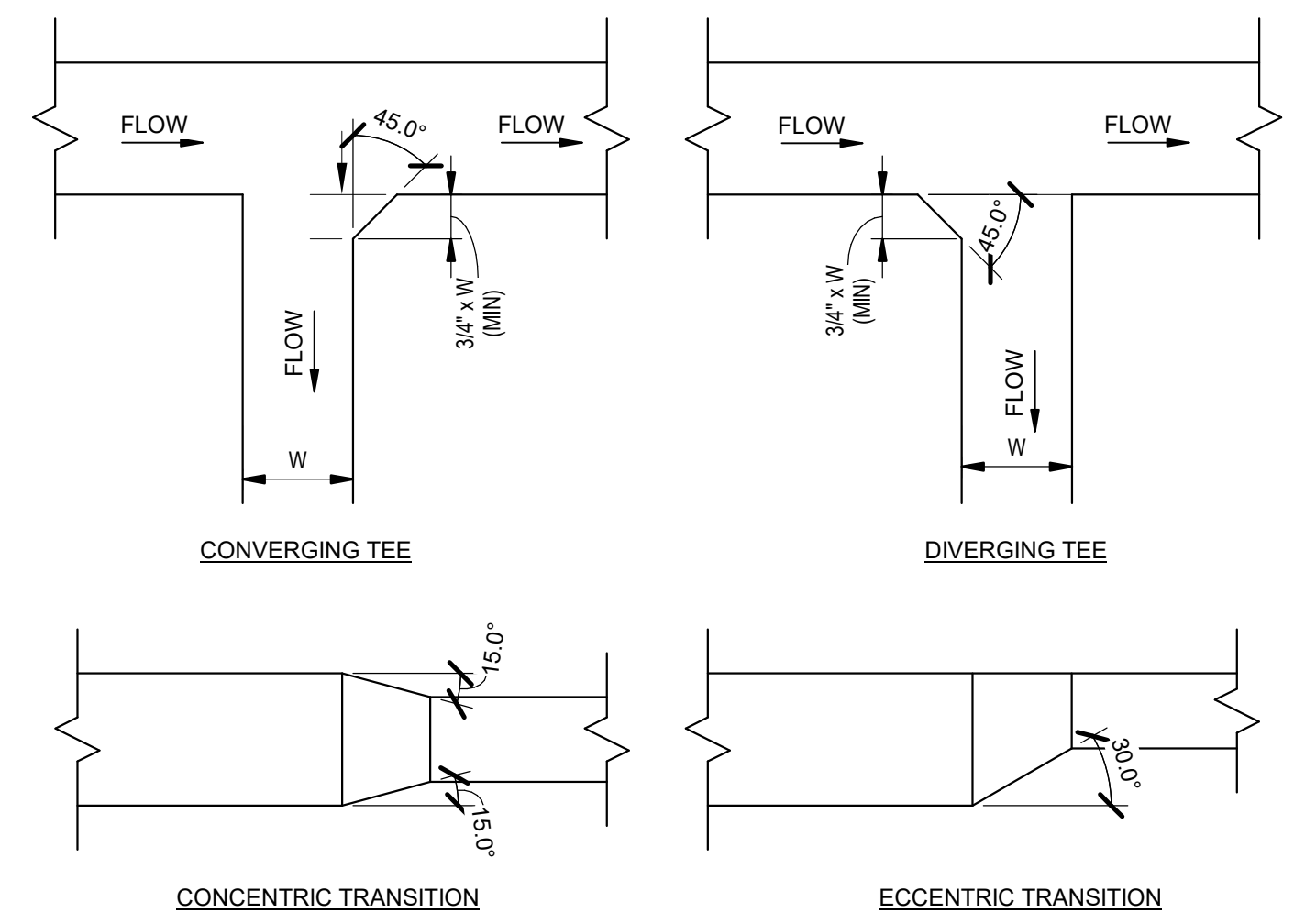
- NOTES:**
1. OFFSETS W/ FLEX DUCT SHALL NOT EXCEED 30\"/>
 - 2. FLEX DUCT SHALL NOT HAVE MORE THAN 1/3\"/>
 - 3. FOR PLENUM LENGTH REFER TO PLANS.

D3 LINEAR DIFFUSER PLENUM DETAIL
NOT TO SCALE

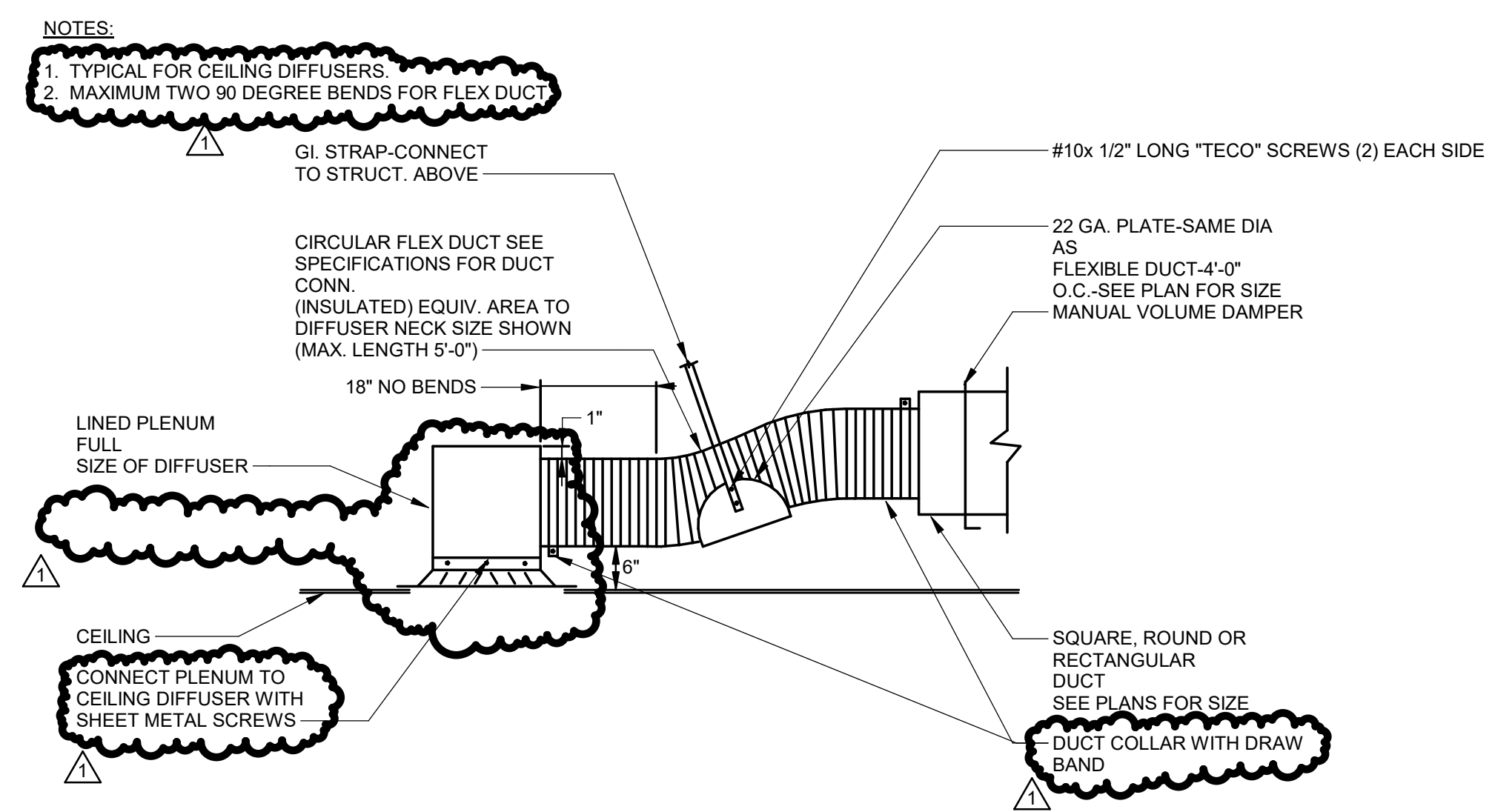


- NOTES:**
1. PROVIDE WALL REGISTER WHEN THE ROOM HAS NO CEILING.
 2. PROVIDE ADDITIONAL ELBOW IN RESTROOMS AS SHOWN ON PLANS.

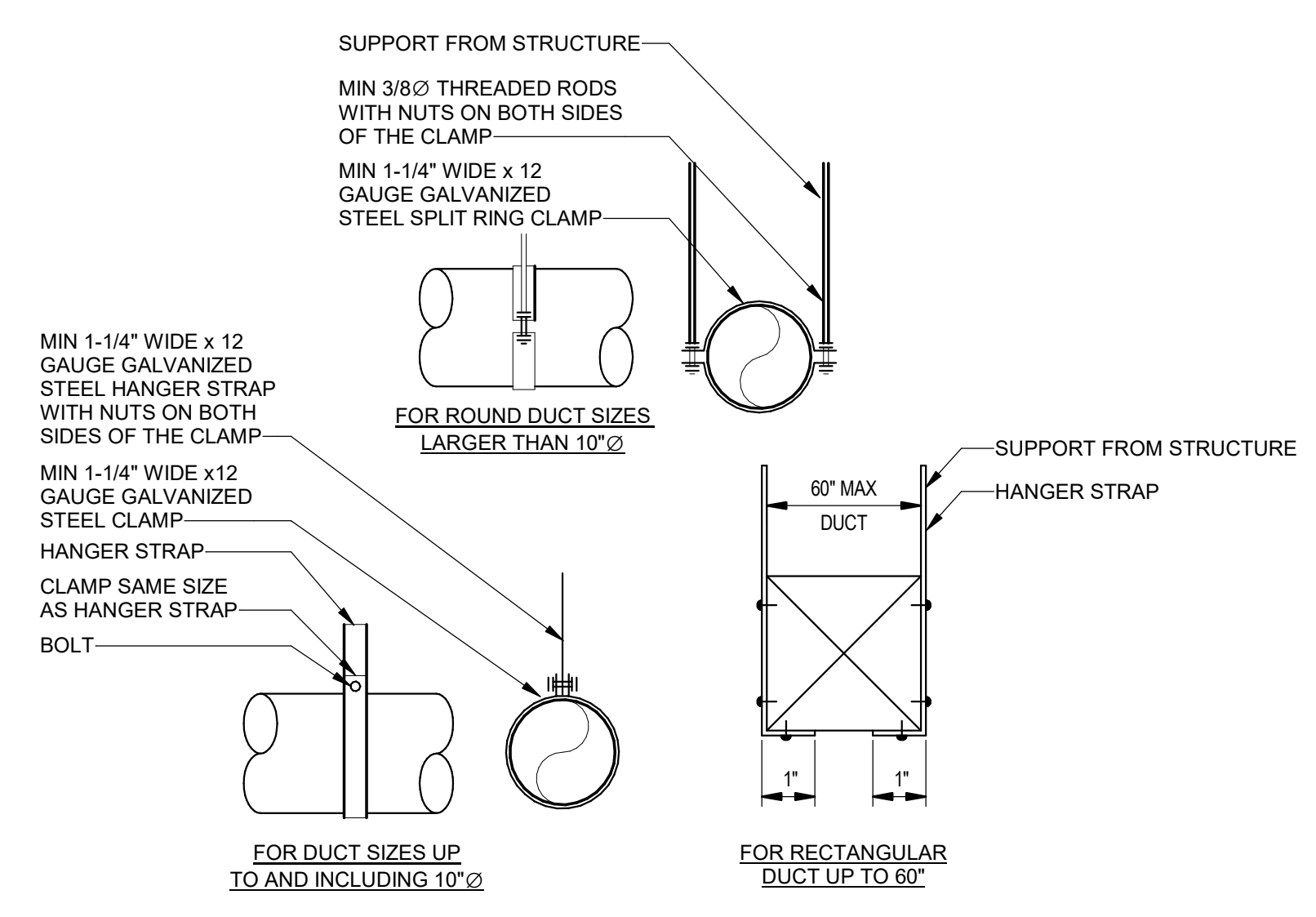
C5 TRANSFER DUCT DETAIL
NOT TO SCALE



C3 RECTANGULAR DUCT TRANSITION DETAIL
NOT TO SCALE

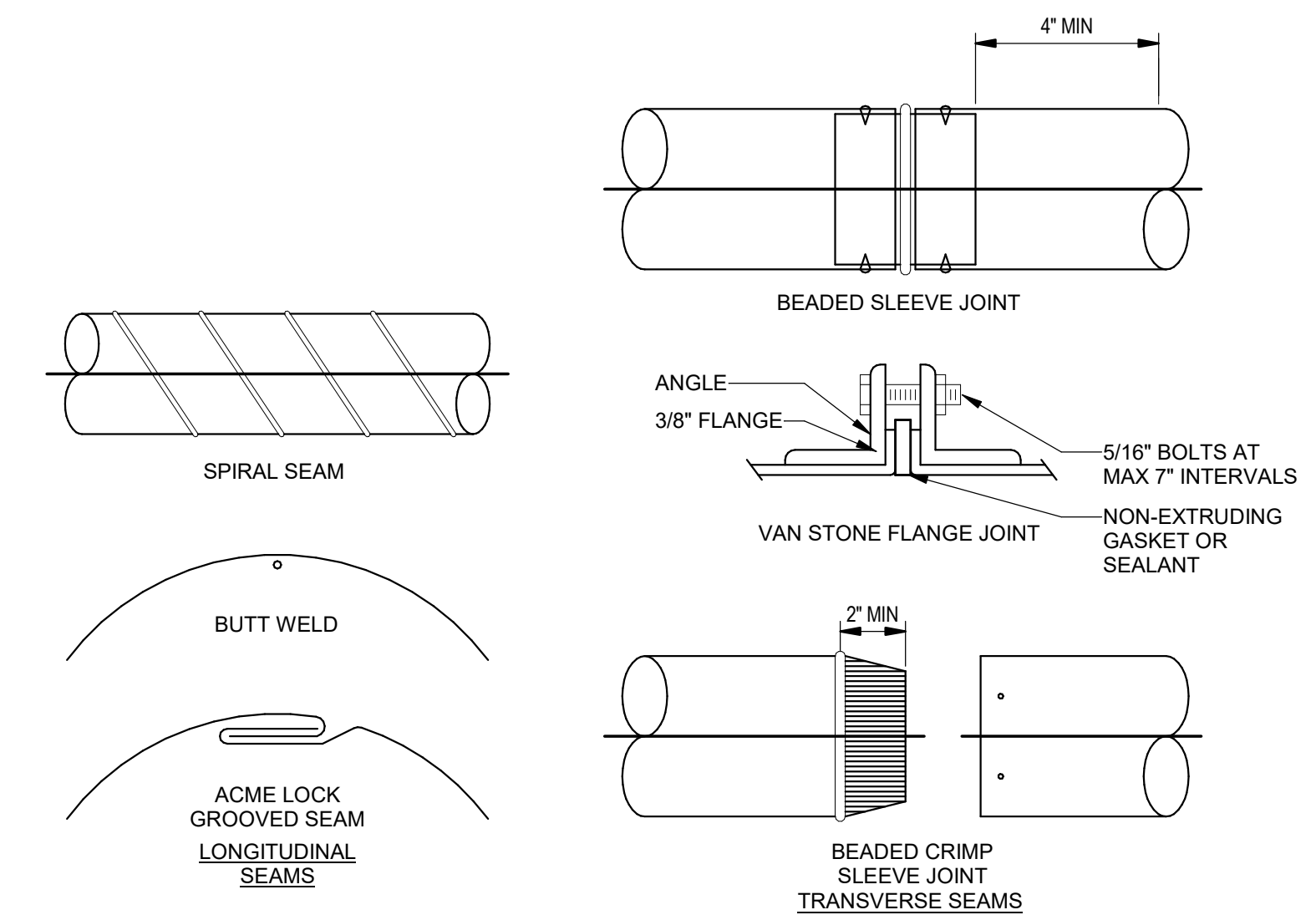


A1 CONNECTION TO CEILING DIFFUSER DETAIL
NOT TO SCALE



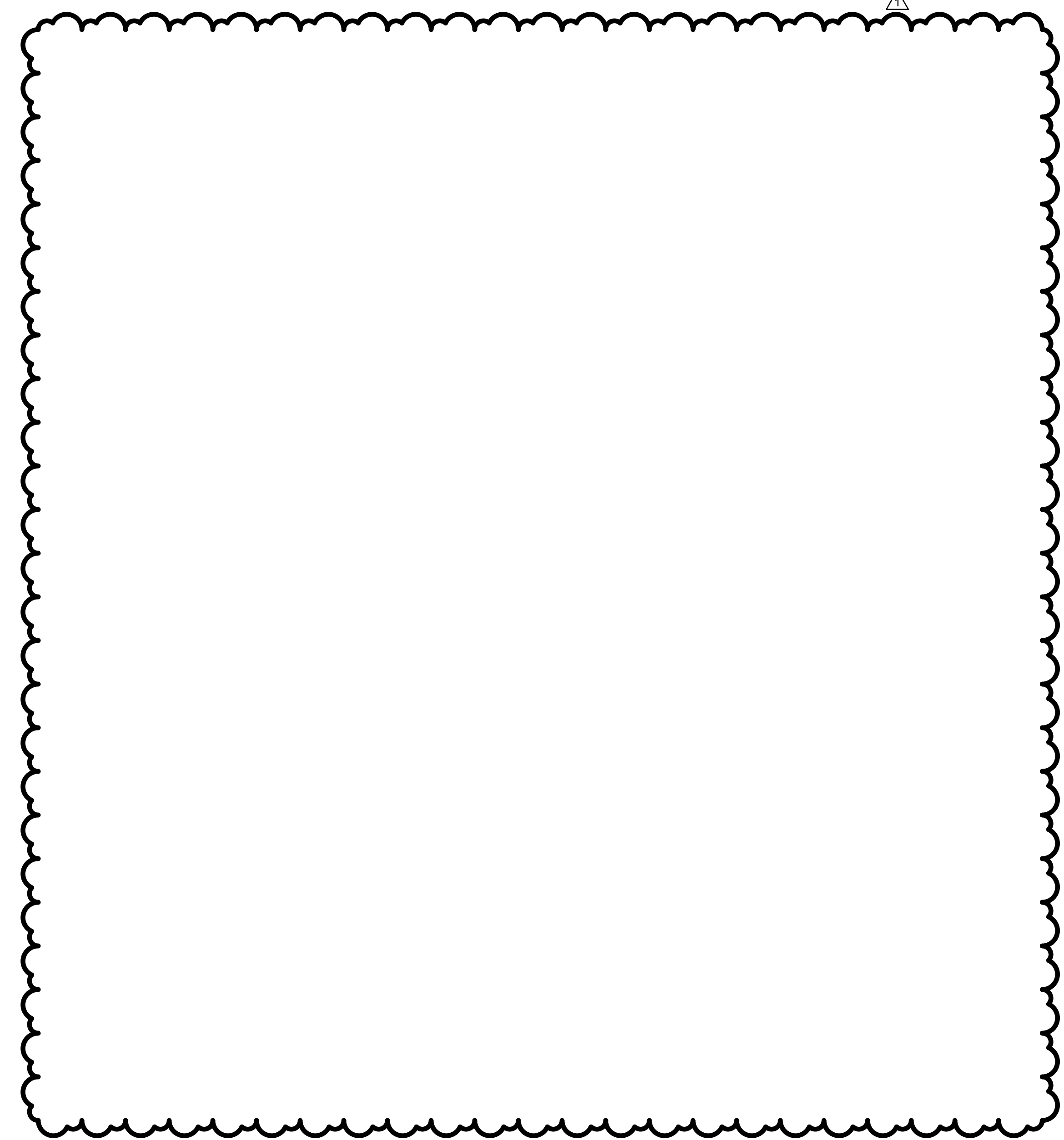
- NOTE:**
1. ALL HARDWARE SHALL BE NON-CORROSIVE STEEL.
 2. SIZE & RATING OF HANGERS & SUPPORTS SHALL BE PER LATEST \"SMACNA\" STANDARDS.

A3 DUCT HANGERS DETAIL
NOT TO SCALE



- NOTE:**
1. SNAP LOCK LONGITUDINAL SEAMS SHALL NOT BE PERMITTED.

A5 ROUND DUCT SEAMS AND JOINTS DETAIL
NOT TO SCALE



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AUGUSTA, MAINE 04333-0077
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ISSUED FOR BID
MARCH 31, 2022

PROJECT:
RAY BUILDING RENOVATION
28 TYSON DRIVE, AUGUSTA, MAINE

REV	DATE	DESCRIPTION
1	04-28-2022	ADDENDUM NO. 2
0	03-31-2022	ISSUED FOR BID

PROJECT NO: 3616206102
PROJECT MANAGER: KFM
A/E OF RECORD: MG
DESIGNED BY: MEL
DRAWN BY: STR

SHEET TITLE:
MECHANICAL DETAILS

SHEET ID:
M-501