

Bid Addendum 01



CLARK NEXSEN

1523 Elizabeth Ave, Suite 300
Charlotte, NC 28204

Project: UNC Charlotte Science Building:
STEM

Date: May 10, 2019

COMM #: SCO ID #: 16-14335-02D
Code: 46626 Item: 301
Clark Nexsen #: 6222A

Prepared by: Mike Romot, AIA, LEED BD+C

This ADDENDUM is to be a part of the contract documents and modifies and takes precedence over the original bid documents, as noted below and in any attached documents. Original items of the plans and specifications that have been modified, amended, voided or suspended through previous addendums, shall remain in effect. It is the responsibility of the Bidder to notify and/or distribute this ADDENDUM to those sub-bidders who have received prints or digital files. The Bidder is to acknowledge receipt of this ADDENDUM in the space provided on the Bid Form.

DRAWING MODIFICATIONS

- Replace the following sheets with the attached revised sheets:
 - C-510 – SITE DETAILS
 - SF102 - LEVEL 2 FRAMING PLAN
 - SF104 - LEVEL 4 FRAMING PLAN
 - SF106 - ROOF FRAMING PLAN
 - SF201 - ATTIC RIGID FRAME ELEVATIONS AND DETAILS
 - SF306 - MAIN ENTRY DETAILS
 - SF307 - MAIN ENTRY DETAILS
 - SF801 - PLAN DETAILS
 - A7.10 – ELEVATOR 1
 - A7.11 – ELEVATOR 2
 - A7.13 – ELEVATOR AND SHAFT DETAILS
 - H0.03 - HVAC BASE DESIGN
 - H8.08 - HVAC CONTROLS RESEARCH LAB SPACES
 - E1-11 - ELECTRICAL SITE LIGHTING PLAN SOUTH
 - E1-12 - ELECTRICAL SITE LIGHTING PLAN NORTH

- Add the following sheets to the drawing set:
 - N/A

Bid Addendum 01



PROJECT MANUAL MODIFICATIONS

- Replace the following specification sections in their entirety:
 - 200000 - COMMON MECHANICAL/ELECTRICAL REQUIREMENTS
 - 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT
 - 220719 - PLUMBING PIPING INSULATION
 - 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
 - 230700 - HVAC INSULATION
 - 230995 - LABORATORY AIRFLOW CONTROL SYSTEM
 - 238219 - FAN COIL UNITS
 - 250000 - INSTRUMENTATION AND CONTROL FOR HVAC

- Add the following specification sections to the Project Manual:
 - N/A

ATTACHMENTS

- RFI Responses
- Drawings
- Specifications

END OF BID ADDENDA 01

Addendum 1 - 5/10/2019

#	Addendum	Page / Sheet / Section	Bidder Question / Comments	Response
1a	Addendum 1	233113, 3.12 C	Duct Cleaning - 233113, 3.12, C states to clean duct systems that do not pass visual or random testing. Who would be doing the inspection?	The Owner's Project Manager, Commissioning Agent, Engineering Design Professional will conduct random visual inspections. The contractor will perform the vacuum tests in random locations selected by the Engineering Design Professional as stated in section 233113, Article 3.12.B.2
1b	Addendum 1	233113, 3.12 C	Duct Cleaning - Can you create an allowance for all contractors to carry for Duct Cleaning? We would do our best to keep inside of ducts clean via plastic wrapped ends and not using returns during temp HVAC via permanent heating system, but In a project like this, this spec is so vague, that the owner could have the contractor "Clean" the whole system and that would be hundreds of thousands of dollars.	<p>There is nothing vague in the requirements of the specifications. Duct cleaning is only required if the visual inspections or vacuum test referenced in the specifications results in a "fail".</p> <p>To be clear; there is no requirement to clean the ductwork if the visual inspections and the vacuum testing referenced in the specifications results in a "pass".</p> <p>However, we have been on projects wherein the ductwork was not properly protected during fabrication, shipping, job-site storage and installation resulting in significant levels of debris within the duct system resulting in a "fail" on the visual inspections and/or random vacuum test referenced in the specifications.</p> <p>We would expect the contractor to perform at a high level to keep the ductwork systems clean. Section 233113, Article 3.12 gives the Owner remedy in the case the contractor performs inadequately to maintain duct cleanliness.</p> <p>Whether or not to carry any costs to clean the duct is entirely based on the contractor's risk tolerance. If his duct system installations pass the visual inspections and vacuum test referenced in the specifications then cleaning will not be needed and he would not realize any costs associated with duct cleaning. On the other hand if the contractor is not diligent during the construction process, the installation may not pass the visual inspections or vacuum test resulting in the need to clean the duct system at some cost to the contractor.</p> <p>Whether or not the duct systems are properly installed resulting in a pass or fail on the visual inspections or the vacuum test is entirely in the hands of the contractor.</p> <p>If, during the random inspections and tests noted in the specifications, a duct does not pass, the entire system to which the failed duct is connected shall be cleaned.</p>
11	Addendum 1		Alternate 12 is for Division 23 specified Hydronic Piping in lieu of Base Bid Mechanical Joints in exposed areas. Please provide Mechanical Joint Specifications.	Drawing H0.03 will be updated to describe the base bid requirements for mechanical joints on steel and copper piping.
13	Addendum 1		The spec section for Instrumentation and Control for HVAC is listed as 250000 in the spec. index. The specification itself in the specs is listed as 230900. Please advise which spec. number is the correct spec. number.	The correct specification section number is 250000. All references to section 230900 shall be removed or revised to read 250000. Corrected specification sections will be submitted under Addendum 1.

Addendum 1 - 5/10/2019

#	Addendum	Page / Sheet / Section	Bidder Question / Comments	Response
15	Addendum 1		<p>Specification section 230700, HVAC Insulation, calls for PVC jacketing for exposed piping 10' AFF and below. In referencing this specification as well as specification section 223553, we are unable to locate any requirements for color coding of the PVC jacketing. However, it is our understanding that color coding of PVC jacketing is a requirement of the University design and construction manual. The painting specification calls for painting of un-insulated piping and piping with "all service jackets" paintable jackets, but does not mention PVC jackets which typically do not paint well. Please confirm if piping to receive PVC jacketing is to be color coded, if so, please provide an updated specification section detailing the colors and requirements.</p>	<p>Specification section 220553, 220719, 230553, and 230700 will be revised to include appropriate UNCC standards for pipe jacketing colors.</p>
17	Addendum 1		<p>Spec. 084413 3.4 B.1 states that water spray testing is required at areas designated by the architect. Please provide details on the frequency/quantity of testing required so it can be properly included in the bidders numbers.</p>	<p>Testing shall comply with AAMA 501.2 as identified in the specifications as well as the requirements outlined in 072700. Testing shall include at a minimum the head, sill, jamb, floor mullion condition, typical vertical mullion, mullion cap penetrations and custom cap profile mullions of the curtain wall assembly. Testing shall include at least one of each of the following types of curtain wall: CW-01, CW-03, CW05, CW06, CW-07, CW-11, CW-12, CW-13, CW-15.</p>
18	Addendum 1		<p>The Building Envelope Commissioning plan/spec section 019100 lists the testing requirements for the various envelope spec. sections that need testing. Based on the language in the spec, it appears that testing is only required on the mock-up of each spec section listed. A final building envelope test is required once the entire building envelope is complete, however, it does not appear that any other testing is required after the initial mock-up testing. Please confirm if this is correct. If not, please provide clarification on the testing requirements and frequency of testing of building envelope components.</p>	<p>Additional testing will be required after mockup testing. The building will be tested per specification sections 072700 and 084413.</p>
19	Addendum 1		<p>One of the potential bidders noted a section from the North Carolina Science Lab Checklist that for High Schools and Middle schools that requires a single emergency shut-off in each lab that will close valves in the gas, water, and shut power out servicing emergency eye wash stations, fume hoods, or lighting. This project is obviously not a high school or middle school but the question has been asked if there is any similar requirement or college laboratories for a single emergency shut-off in each lab space.</p>	<p>UNCC has stated emergency power shutoffs (EPO) are not utilized in other campus buildings and NC State Construction Office has not indicated the design is deficient due to the lack of EPOs. The Electrical Design Professional is unaware of any requirement for EPOs for this building as the relevant standards, guidelines, and policies do not contain such requirements.</p>

Addendum 1 - 5/10/2019

#	Addendum	Page / Sheet / Section	Bidder Question / Comments	Response
20	Addendum 1		In the newly released contract documentation for the UNCC Science building under the Bid Manual – Tab M Supplemental Info – EP-2 Drawings & Specifications. The specification call for the Acoustical ceilings to be Armstrong brand while the science building specifies Rockfon. Should we keep this as a single source responsibility and use Rockfon in the EP-2 Building. The advantage of Rockfon is that it can be installed without the heat or air on and it will not sag.	Please provide pricing per the supplemental information. The Armstrong ceiling is specific to the data center requirements.

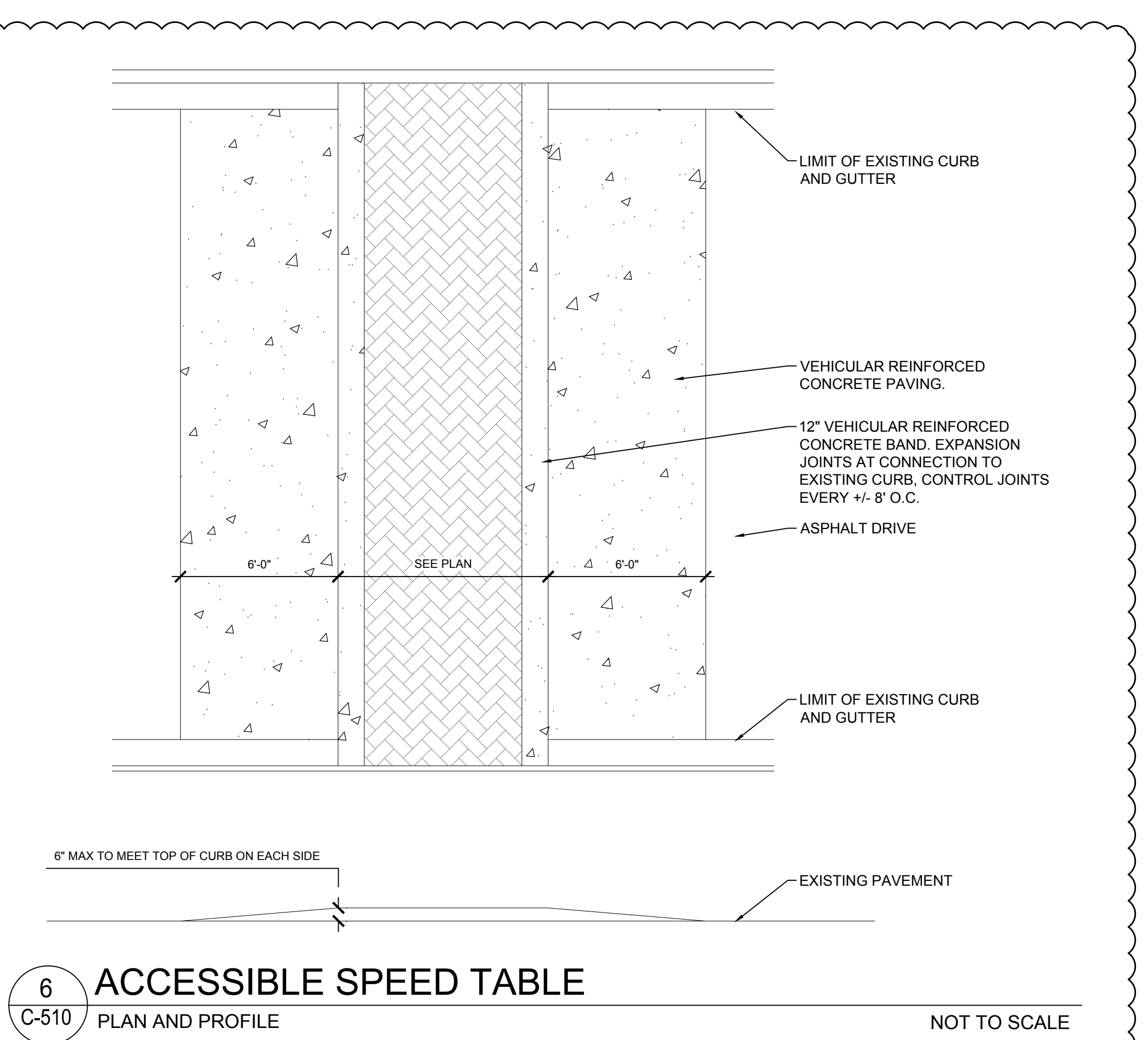
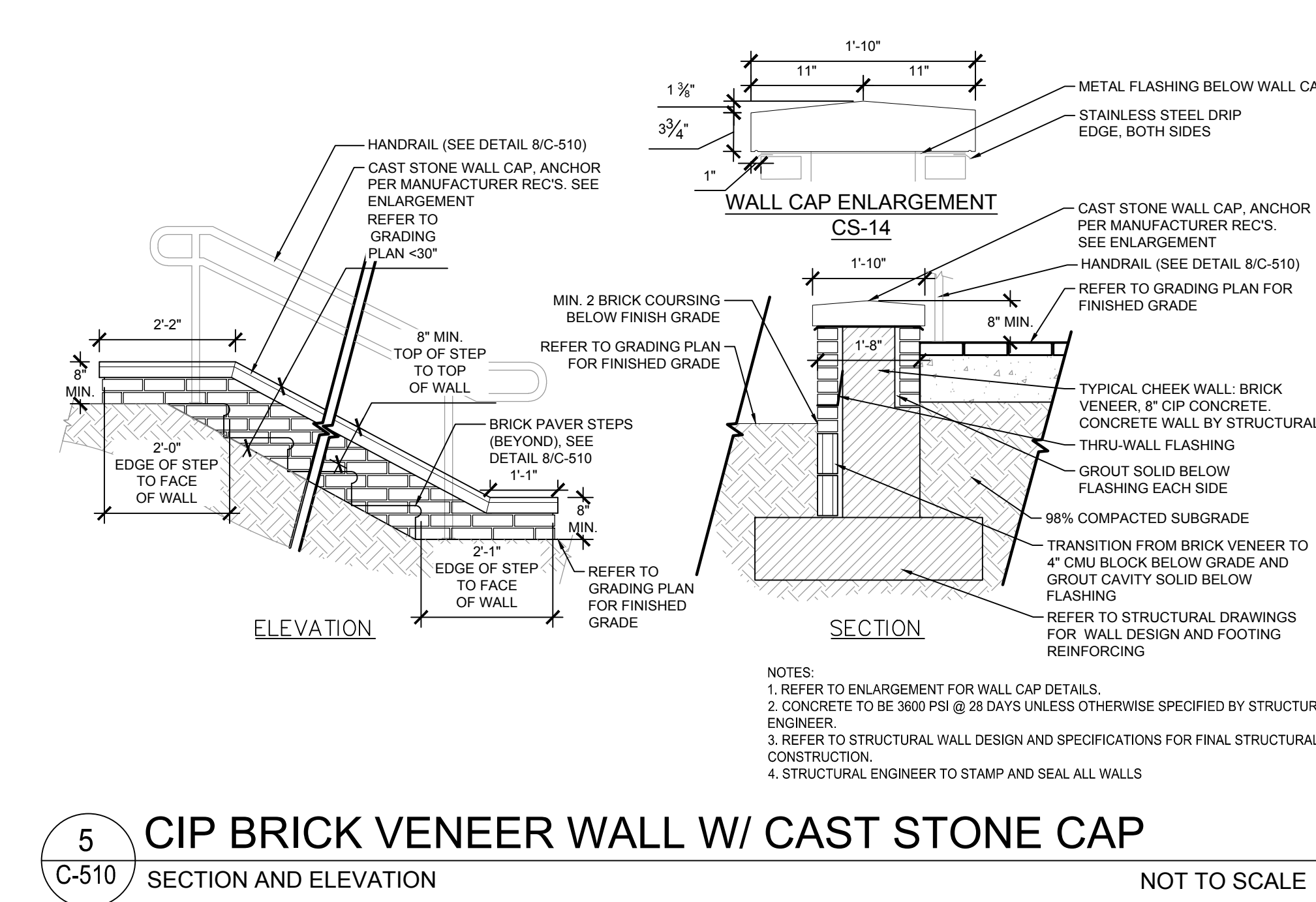
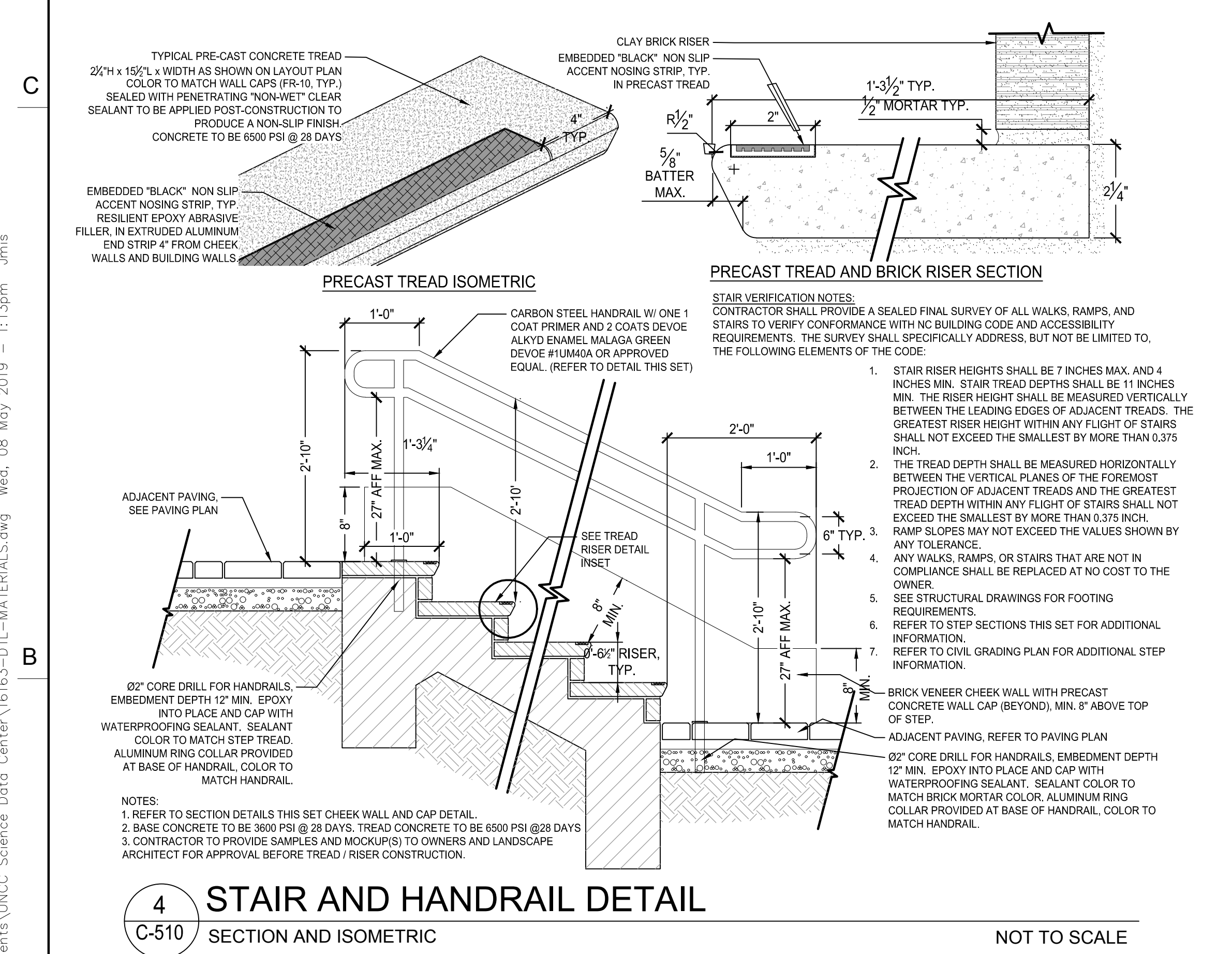
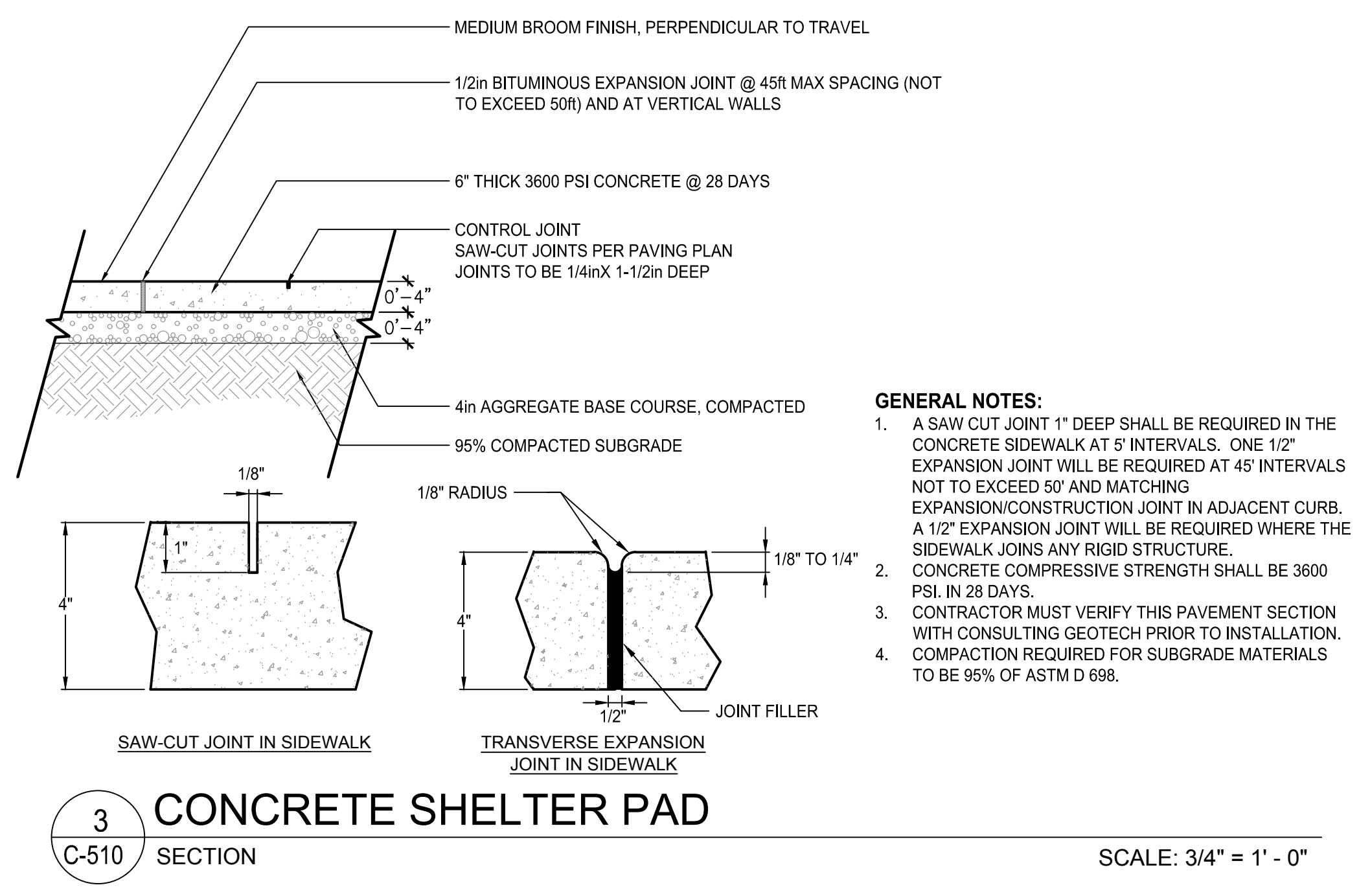
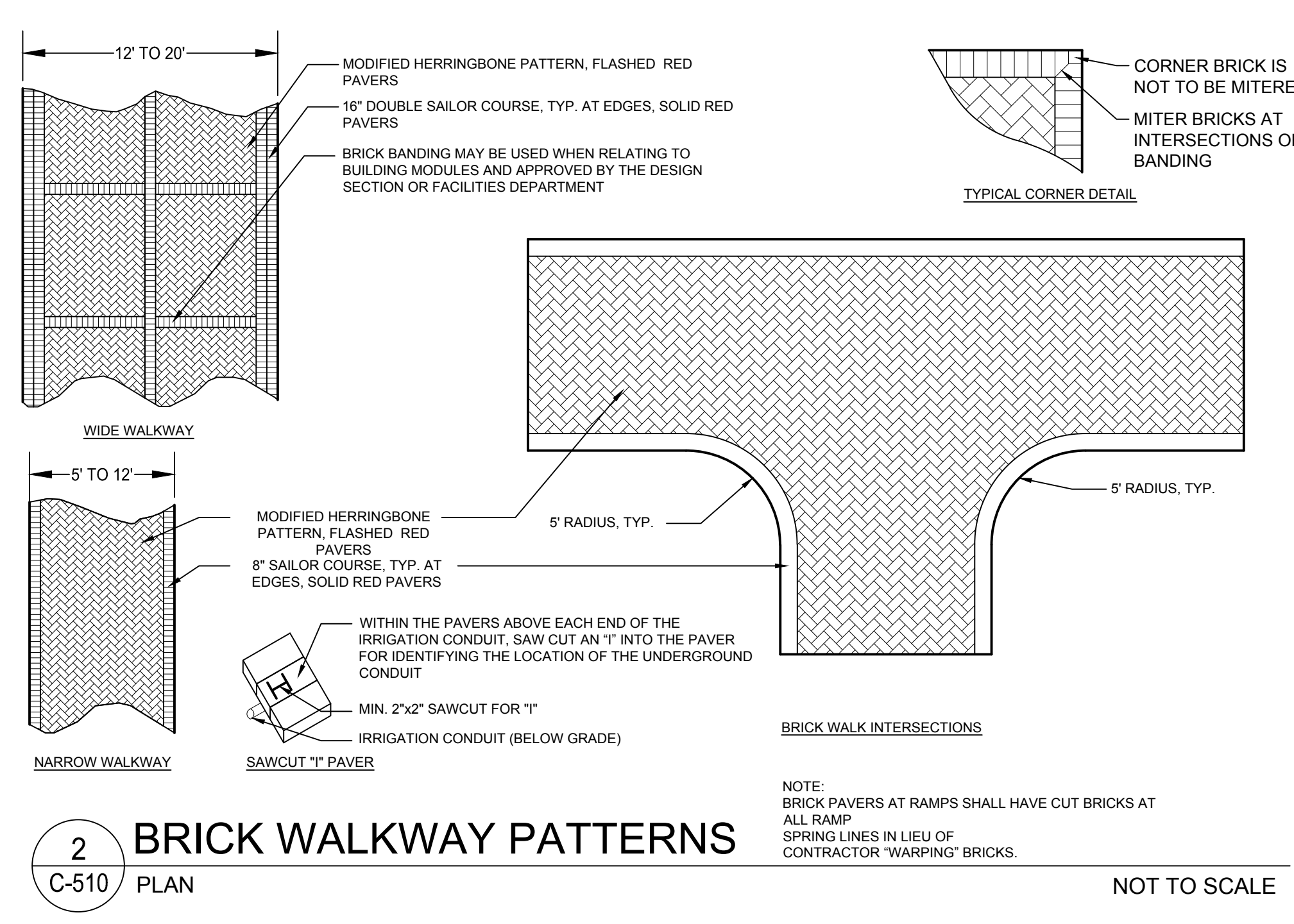
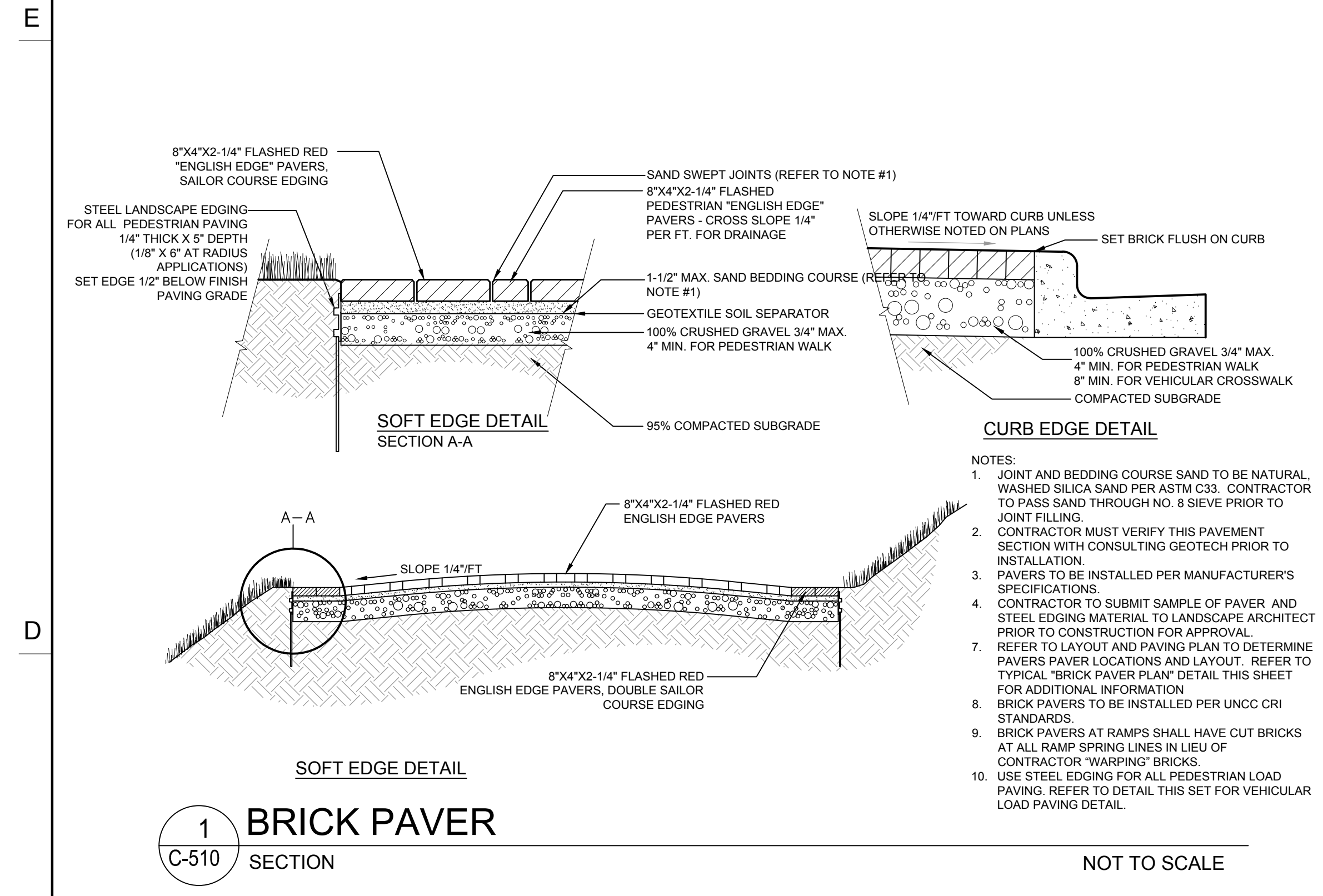
REVISIONS table with columns for revision number, date, and description.

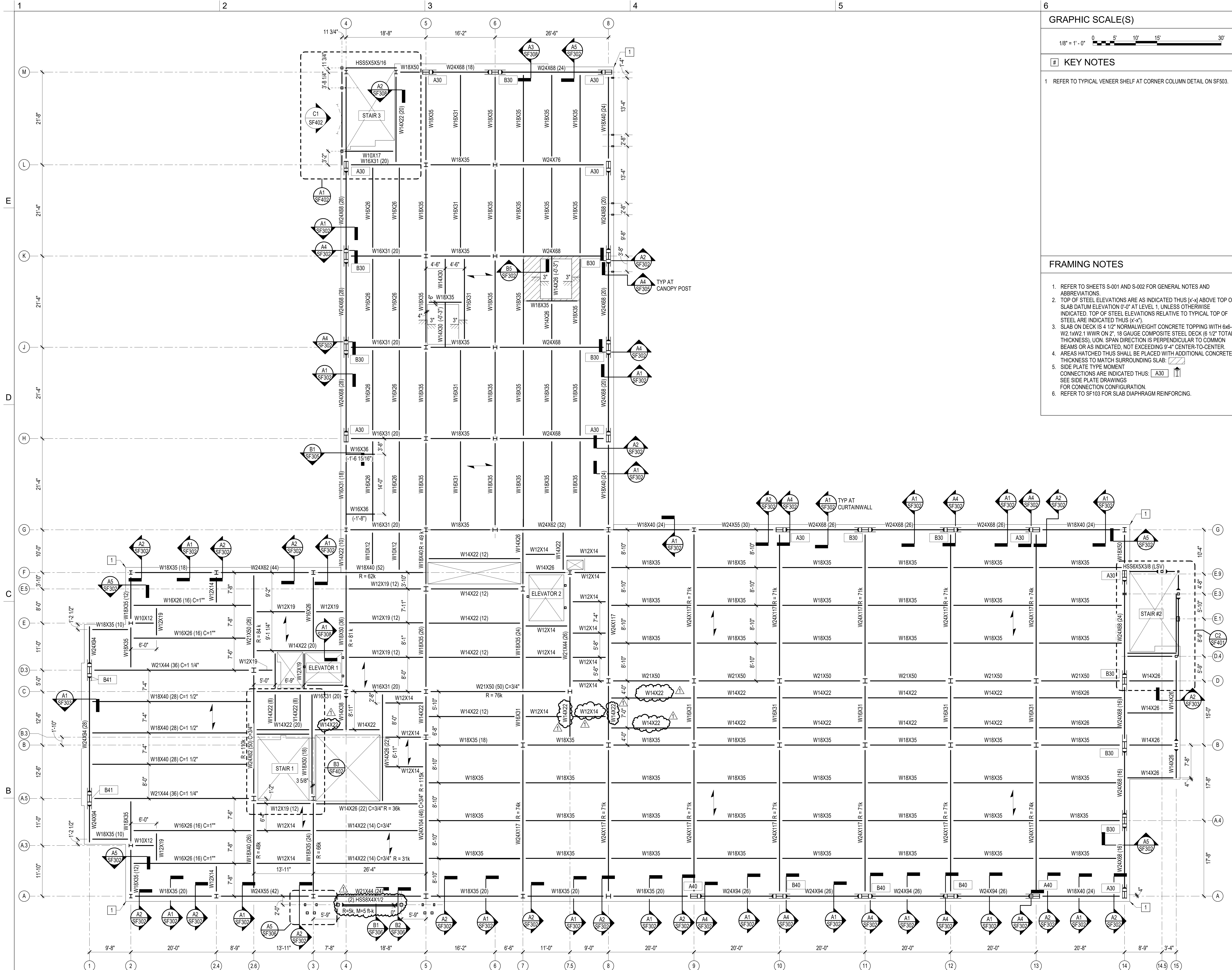
KEY PLAN

SHEET
SITE DETAILS

C-510

DESIGN: MCM
DRAWN: CR
REVIEW: MCM





GRAPHIC SCALE(S)
 1/8" = 1'-0" 0 5' 10' 15' 30'

KEY NOTES
 1 REFER TO TYPICAL VENEER SHELF AT CORNER COLUMN DETAIL ON SF303.

FRAMING NOTES
 1. REFER TO SHEETS S-001 AND S-002 FOR GENERAL NOTES AND ABBREVIATIONS.
 2. TOP OF STEEL ELEVATIONS ARE AS INDICATED THUS (x-y) ABOVE TOP OF SLAB DATUM ELEVATION 0'-0" AT LEVEL 1, UNLESS OTHERWISE INDICATED. TOP OF STEEL ELEVATIONS RELATIVE TO TYPICAL TOP OF STEEL ARE INDICATED THUS (x-x').
 3. SLAB ON DECK IS 4 1/2" NORMALWEIGHT CONCRETE TOPPING WITH 6x6-W2.1XW2.1 WWR ON Z. 18 GAUGE COMPOSITE STEEL DECK (6 1/2" TOTAL THICKNESS). UON. SPAN DIRECTION IS PERPENDICULAR TO COMMON BEAMS OR AS INDICATED, NOT EXCEEDING 9'-4" CENTER-TO-CENTER.
 4. AREAS HATCHED THUS SHALL BE PLACED WITH ADDITIONAL CONCRETE THICKNESS TO MATCH SURROUNDING SLAB.
 5. SIDE PLATE TYPE MOMENT CONNECTIONS ARE INDICATED THUS: A30
 6. REFER TO SF103 FOR SLAB DIAPHRAGM REINFORCING.

UNC CHARLOTTE
 SCIENCE BUILDING

9201 University City Blvd
 Charlotte, NC 28223

SCO ID Number: 16-14355-02D
 CODE: 46626
 ITEM: 301

DESIGNERS
CLARK Nexsen
 1523 Elizabeth Avenue, Suite 300
 Charlotte, NC 28204
 704.377.8800

CONSULTANT
PAYETTE
 290 Congress Street, 5th Floor
 Boston, MA 02201

VANDERWEIL
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 Boston, MA 02201
 NC License # F-1071

LandDesign
 223 North Graham Street
 Charlotte, NC 28202

SEALS

CLARKNEXSEN LICENSE NUMBER: C-1028
 SUBMITTAL
APRIL 26, 2019
 BID SET

Issue Date
 1 5/10/2019 Addendum 1

KEY PLAN

SHEET
LEVEL 2 FRAMING PLAN

SF102

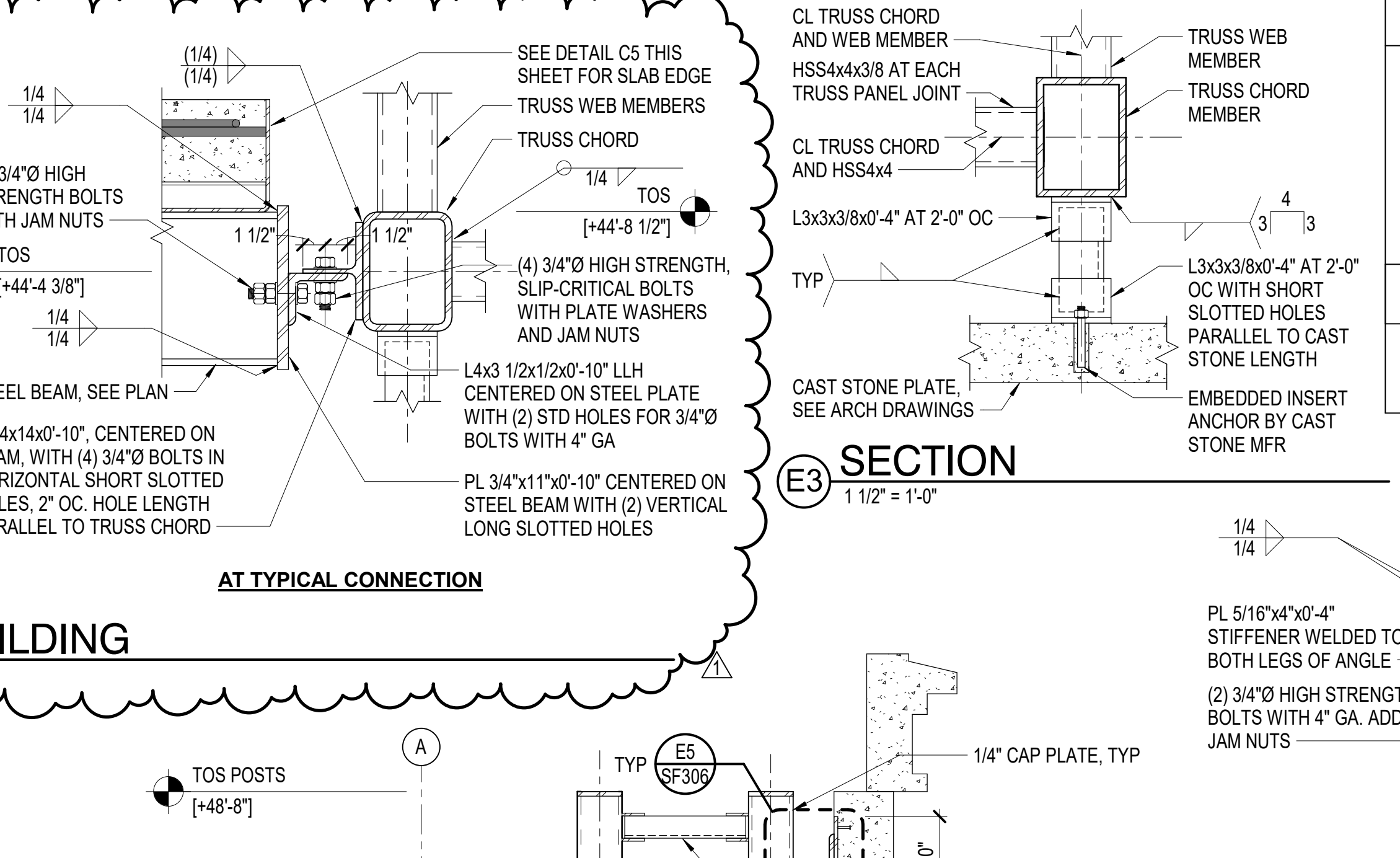
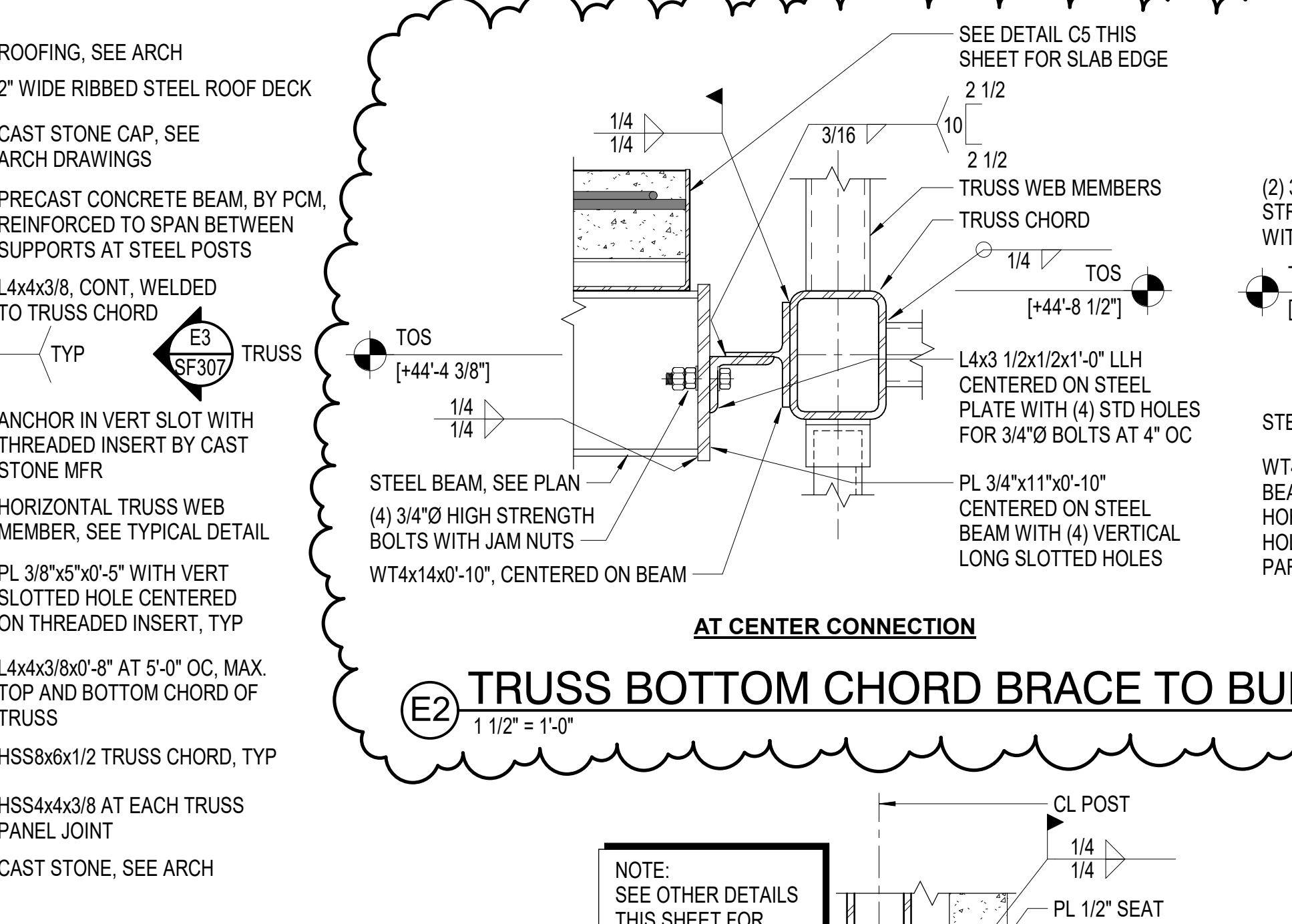
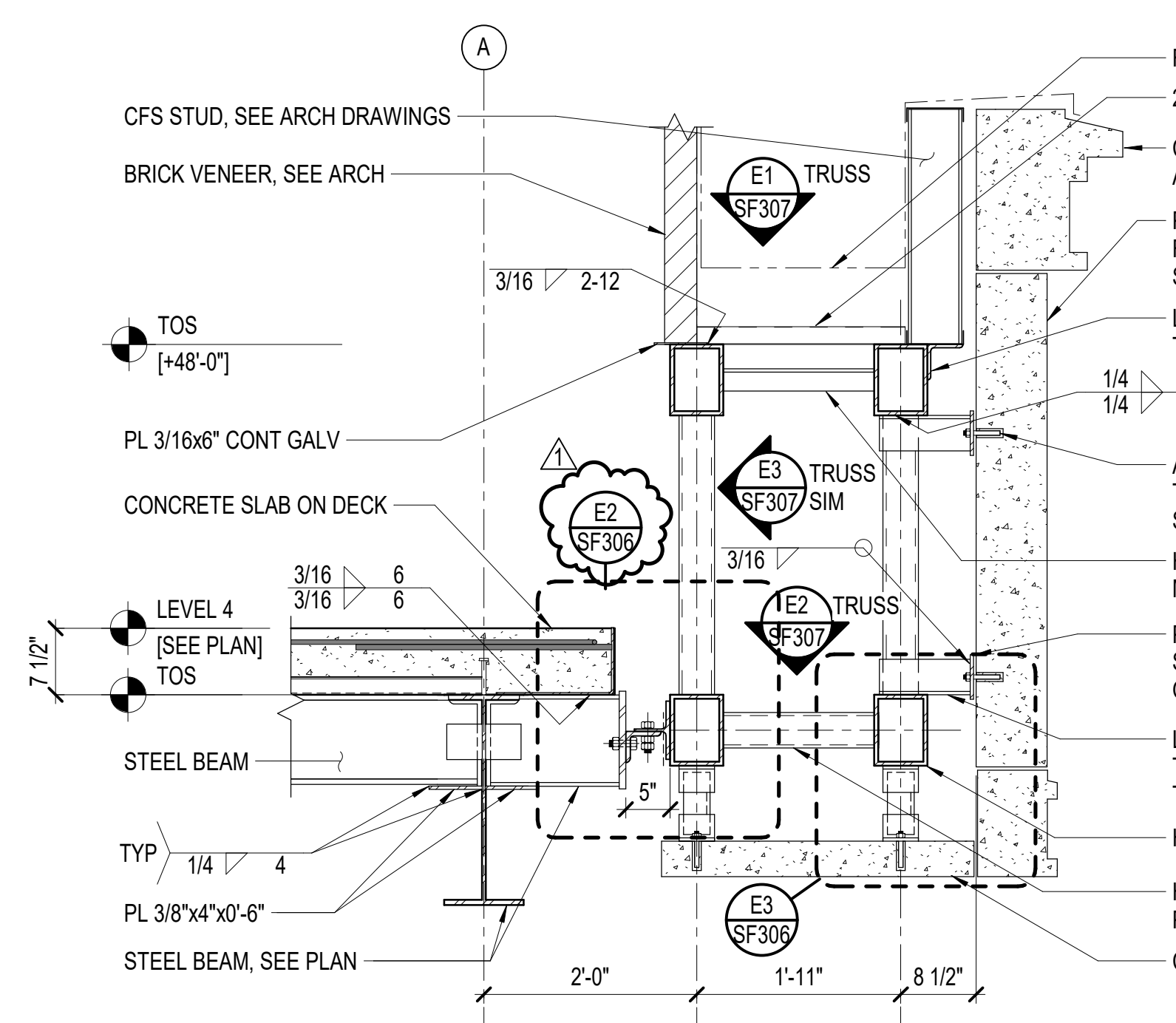
DESIGN: MSH
 DRAWN: YCW
 REVIEW: ECW

CN 6222

5/9/2019 6:02:15 PM B:\16307\UNC Charlotte Science\6222_Science Central_SF17.rvt

LEVEL 2 FRAMING PLAN
 1/8" = 1'-0"

TYPICAL TOS = +13'-4 1/2"

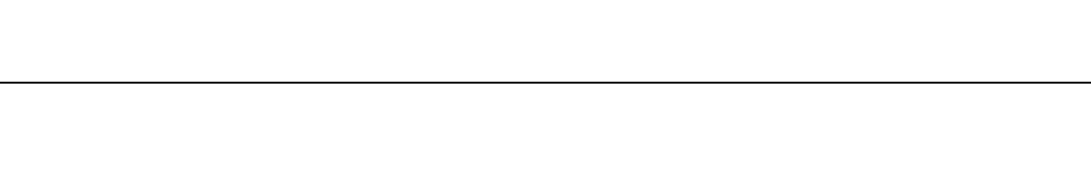
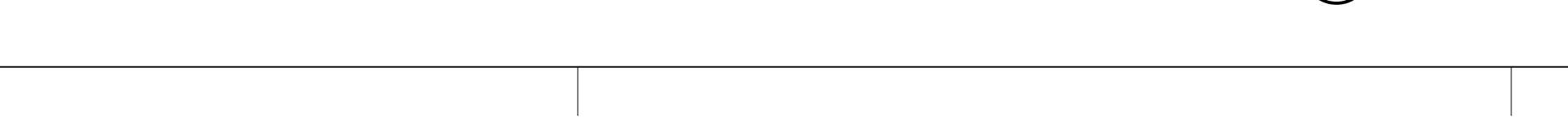
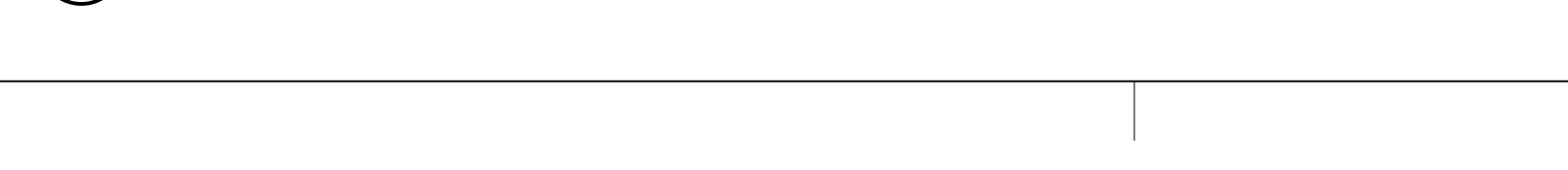
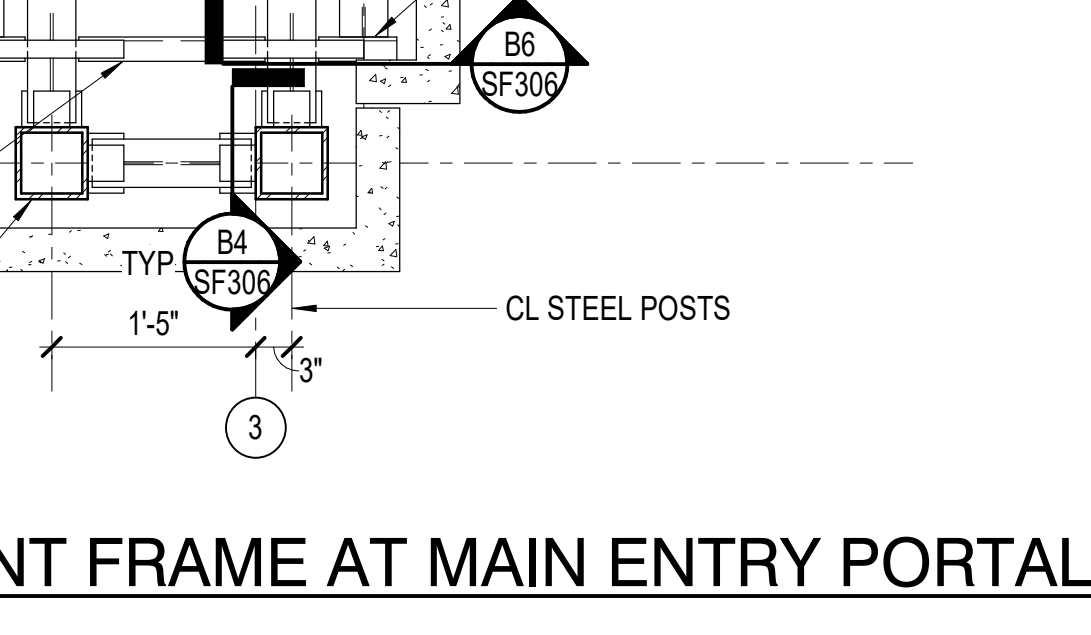
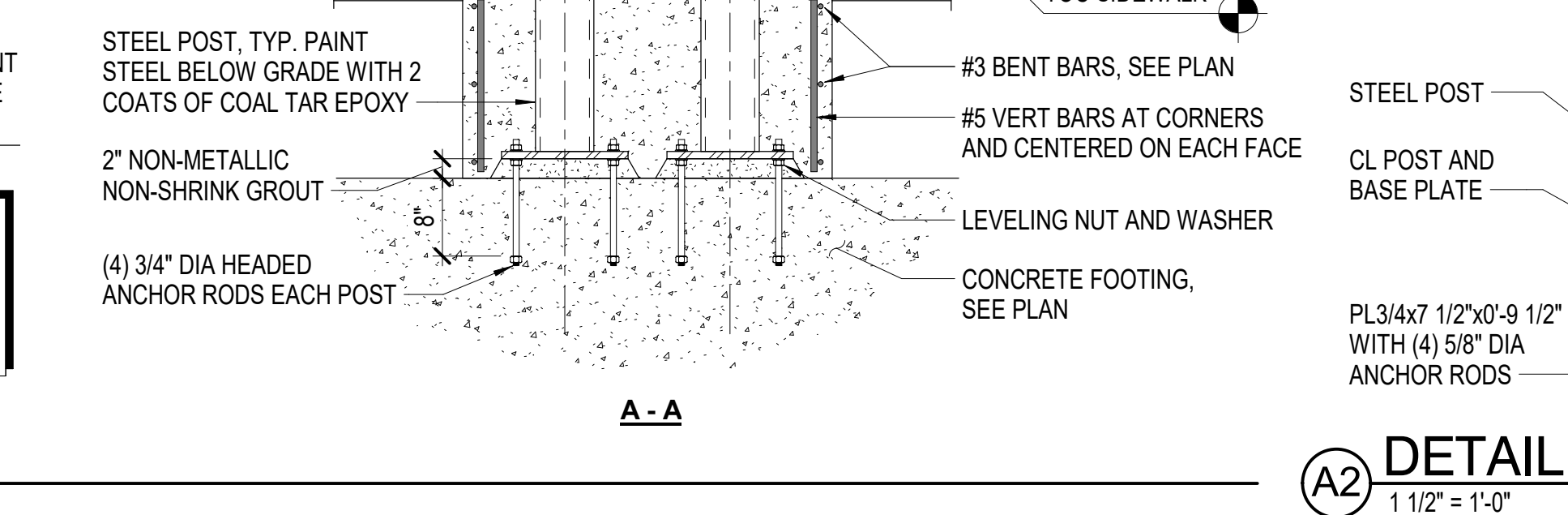
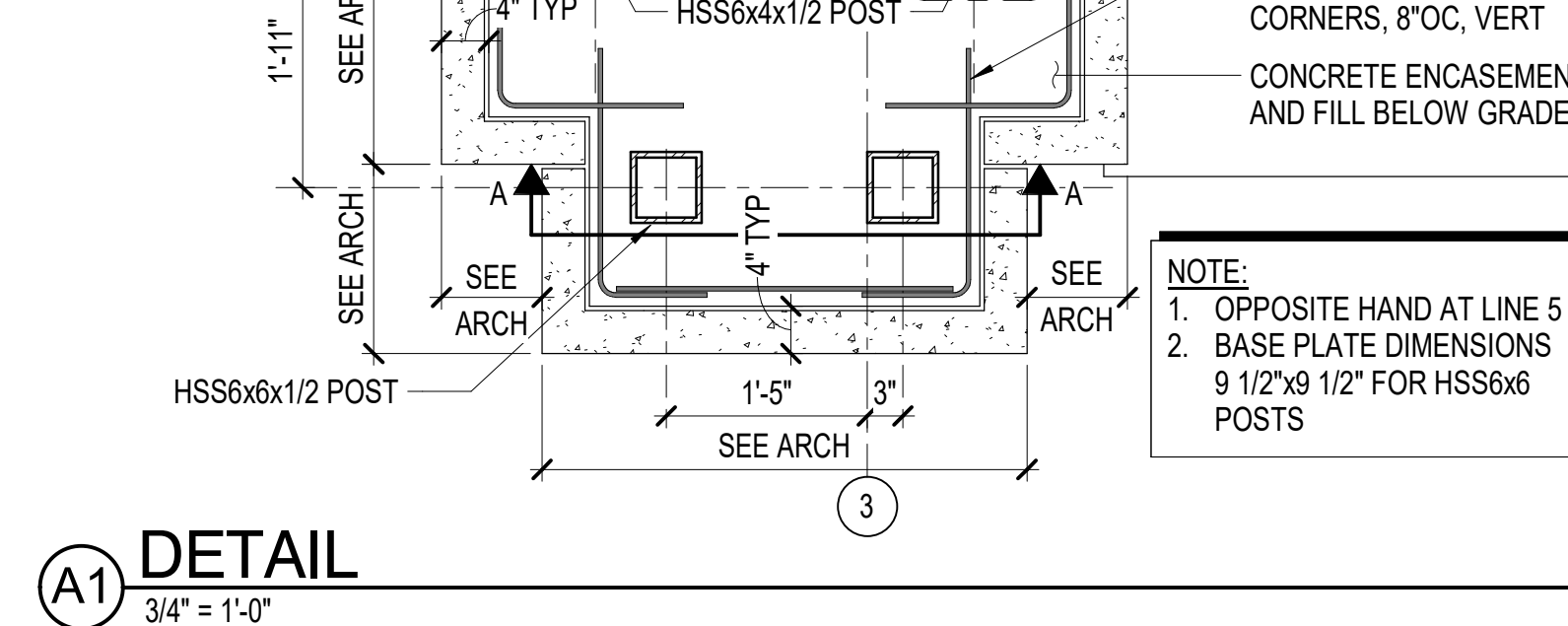
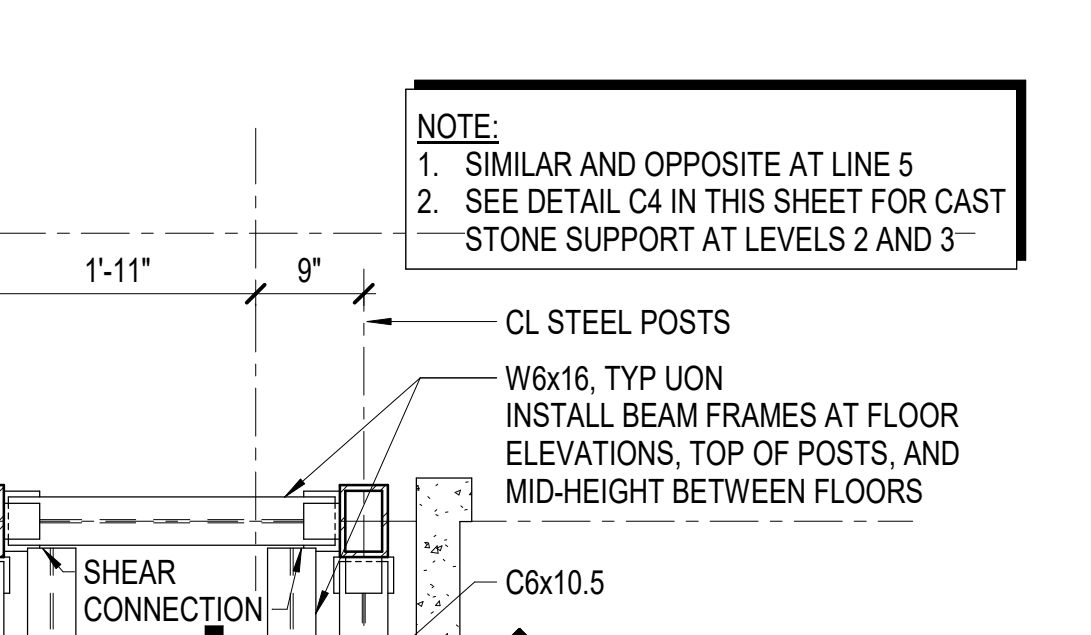
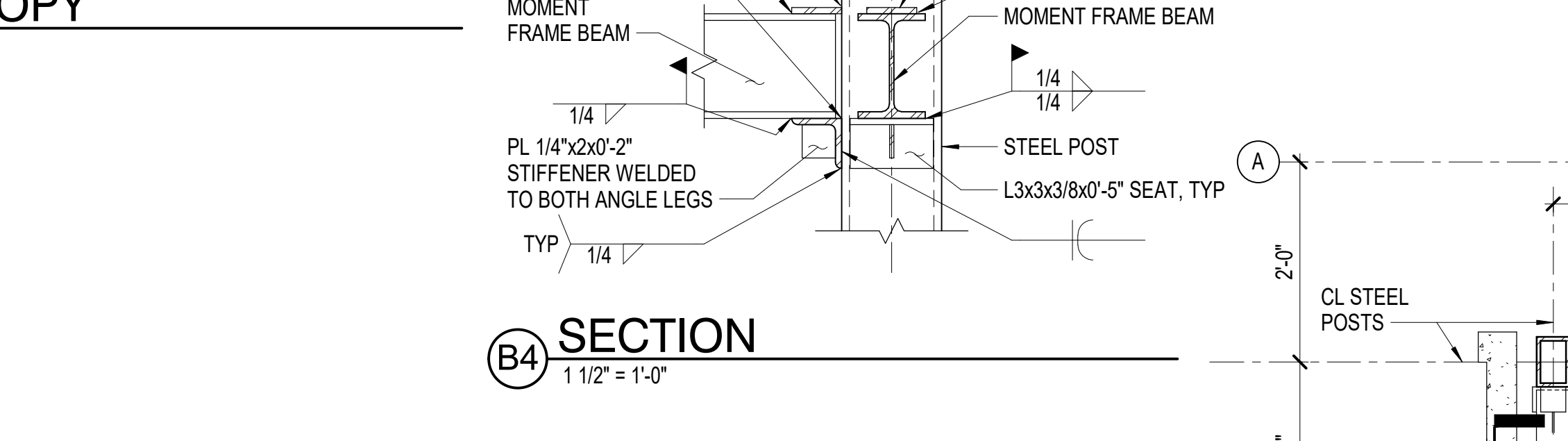
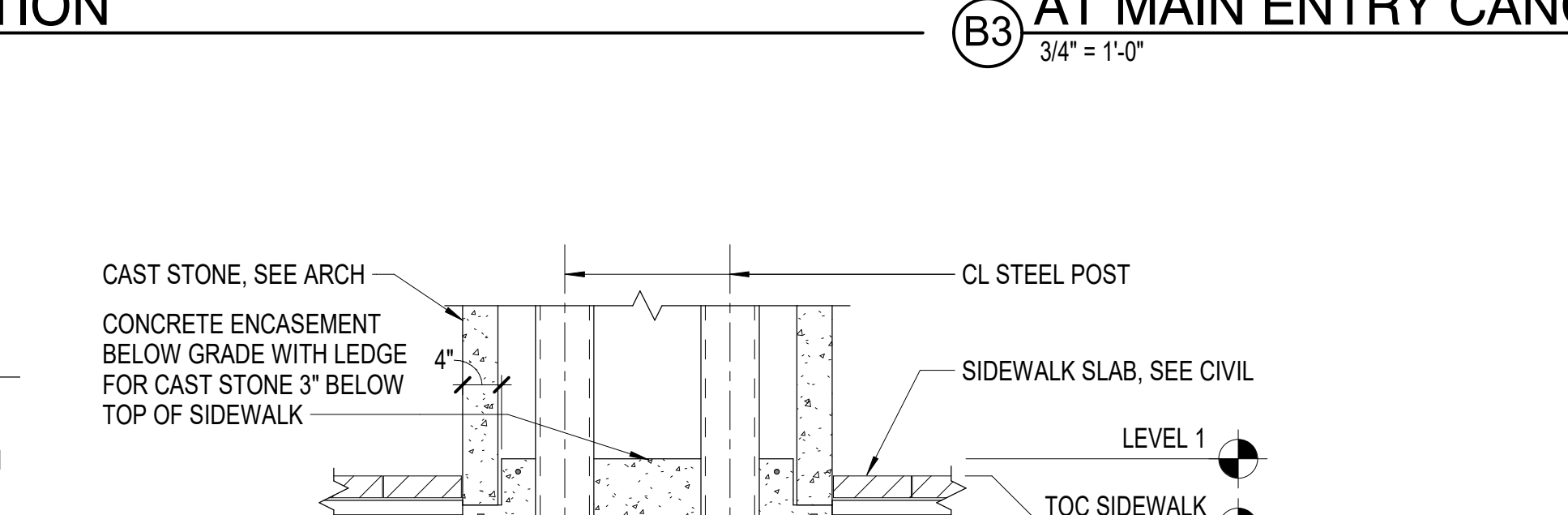
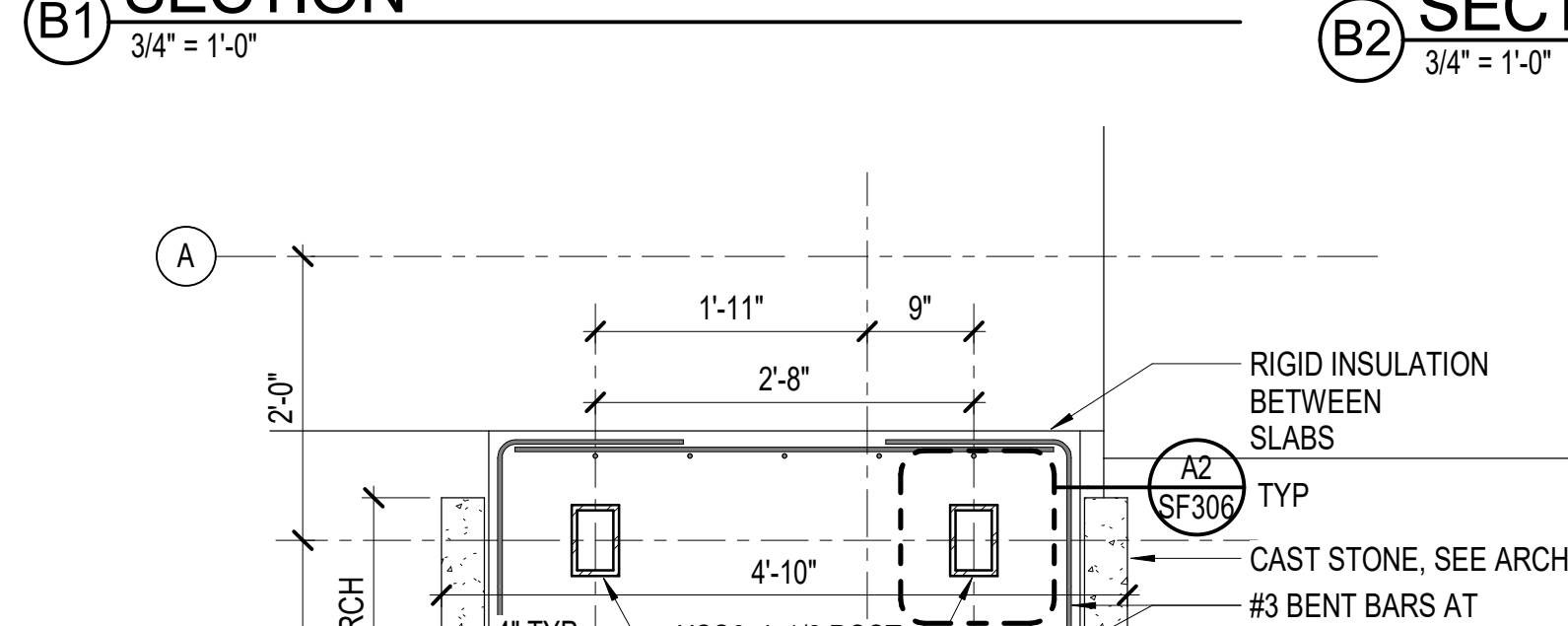
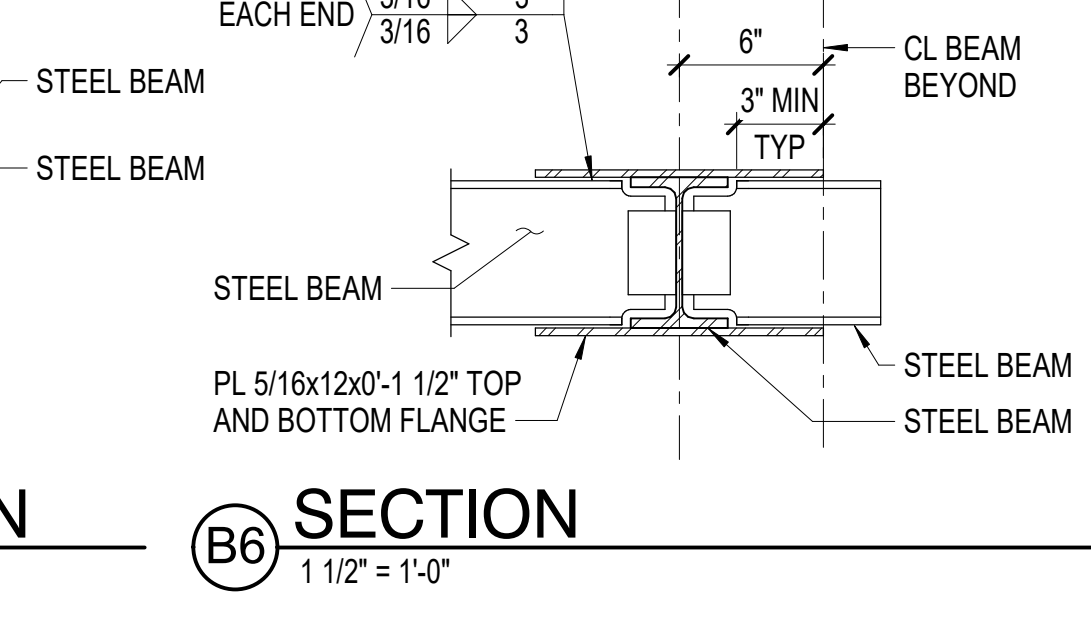
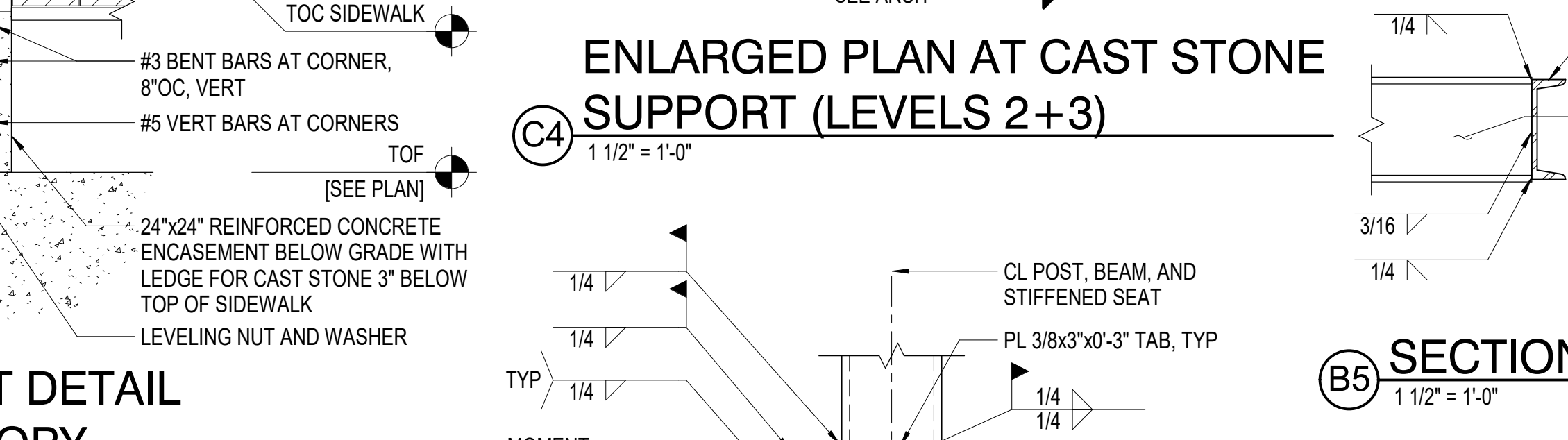
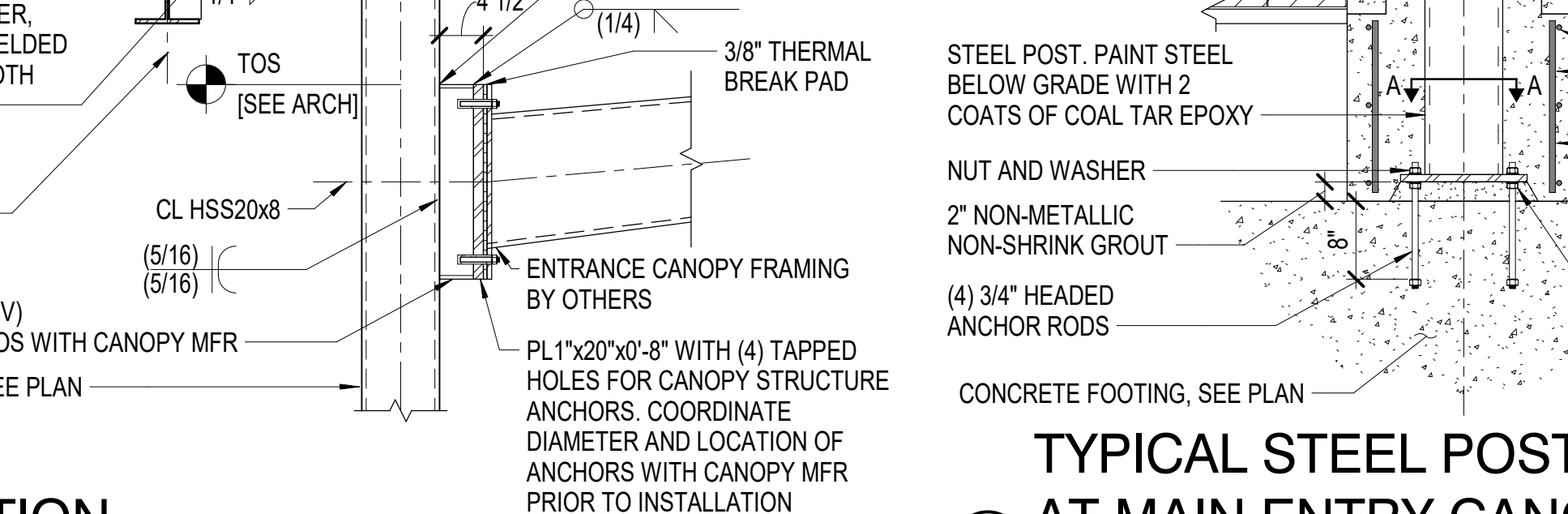
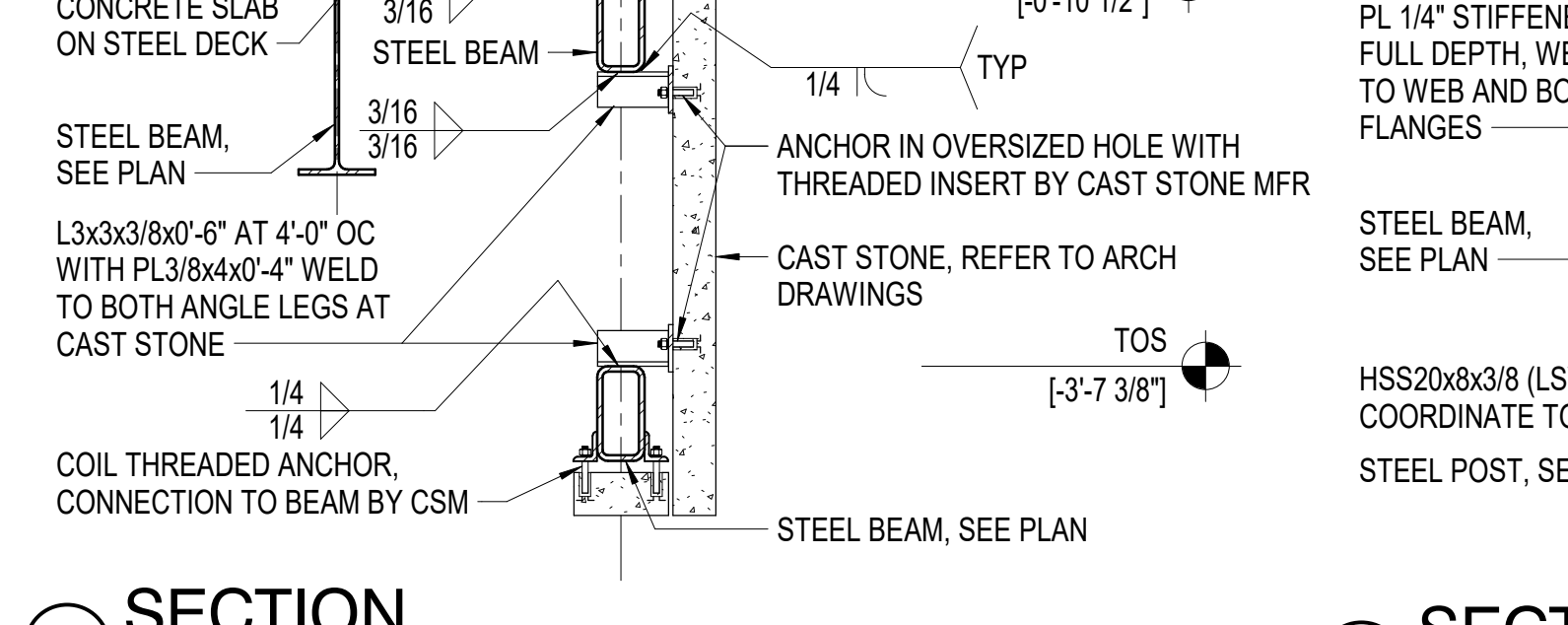
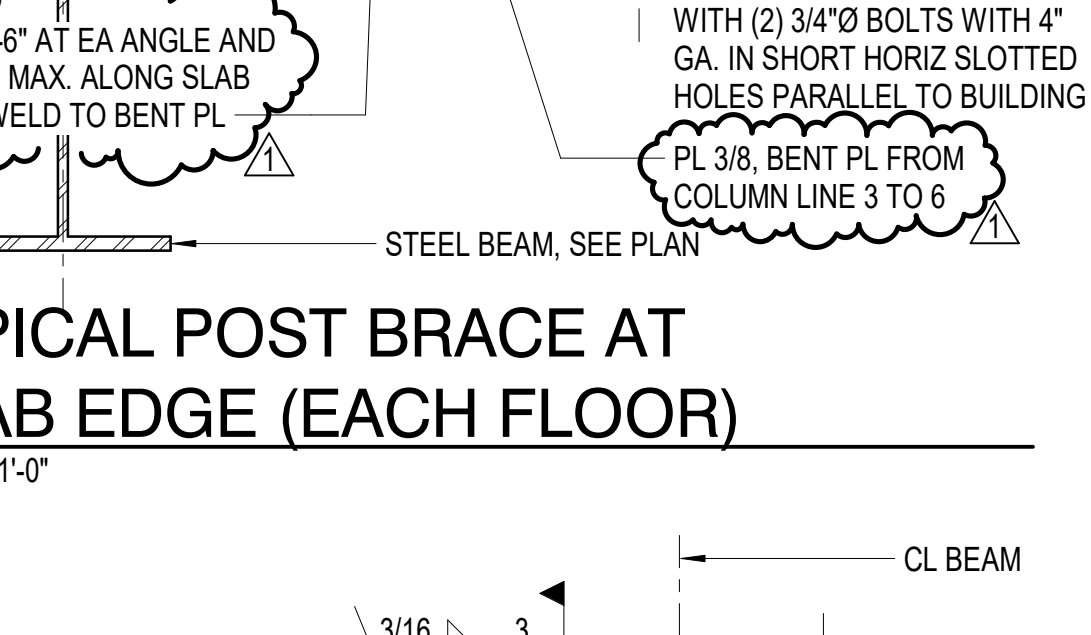
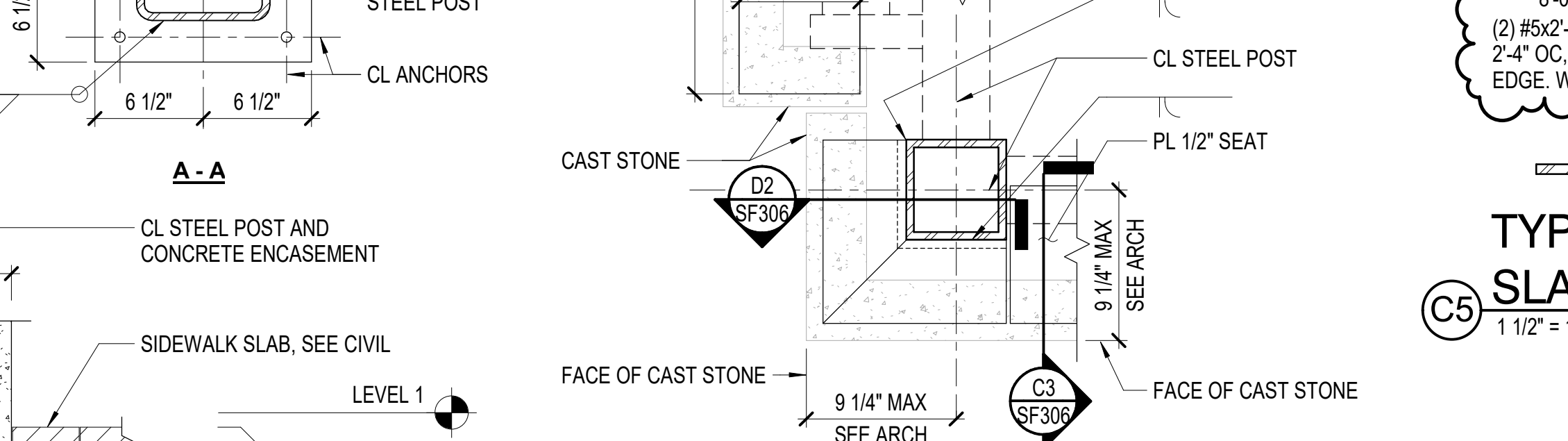
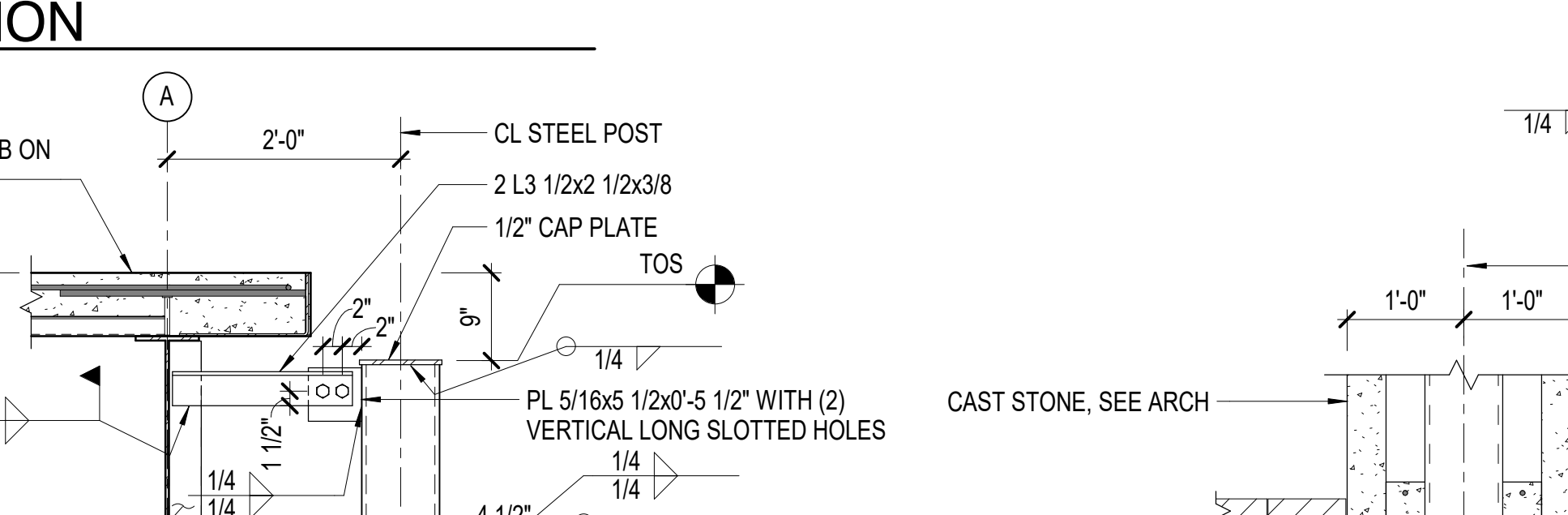
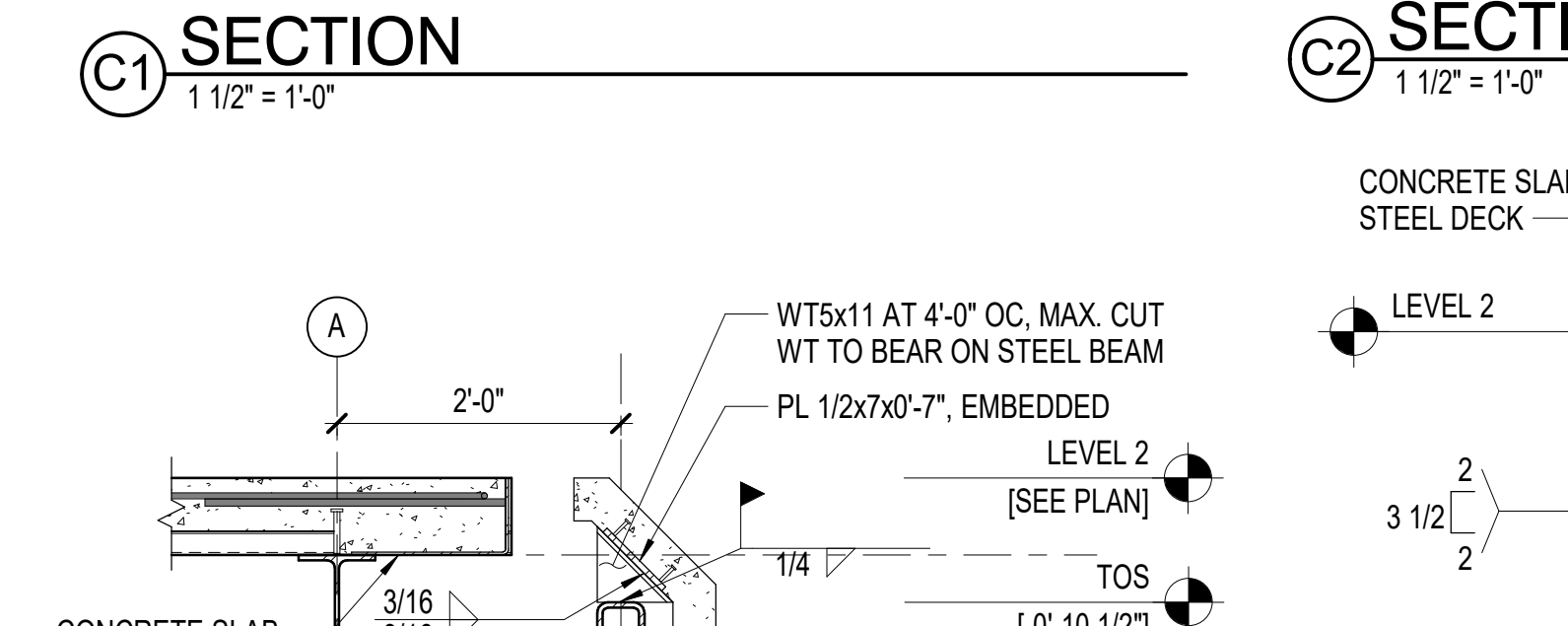
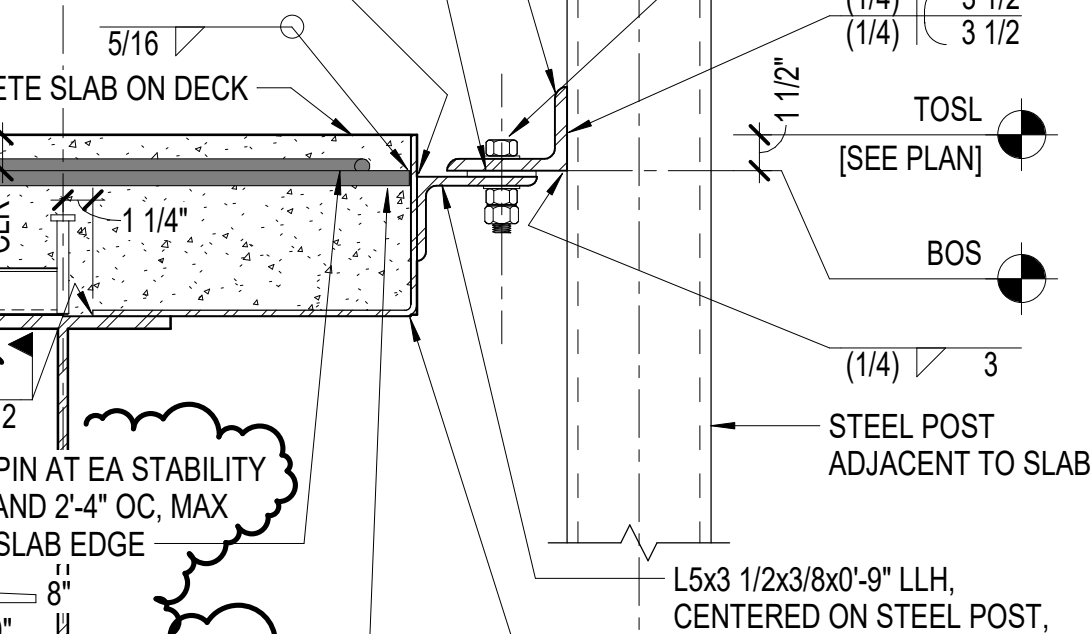
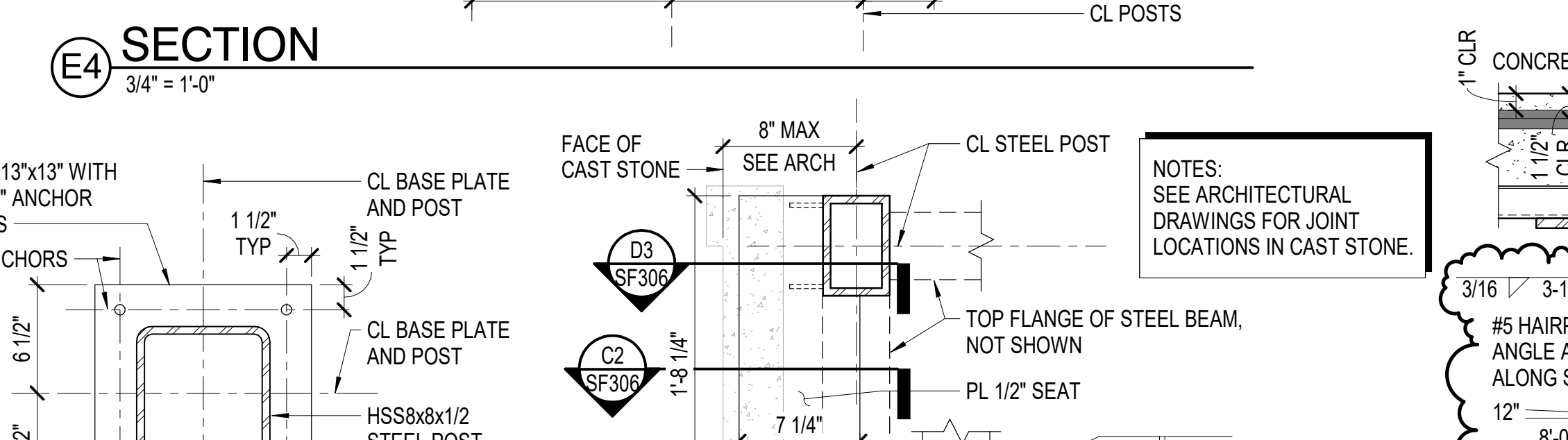
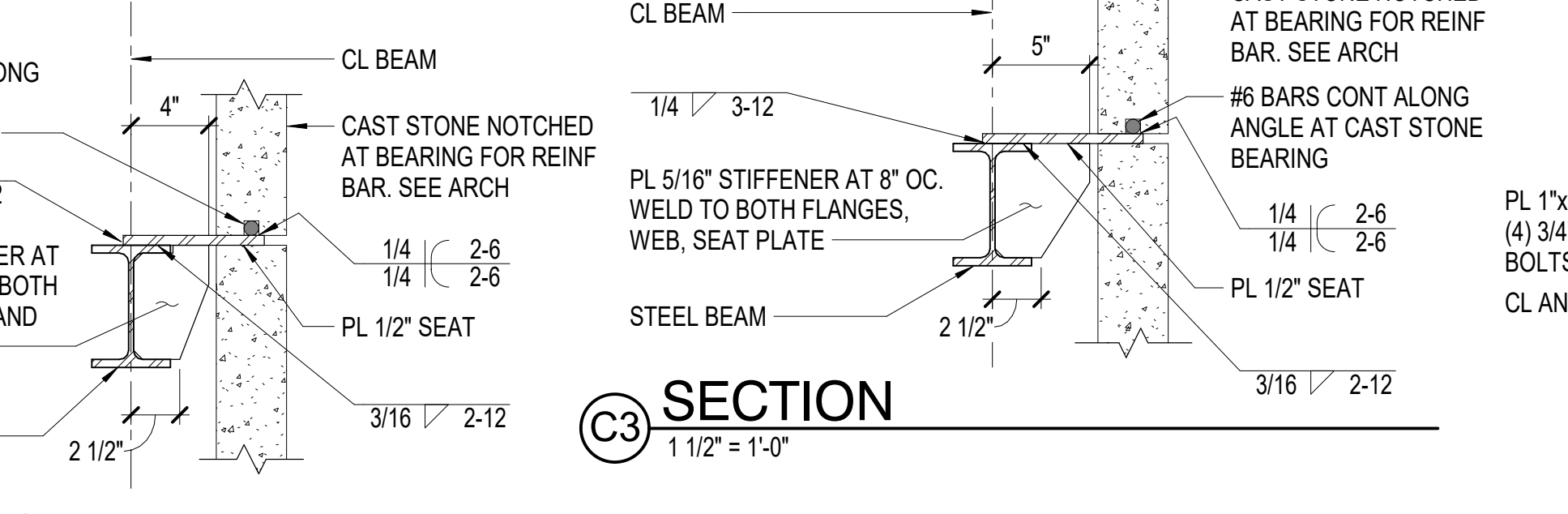
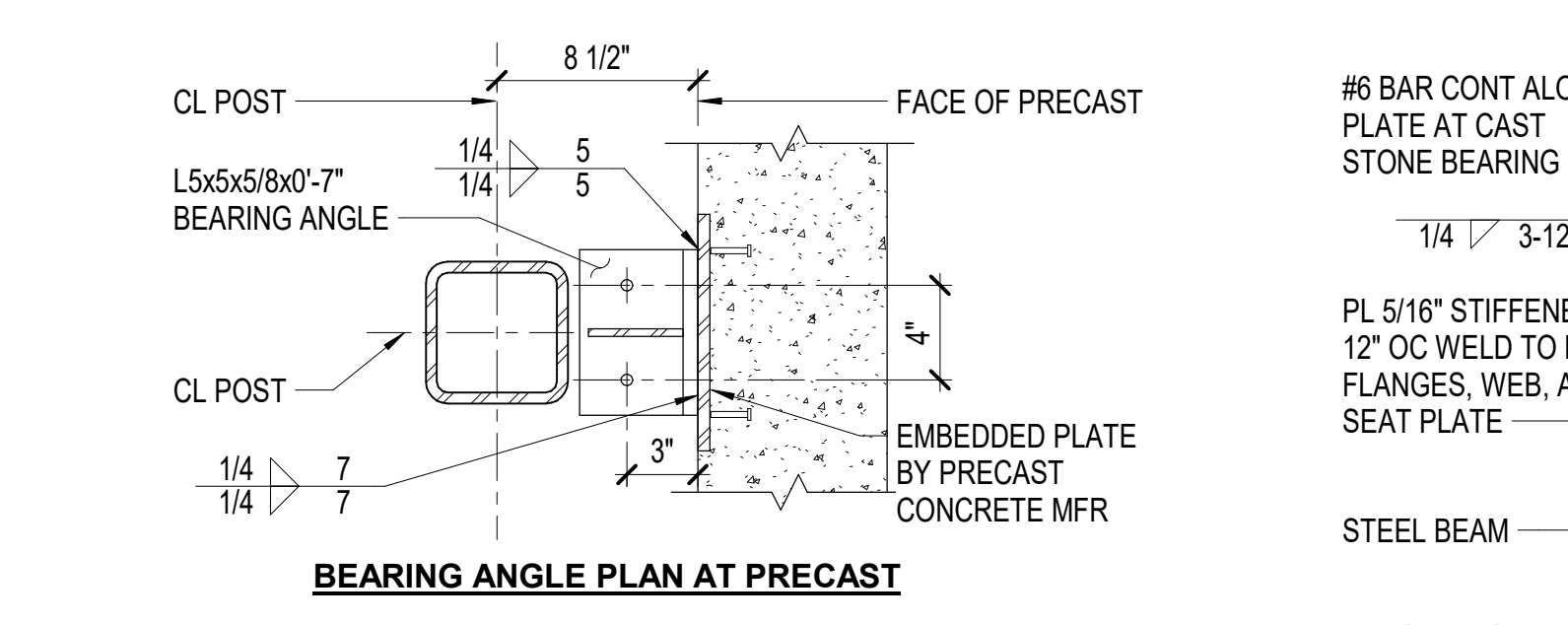
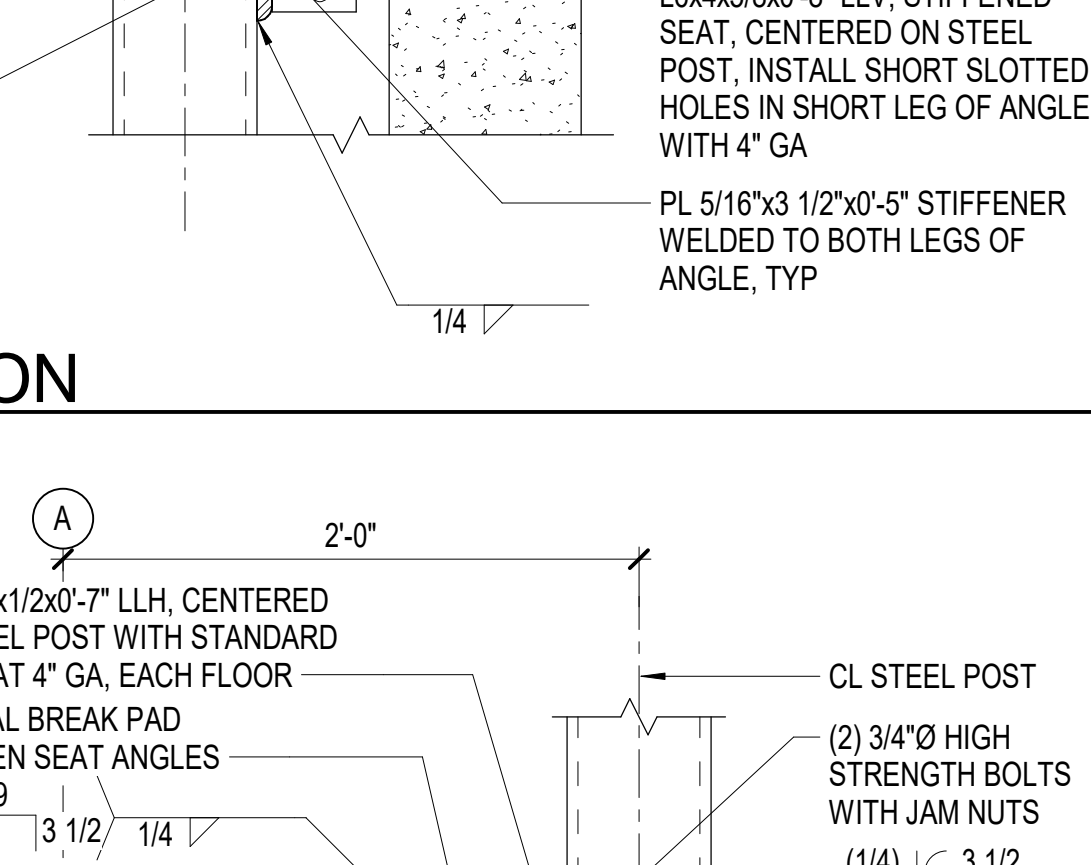
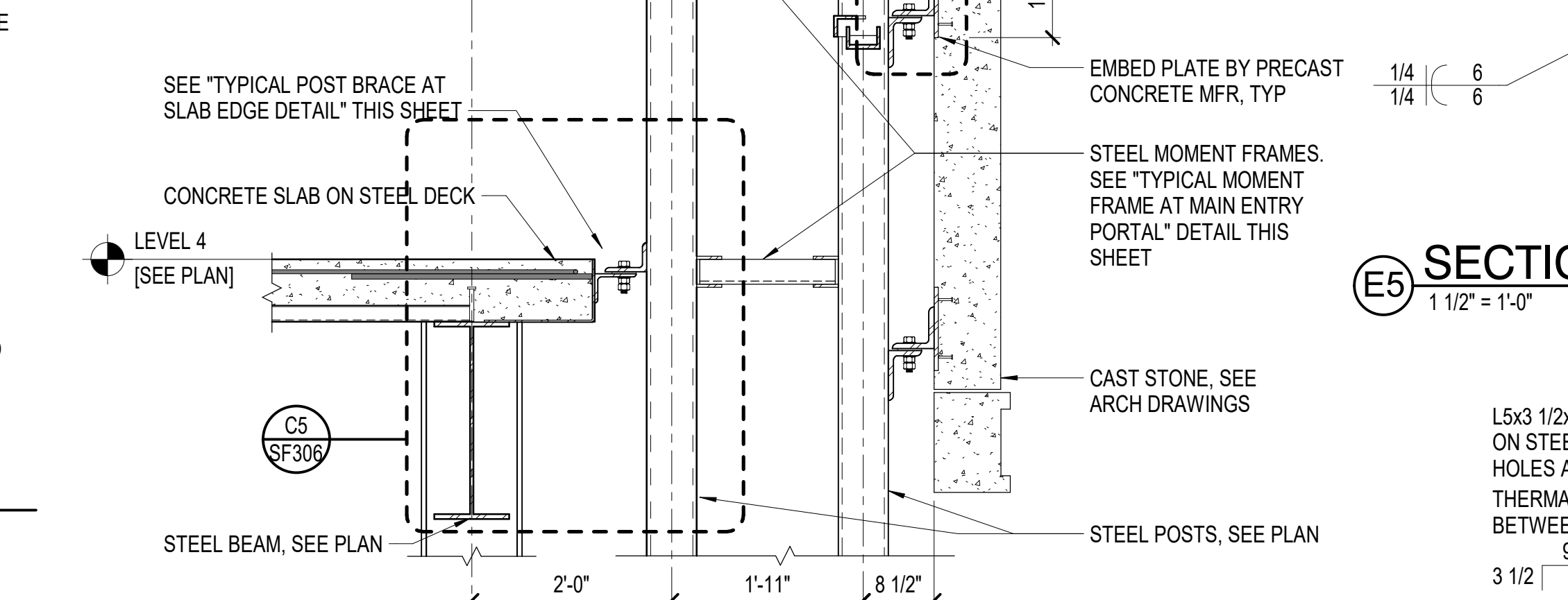
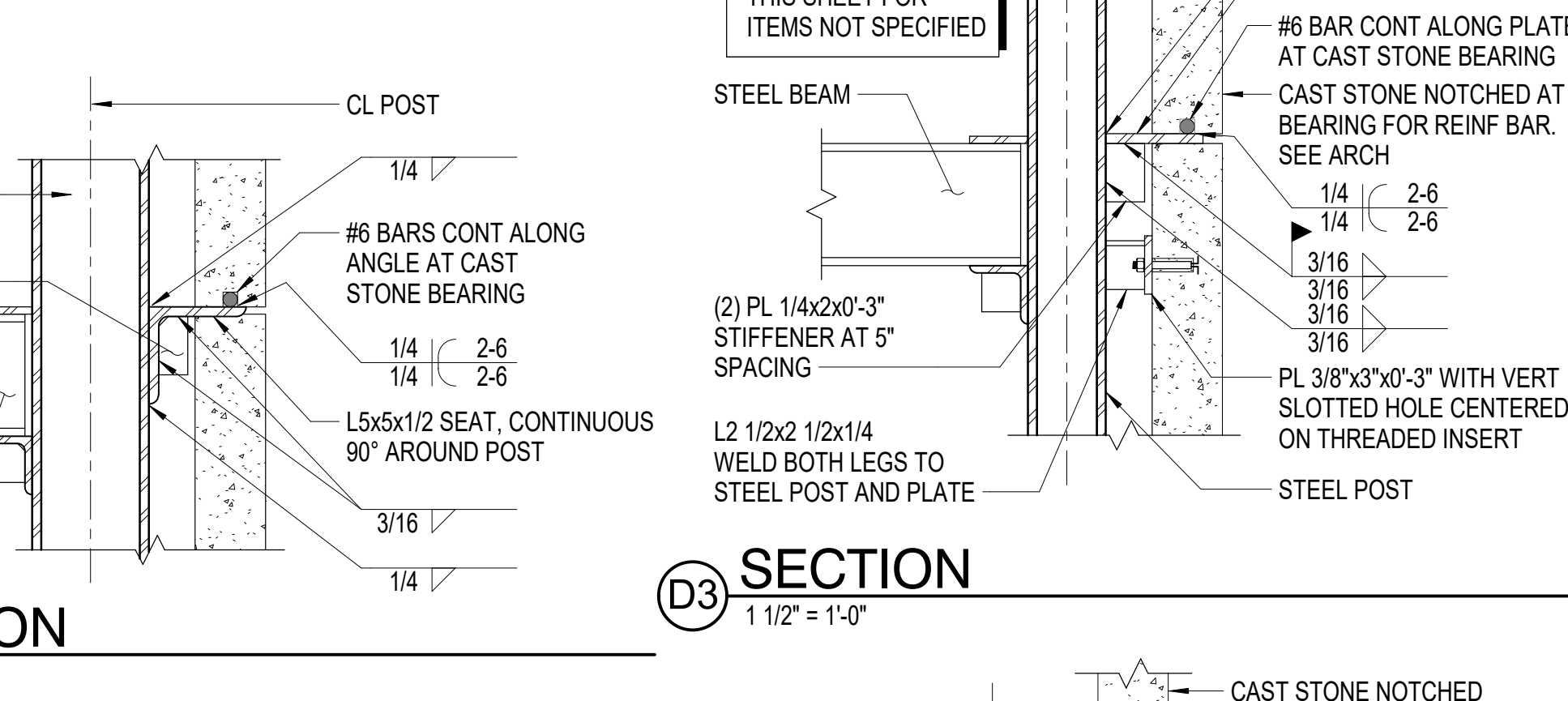
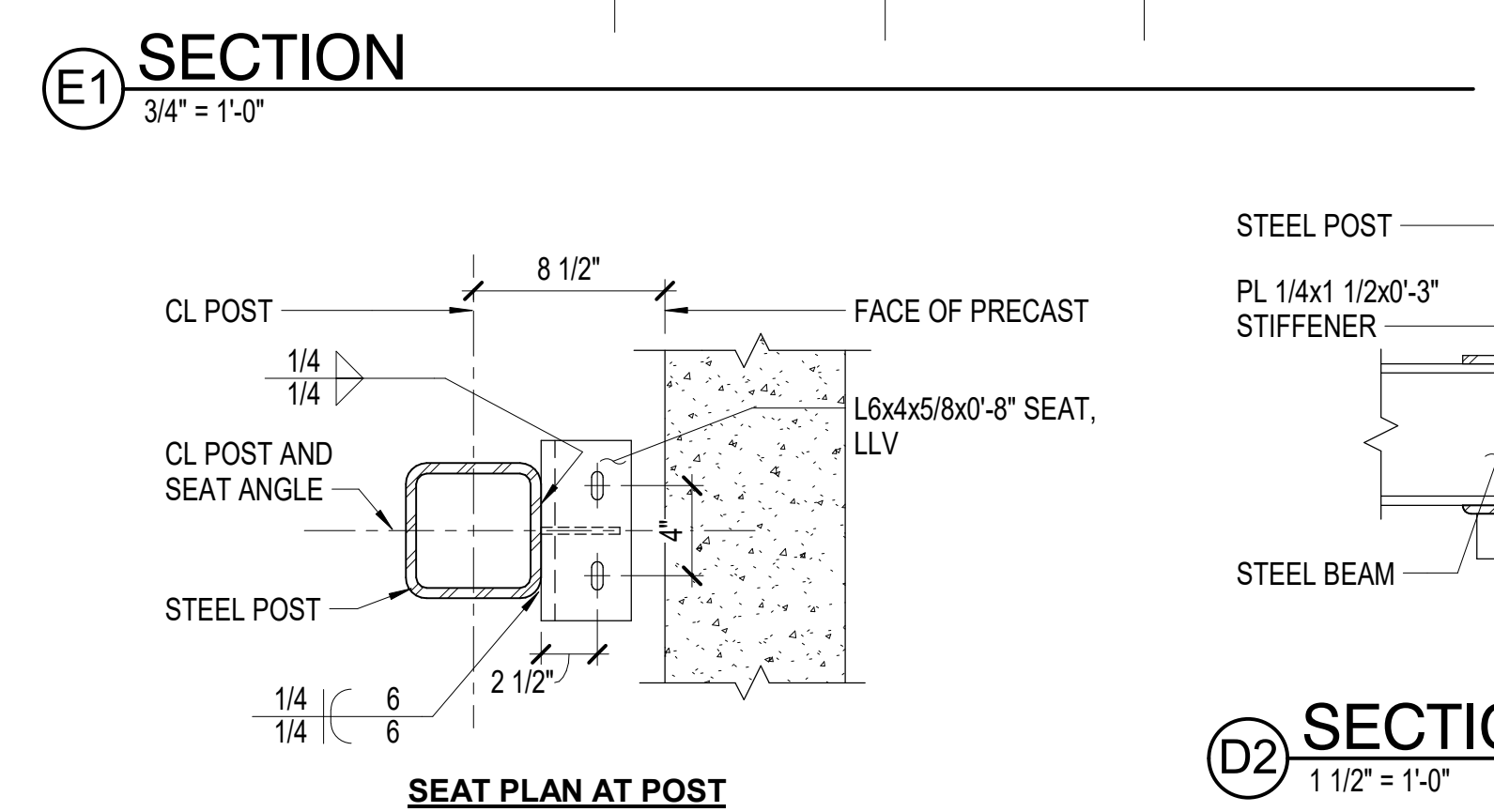


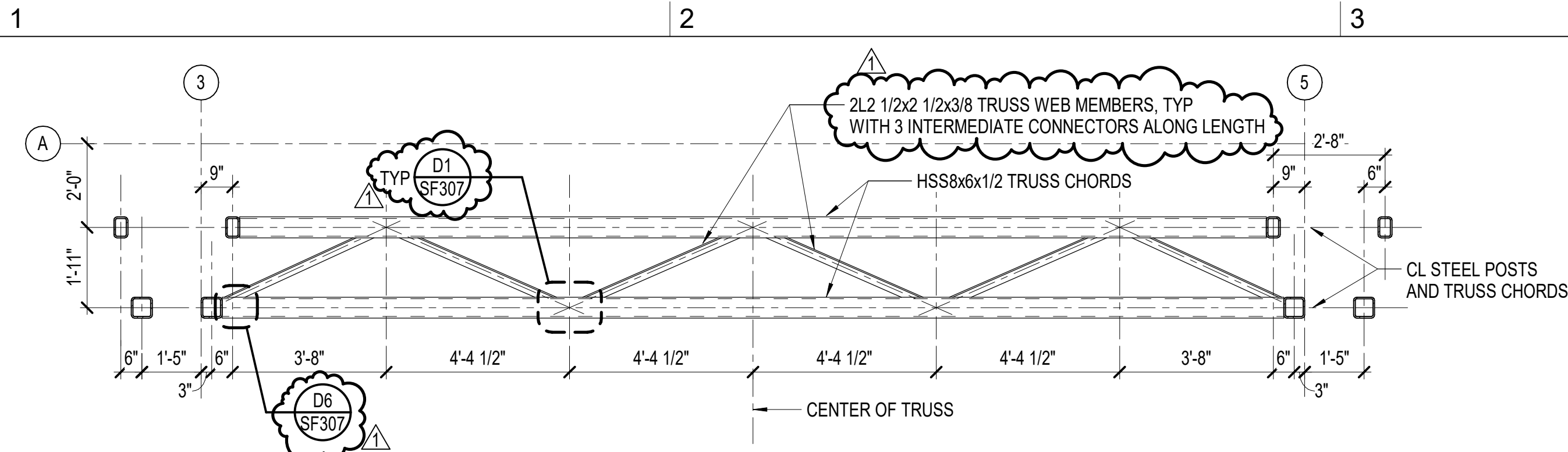
GRAPHIC SCALE(S)

3/4" = 1'-0"
 1" = 1'-0"
 1 1/2" = 1'-0"

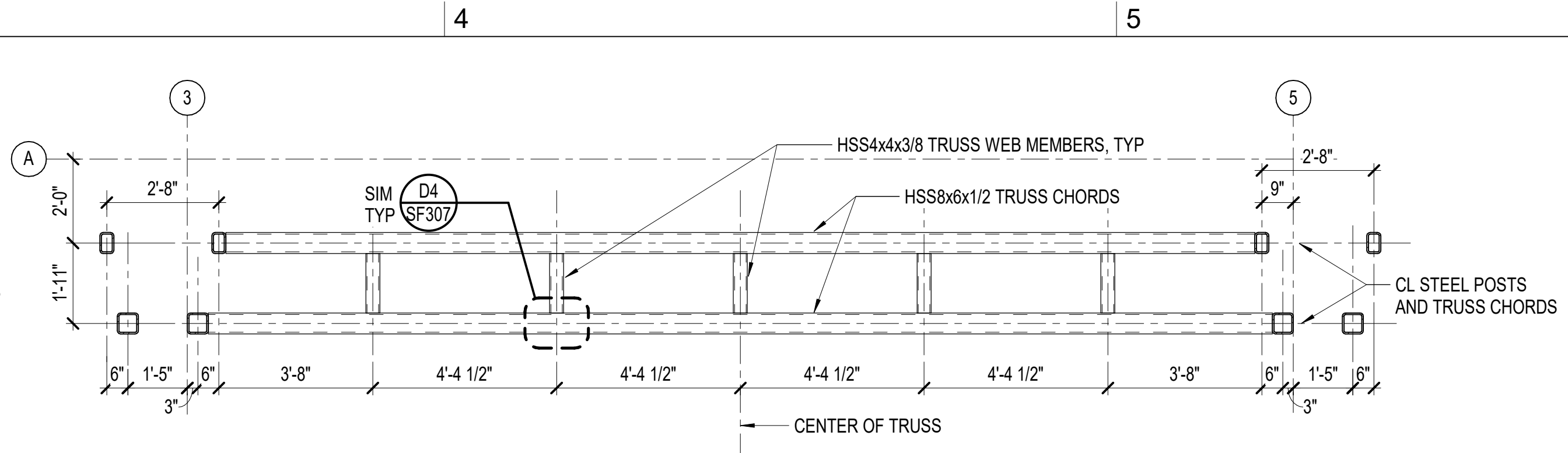
NOTES

1. COAT ALL STEEL WITH ZINC-RICH EPOXY PRIMER.

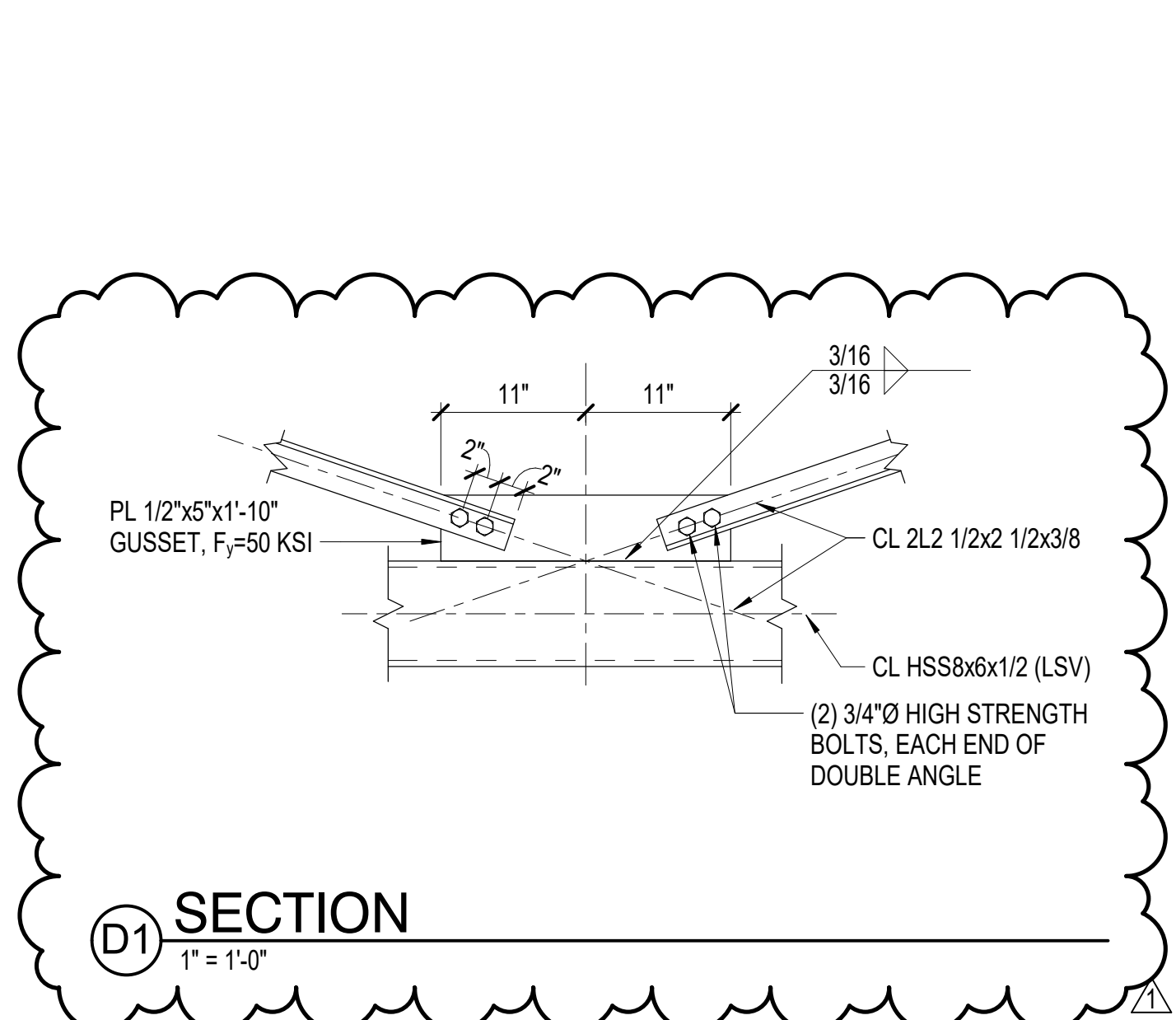
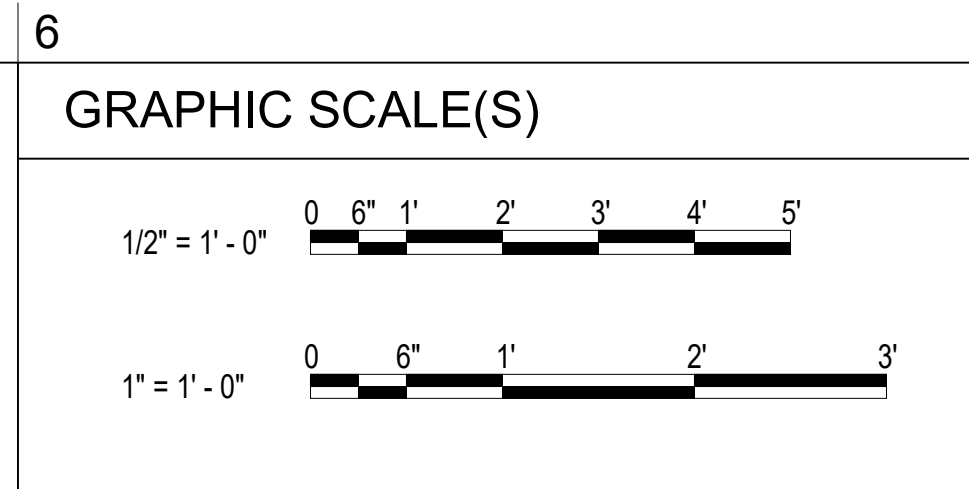




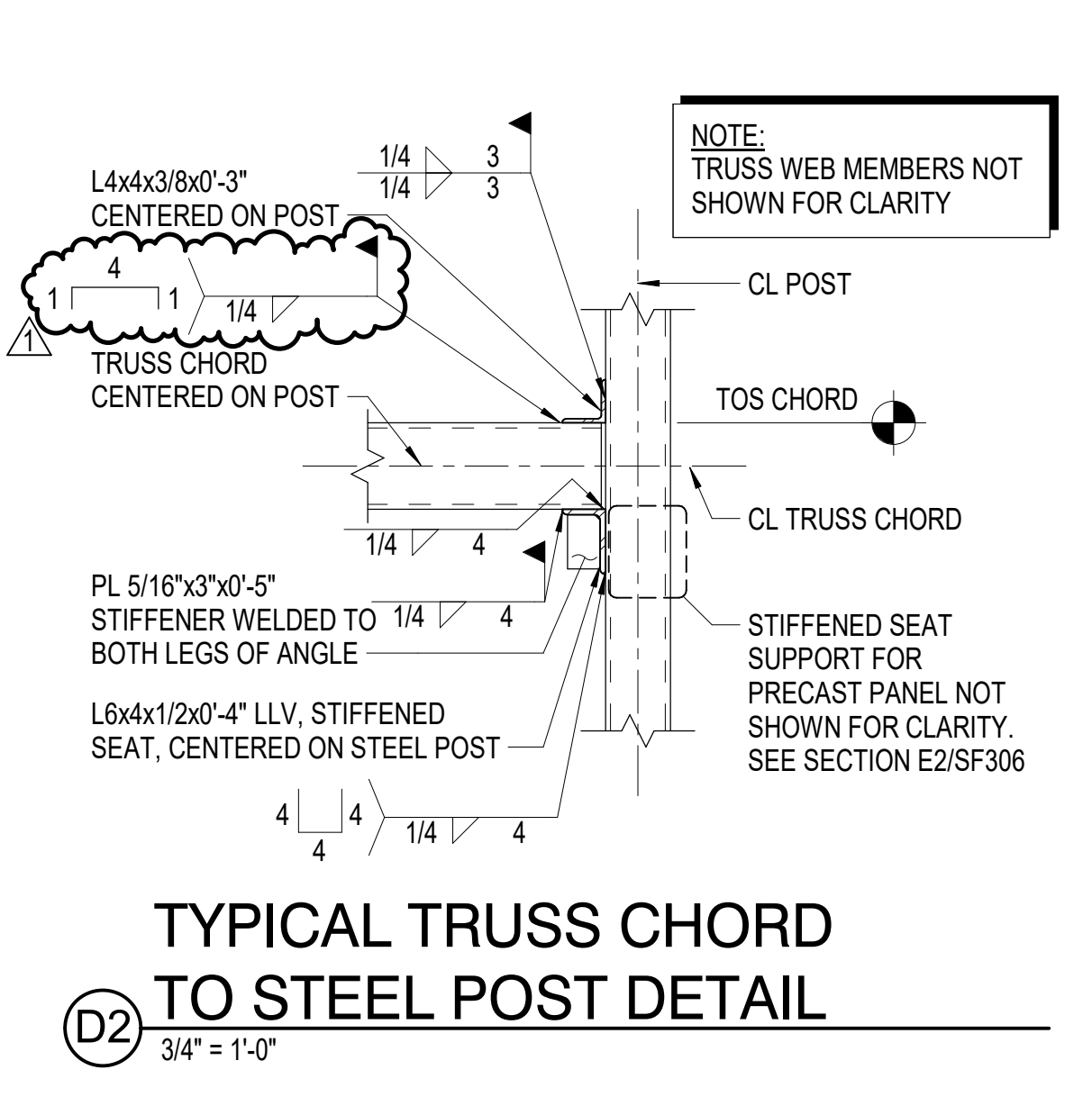
E1 HORIZONTAL TRUSS AT TOP OF MAIN ENTRY FRAME
3/8" = 1'-0"



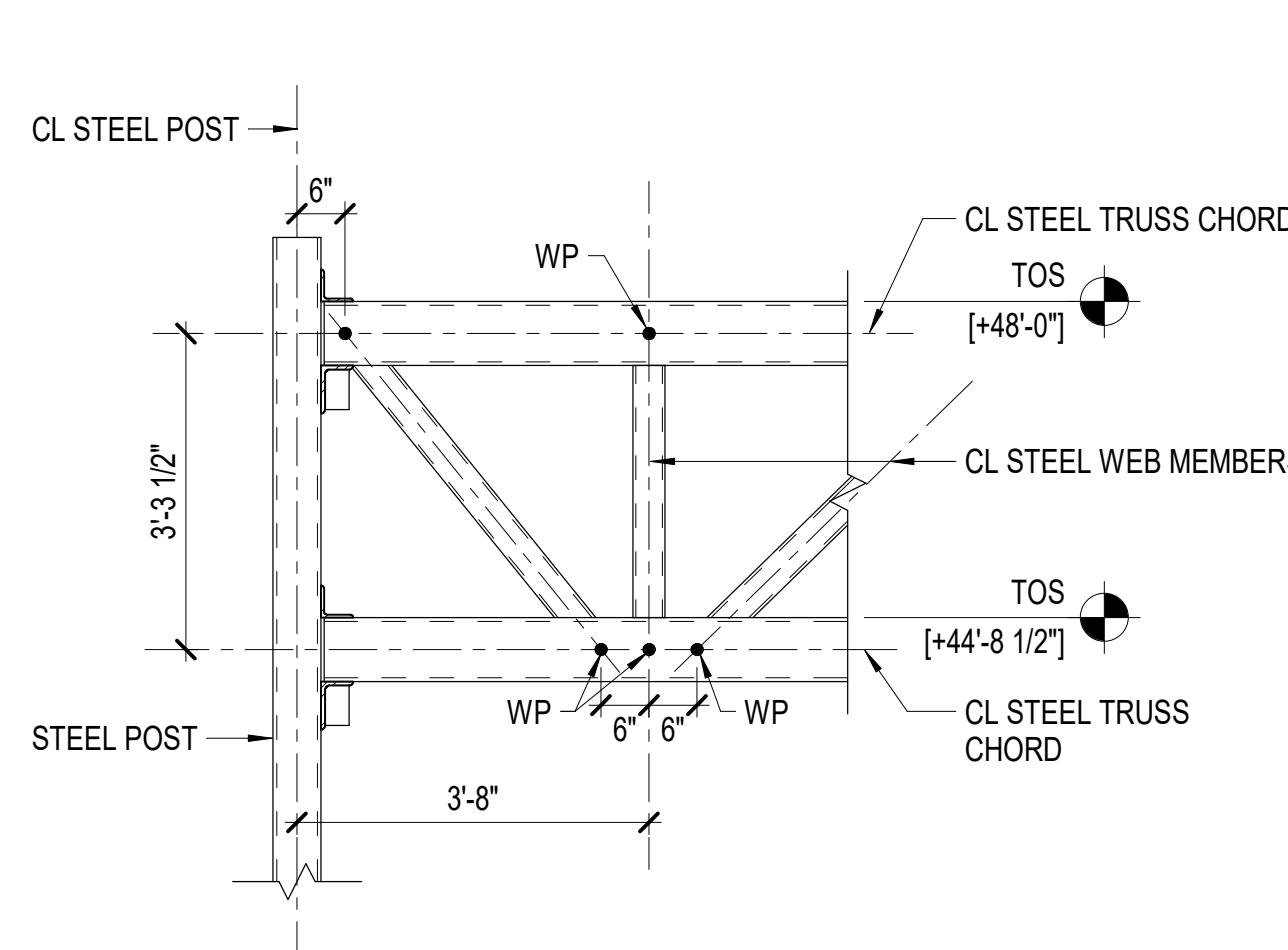
E2 HORIZONTAL TRUSS AT BOTTOM OF MAIN ENTRY FRAME
3/8" = 1'-0"



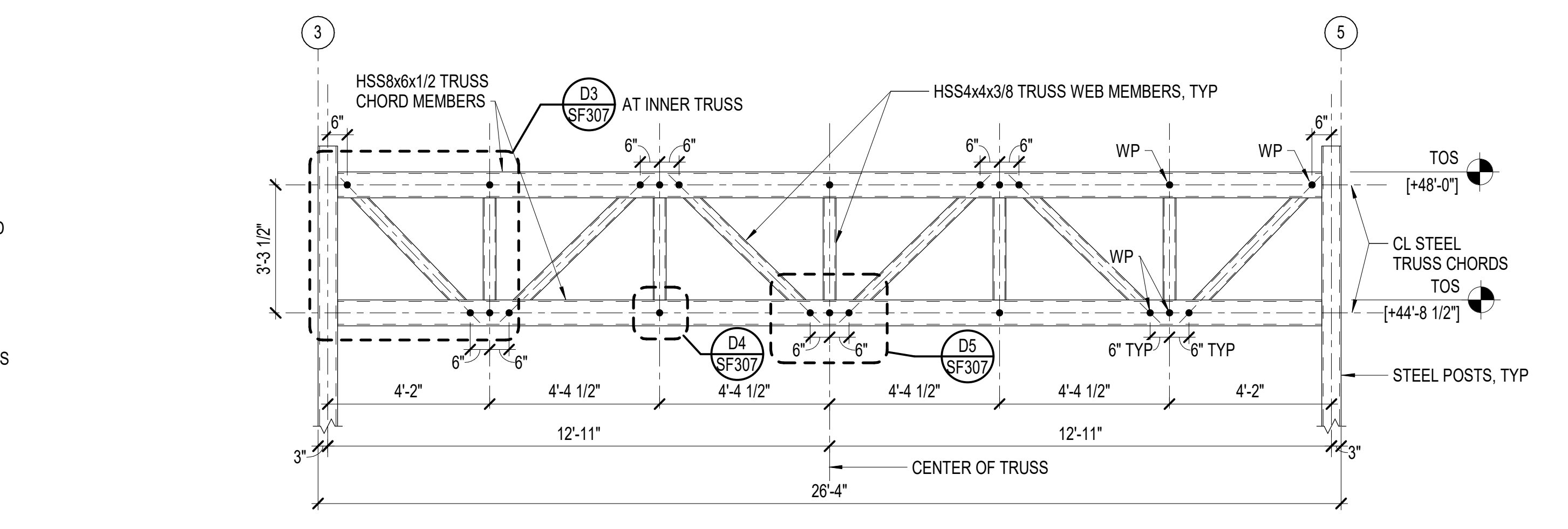
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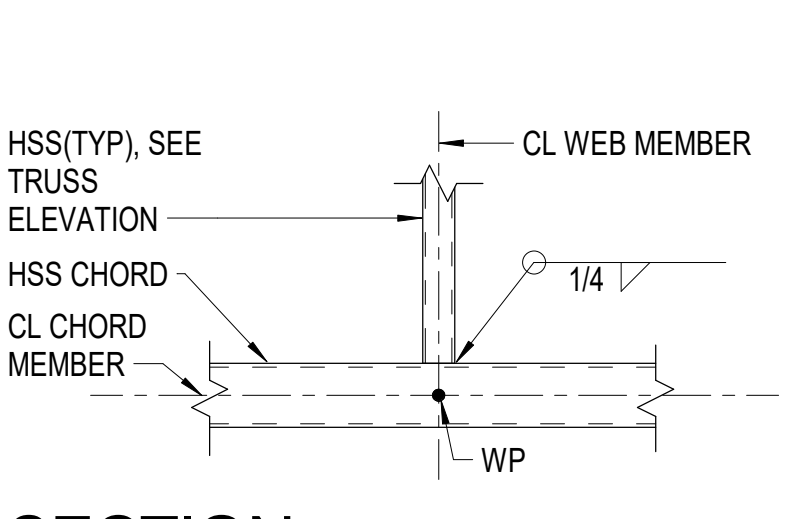
D2 TYPICAL TRUSS CHORD TO STEEL POST DETAIL
3/4\"/>



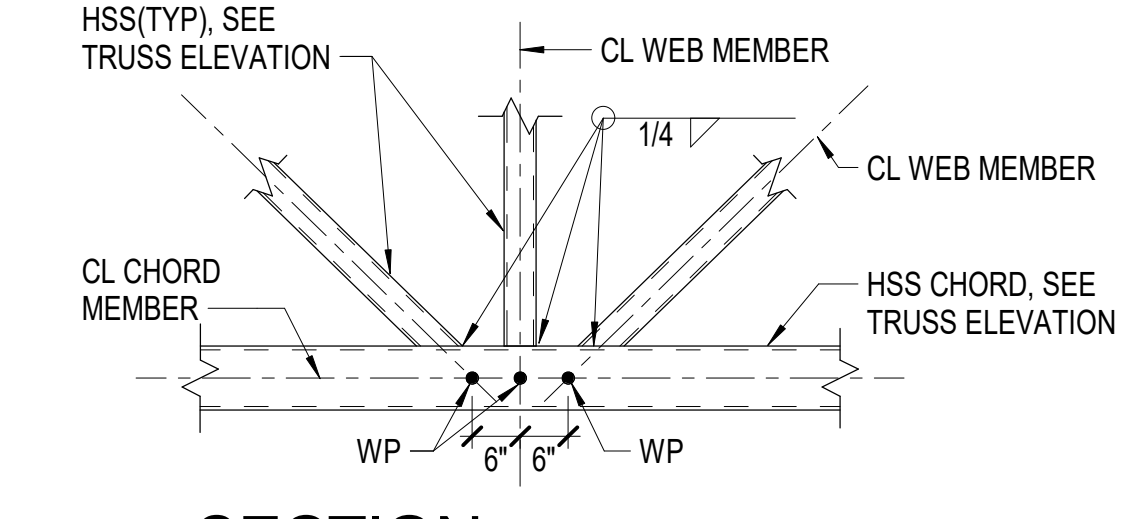
D3 END PANEL ELEVATION OF INNER TRUSS (BOTH ENDS)
1/2\"/>



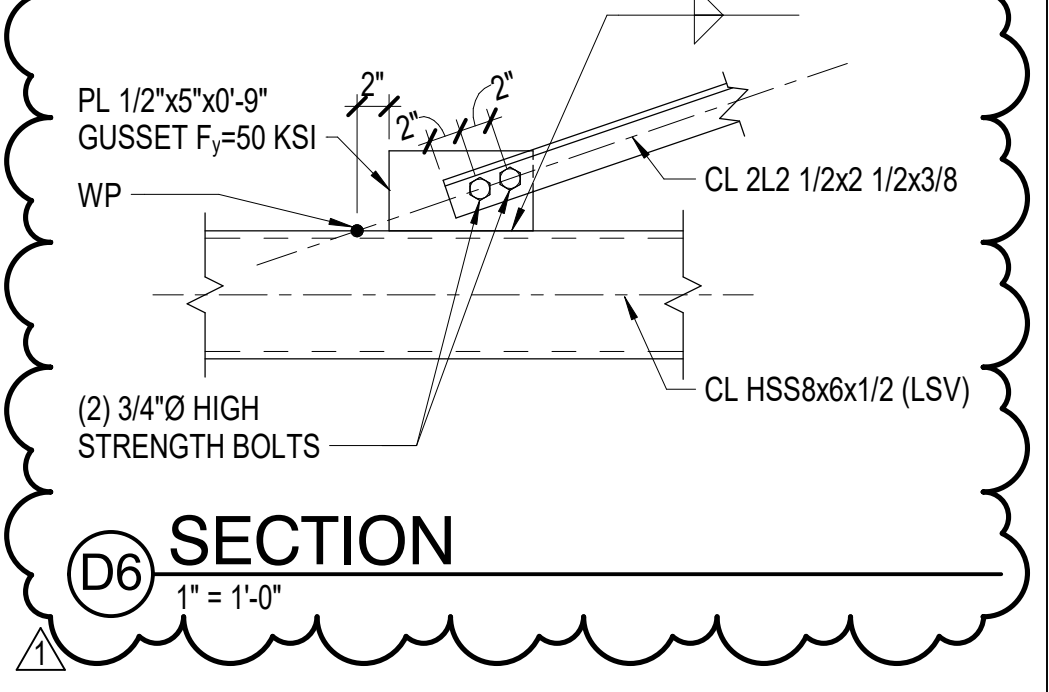
E3 TYPICAL VERTICAL TRUSS AT MAIN ENTRY (OUTER)
3/8" = 1'-0"



D4 SECTION
1/2\"/>



D5 SECTION
1/2\"/>



D6 SECTION
1\"/>

Issue Date

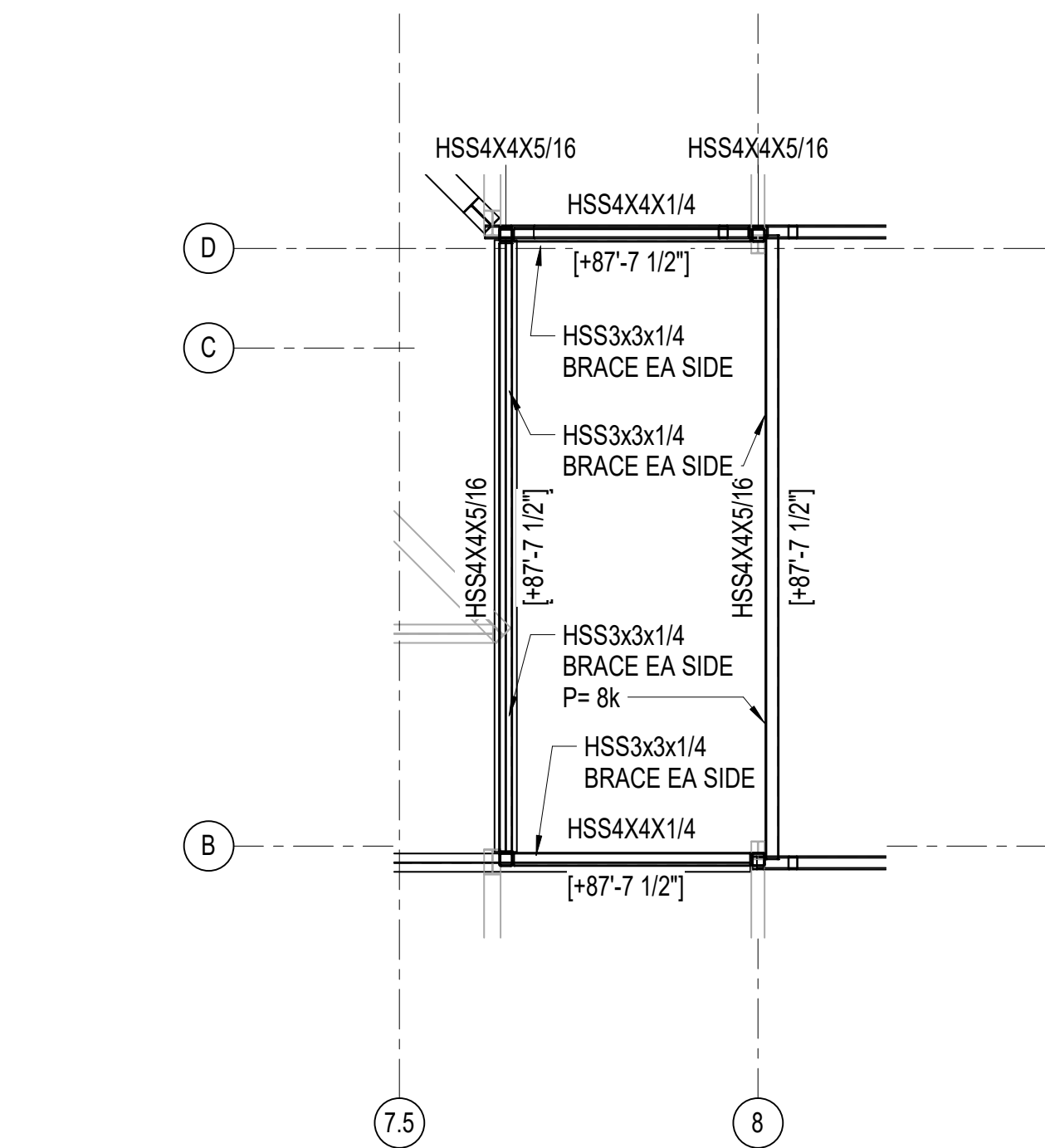
1	5/10/2019	Addendum 1

KEY PLAN

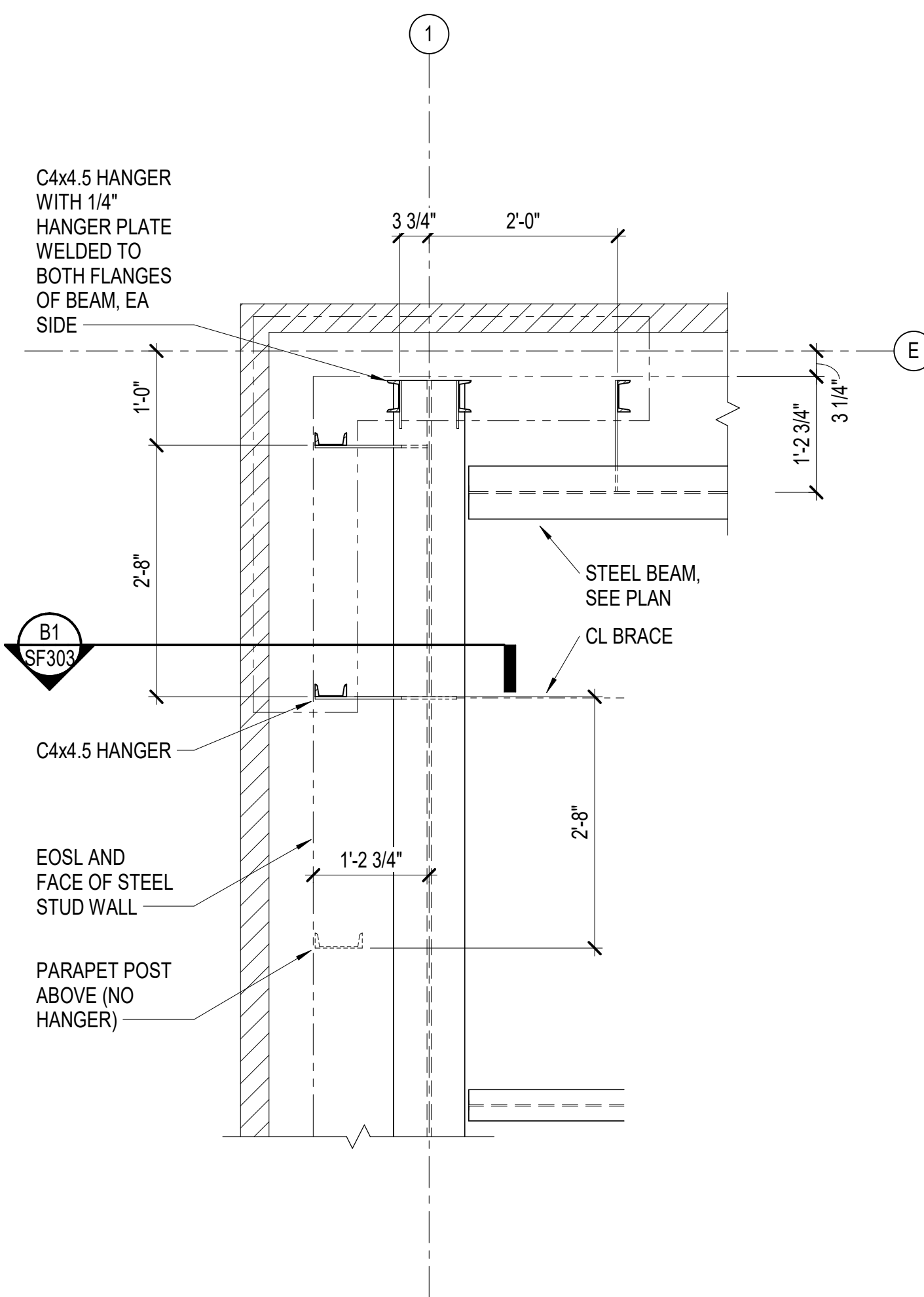
SHEET
MAIN ENTRY DETAILS

SF307

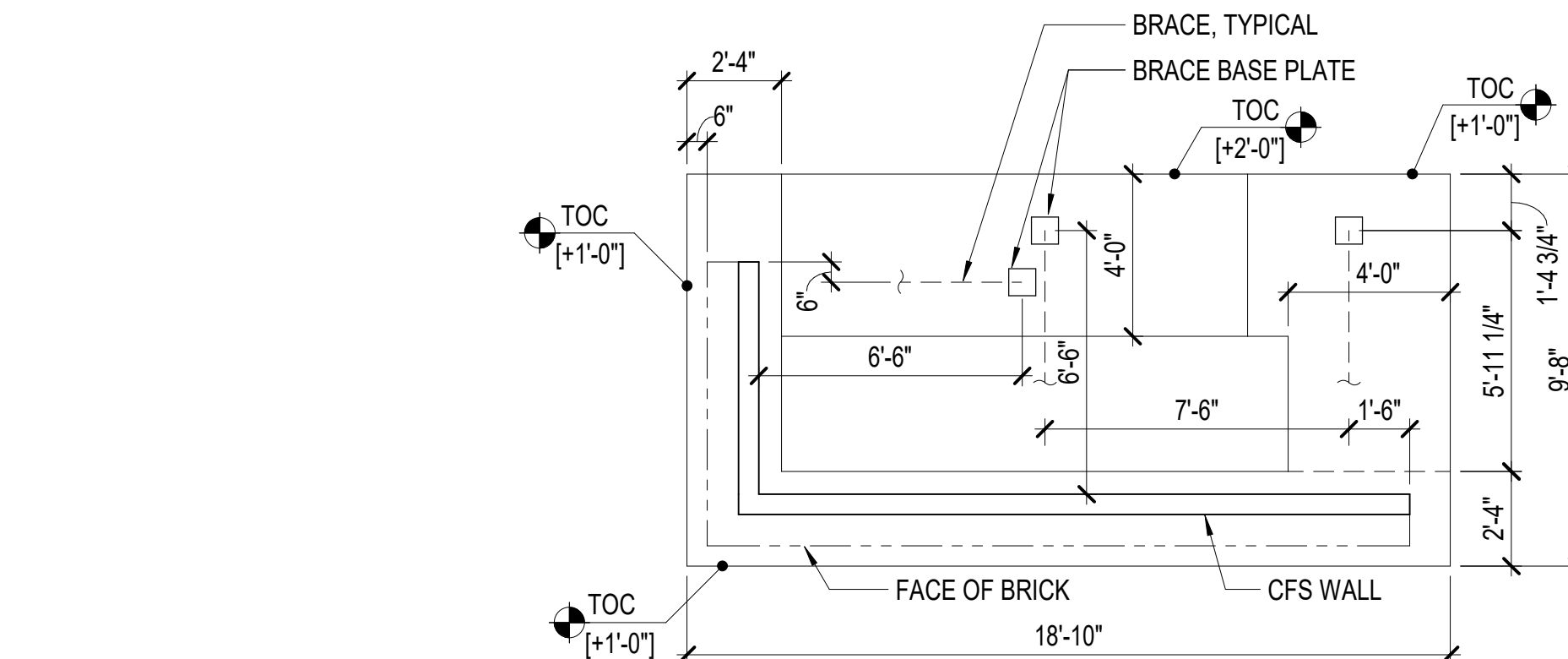
DESIGN: YCW
DRAWN: YCW
REVIEW: YCW
CN 6222



PLAN DETAIL CHIMNEY SUPPORT FRAME
 1/4" = 1'-0"

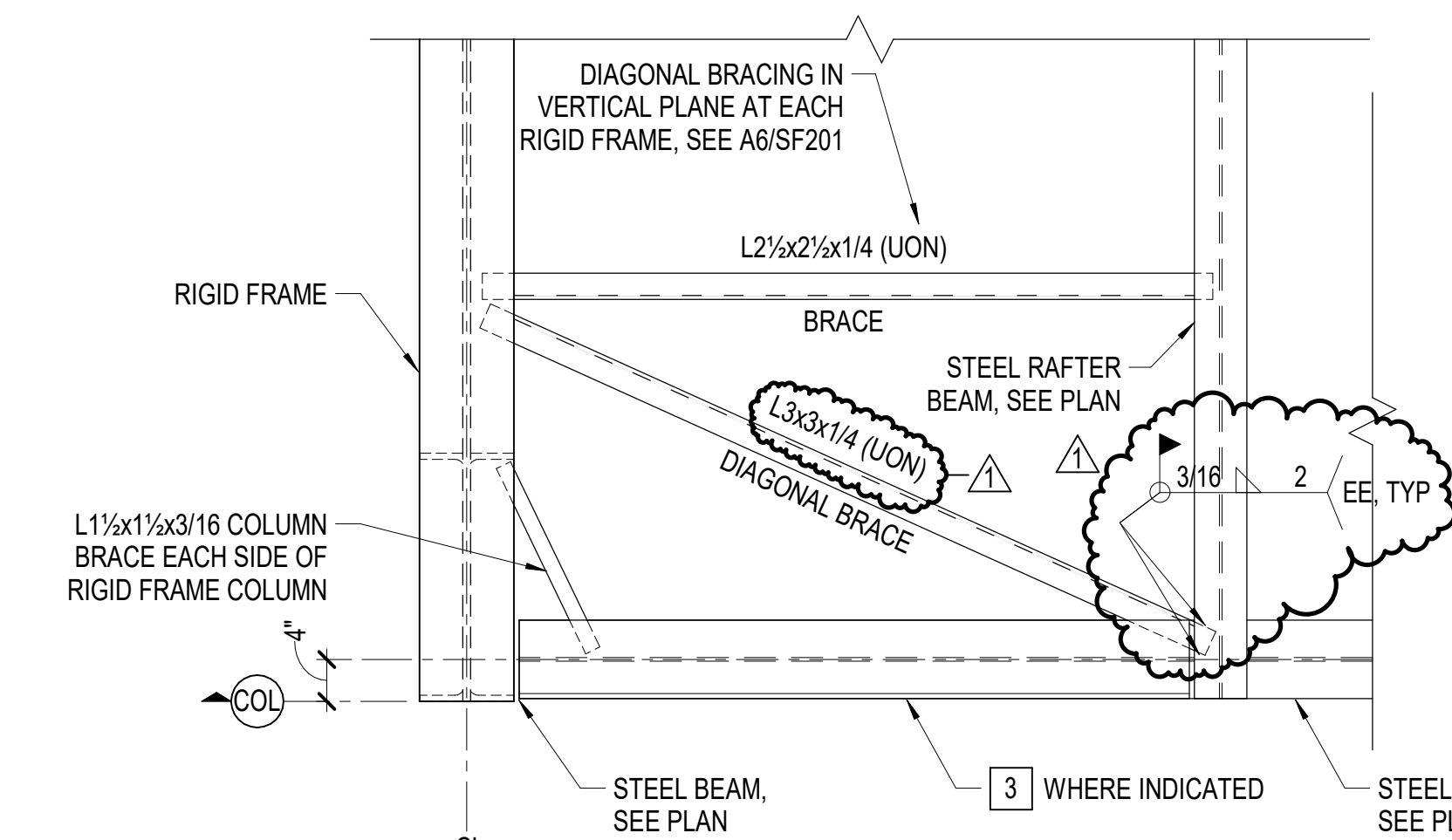


PLAN DETAIL - LEVEL 4 LINE 1
 3/4" = 1'-0"

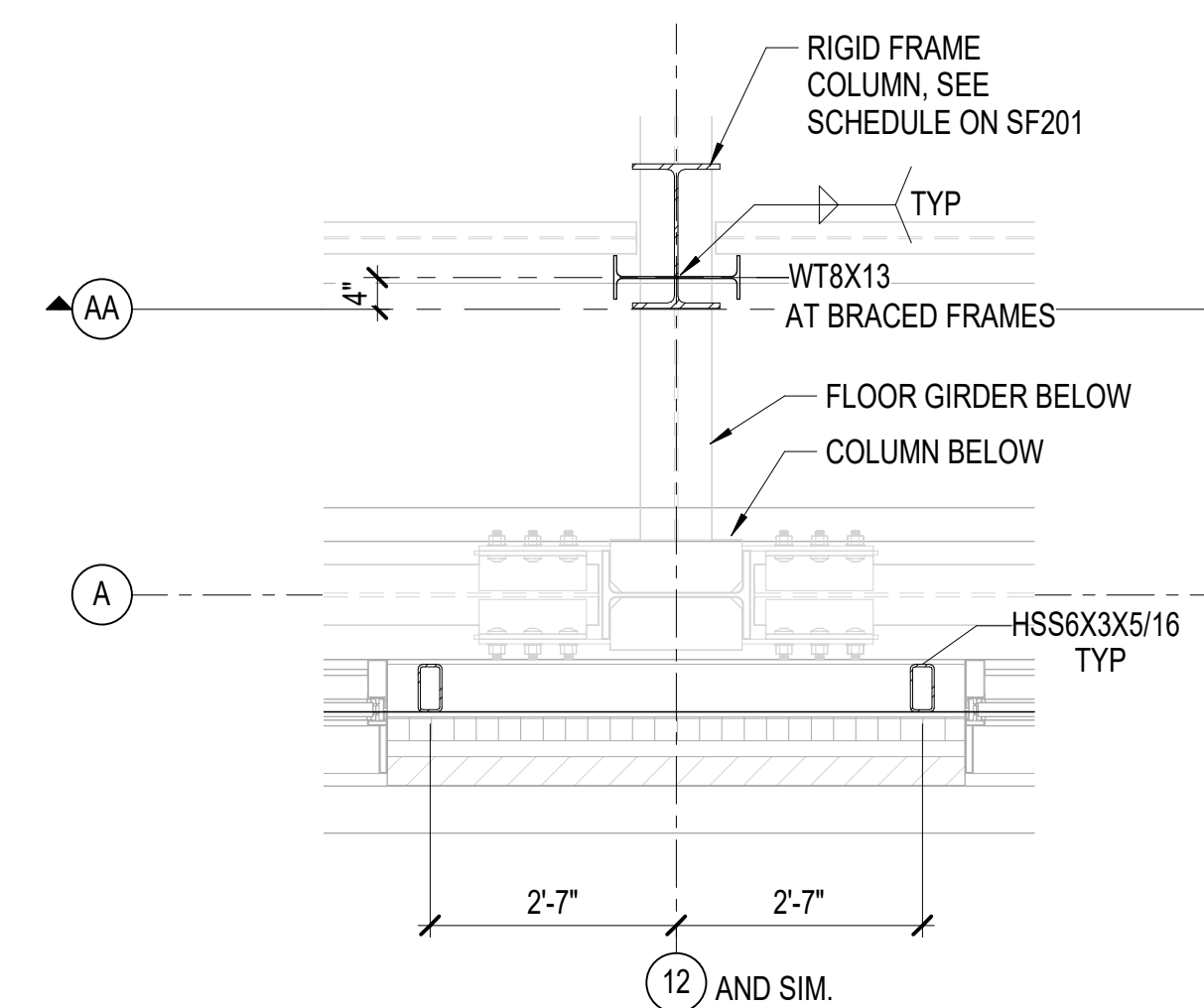


MOCK-UP PANEL FOUNDATION PLAN
 1/4" = 1'-0"

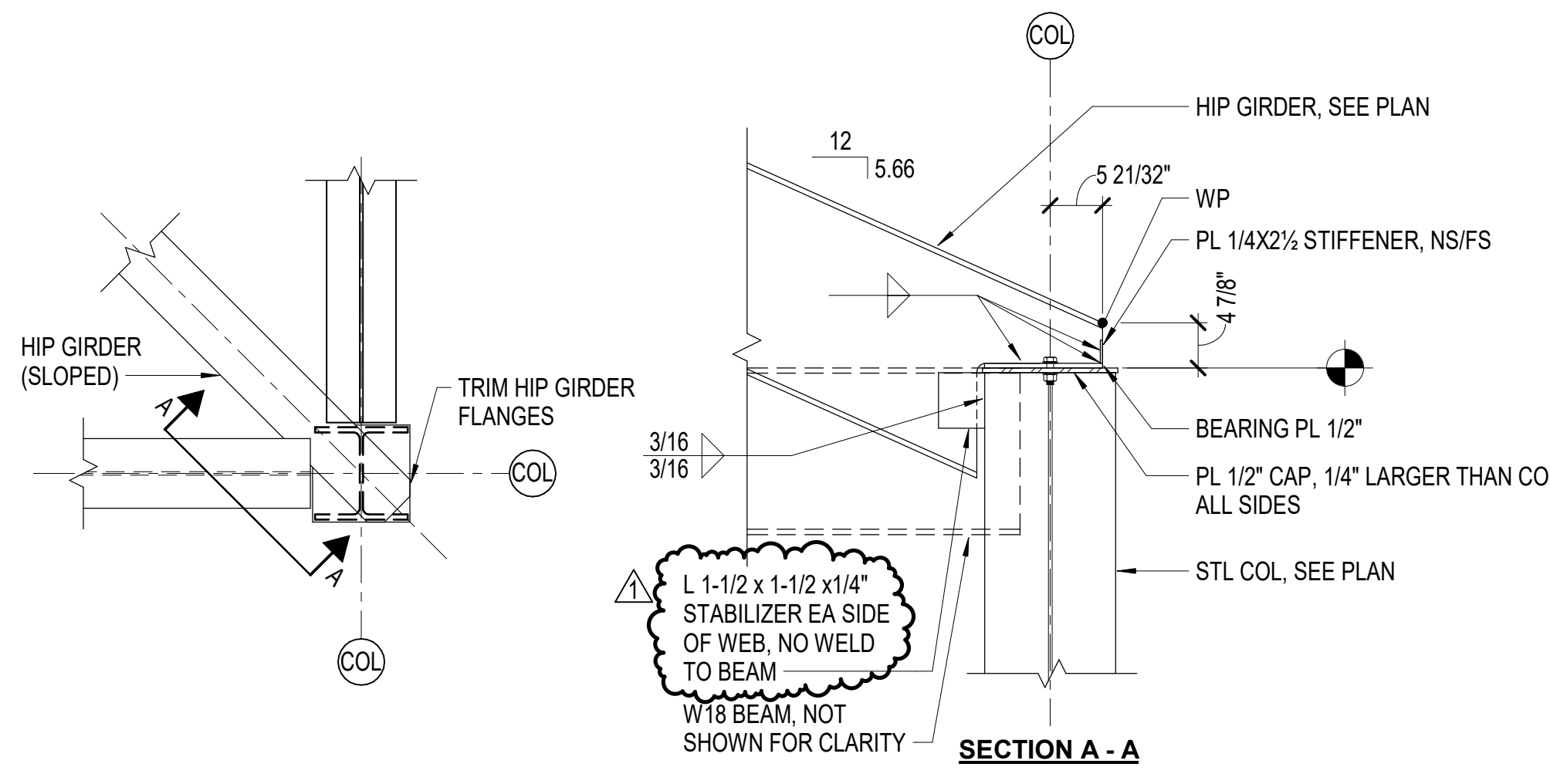
NOTES:
 1. FOOTINGS ARE ASSUMED TO BE FORMED ON TOP OF GRADE
 2. WHERE FOOTING TOP = [+2'-0"], FOOTING SHALL BE 2'-0" THICK
 3. 2'-4" FOOTING SHALL BE REINFORCED WITH (2) #5 LONG BARS AND #5 TRANS. BARS AT 24" OC, BOTTOM
 4. 4'-0" FOOTING SHALL BE REINFORCED WITH (4) #6 LONG BARS AND #5 TRANS. BARS AT 18" OC, BOTTOM
 5. SHEATH INSIDE FACE OF WALLS WITH 1/2" PLYWOOD. FASTEN EDGES OF PLYWOOD TO CFS STUDS WITH SCREWS AT 4" OC



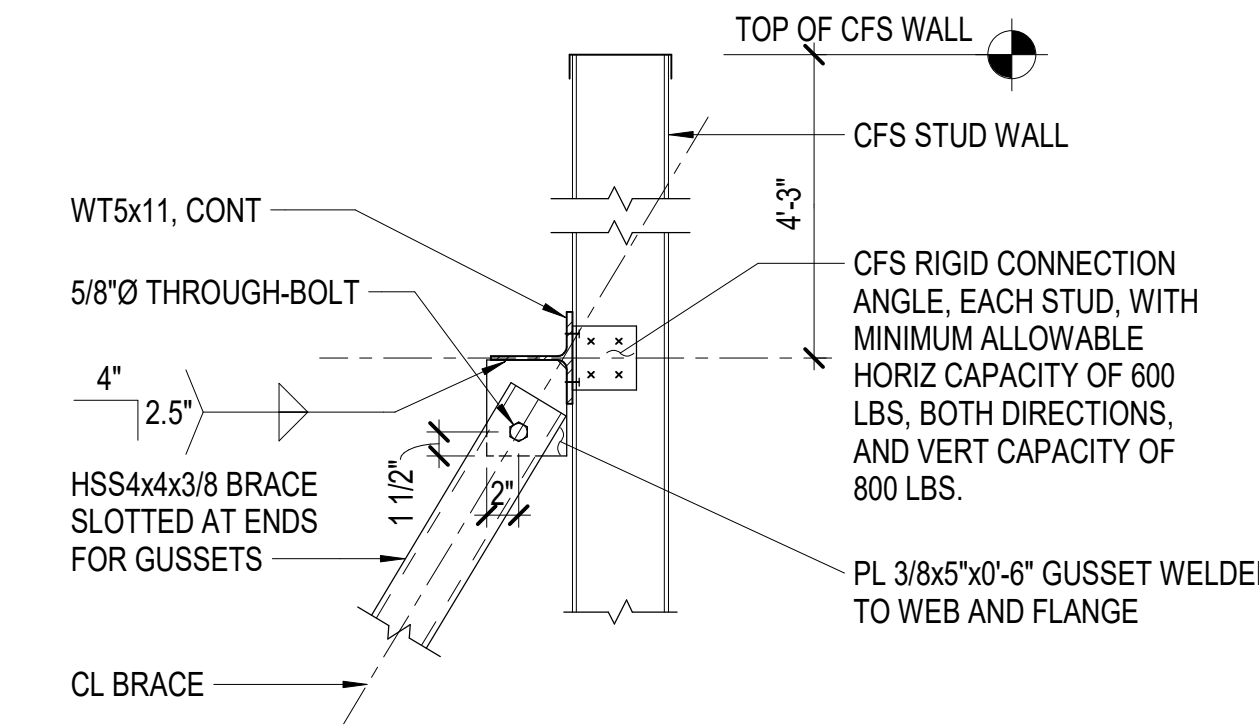
TYPICAL IN-PLANE ROOF BRACING AT RIGID FRAME PERIMETER COLUMN
 3/4" = 1'-0"



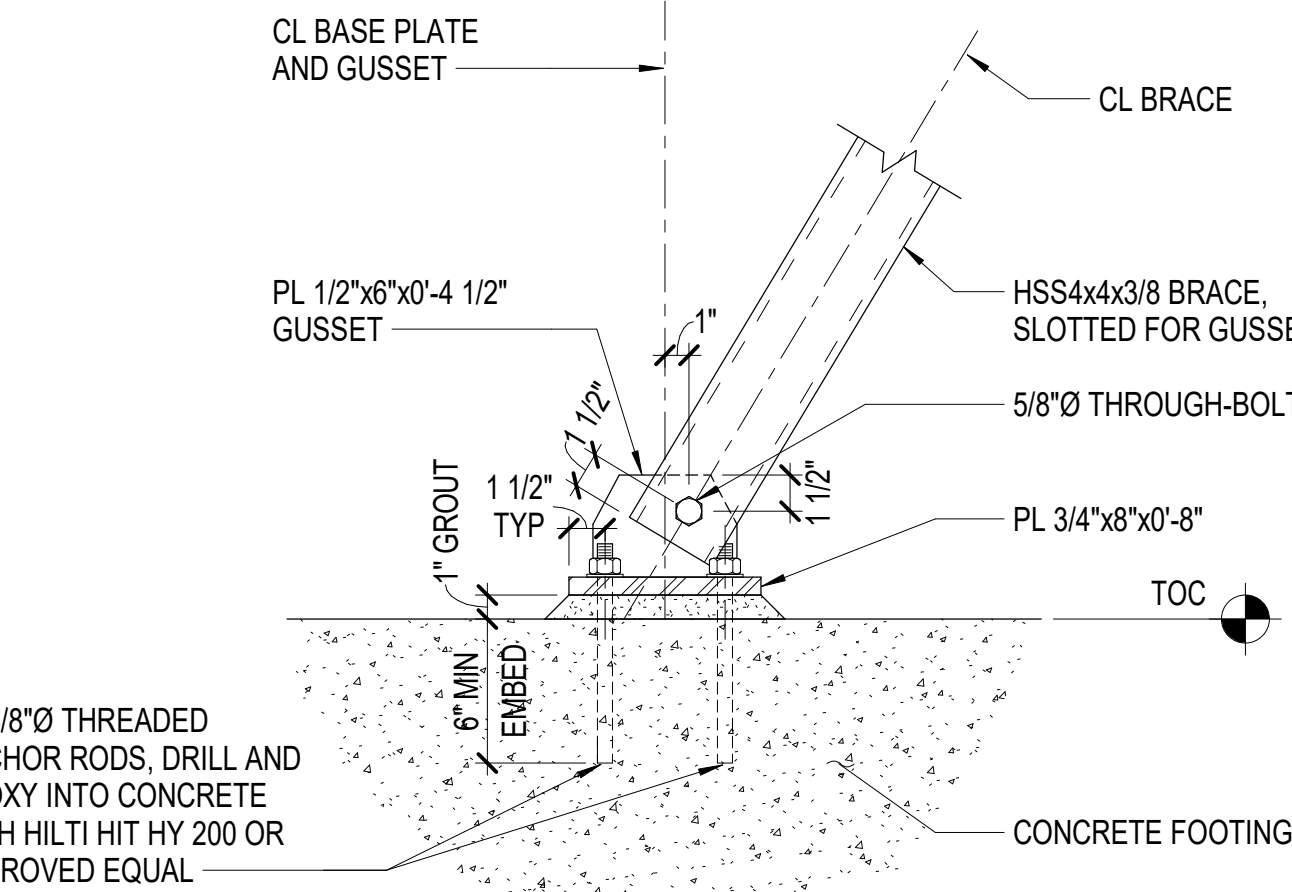
PLAN DETAIL TYPICAL CONDITION AT ROOF GUTTER POSTS
 1/2" = 1'-0"



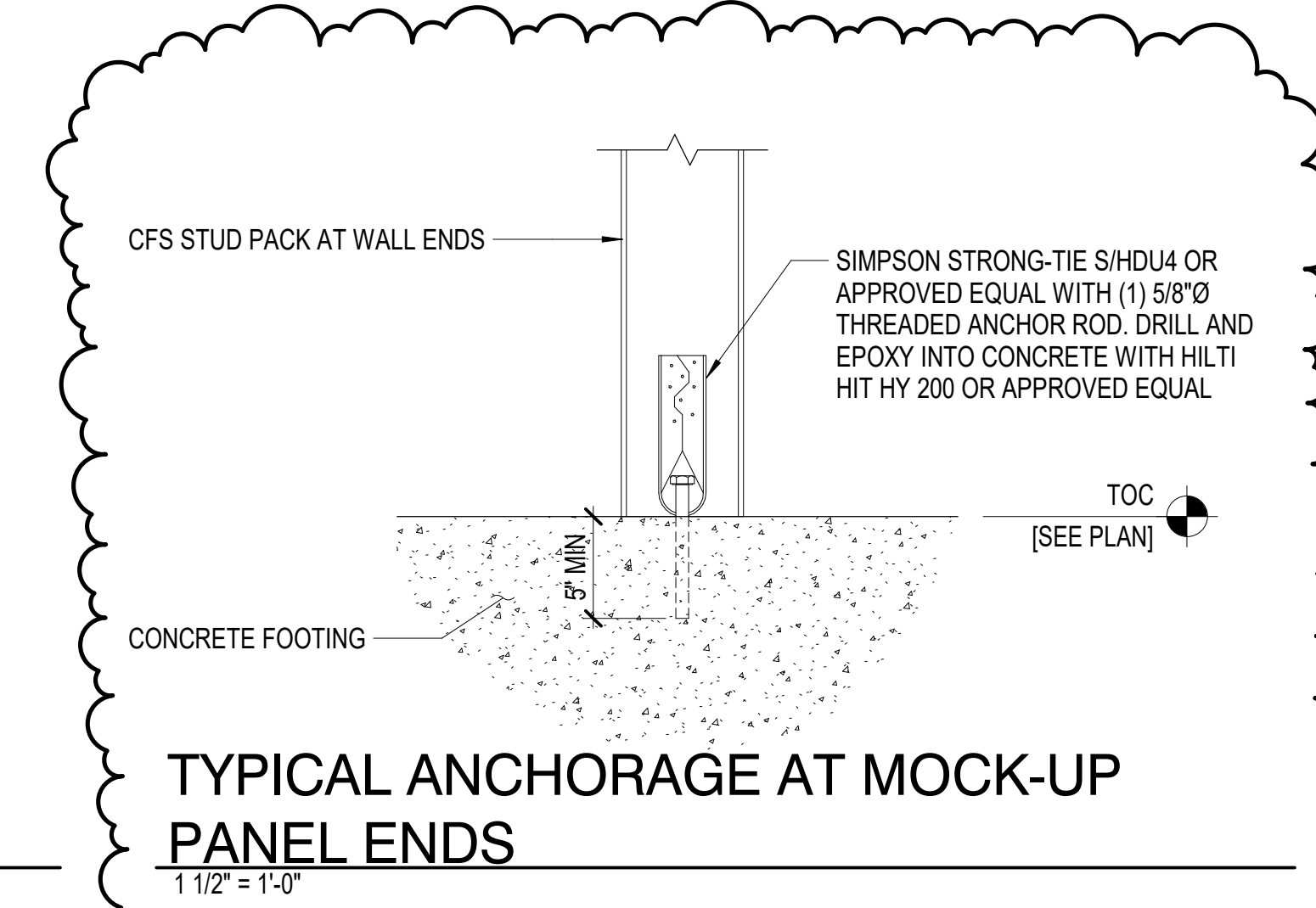
PLAN DETAIL - HIP GIRDER END
 3/4" = 1'-0"



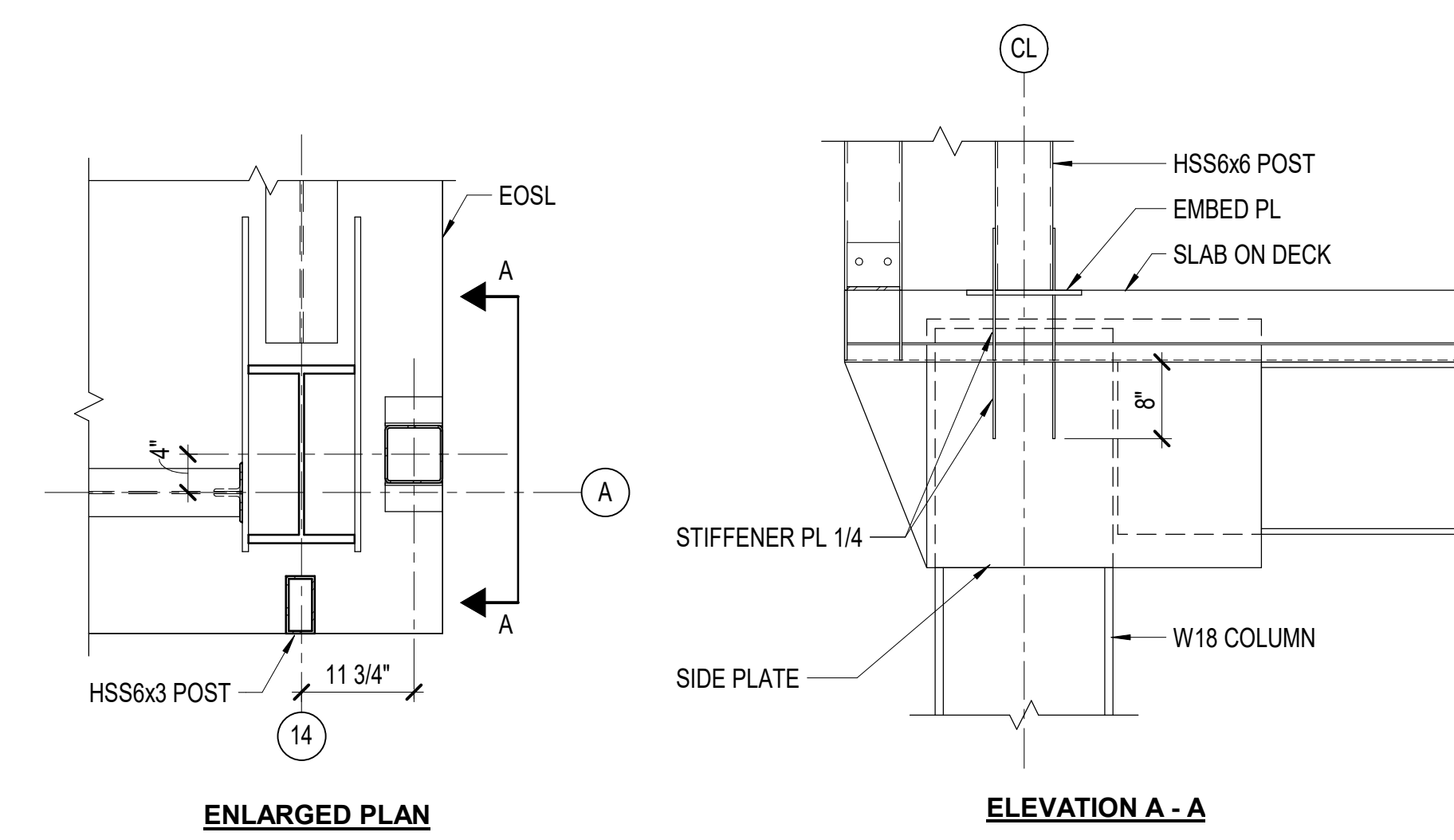
DETAIL AT TOP OF BRACE
 1" = 1'-0"



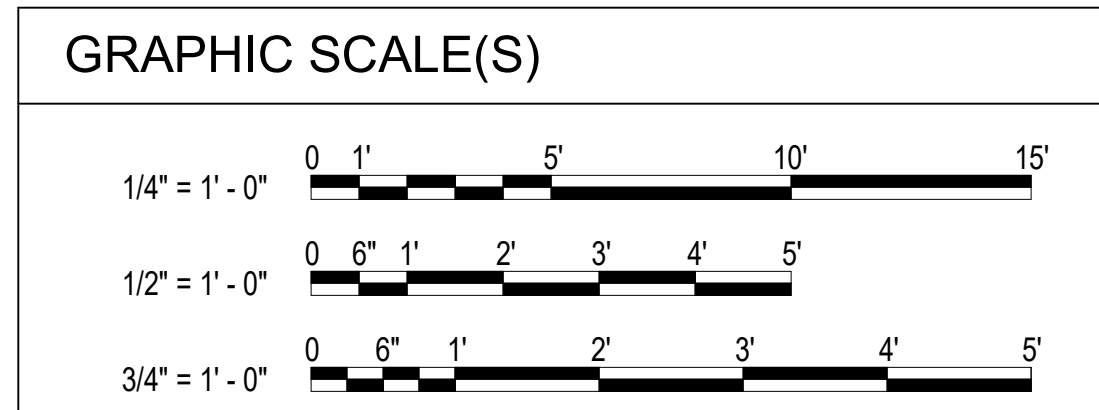
DETAIL AT BASE OF BRACE
 1 1/2" = 1'-0"

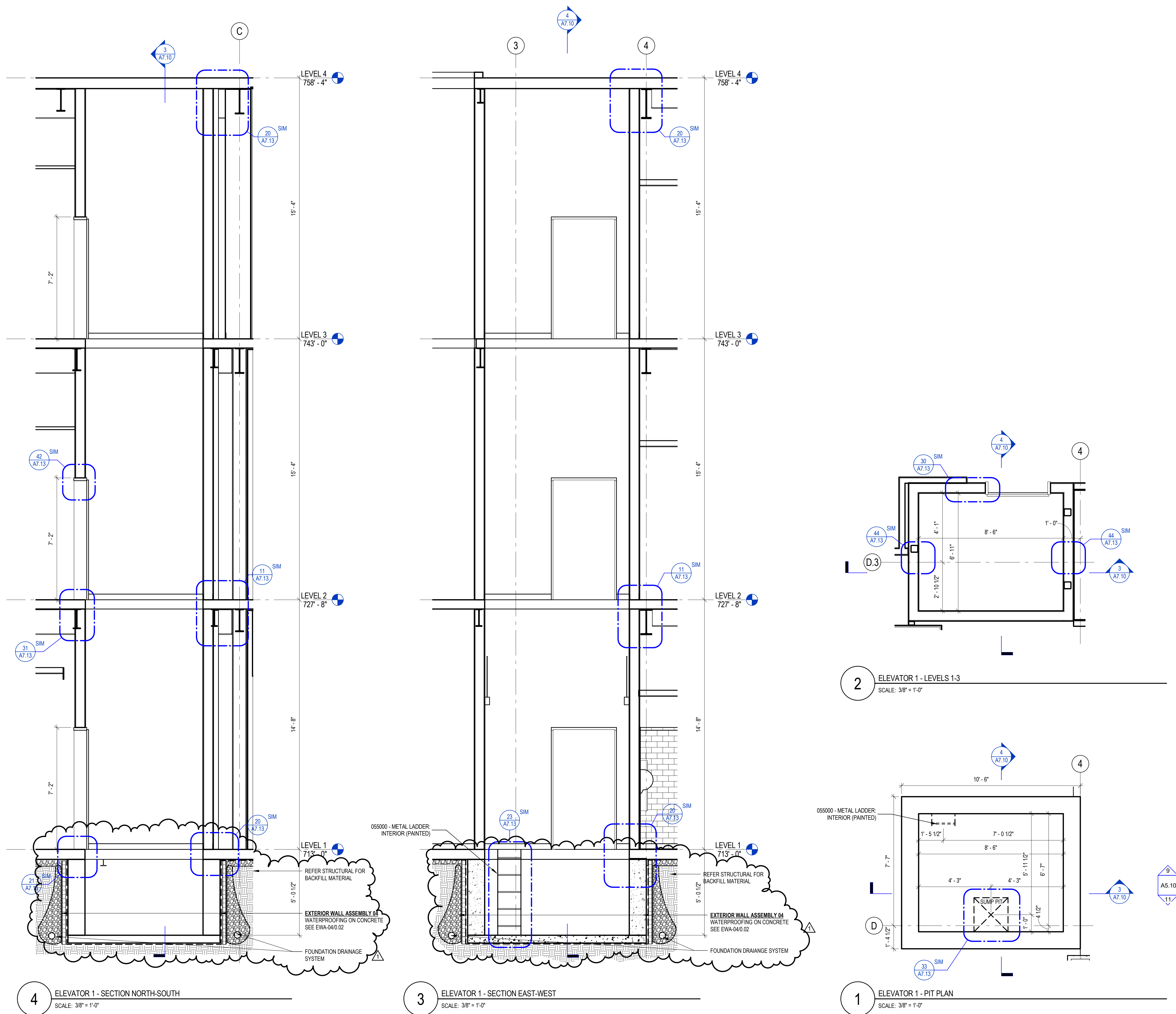


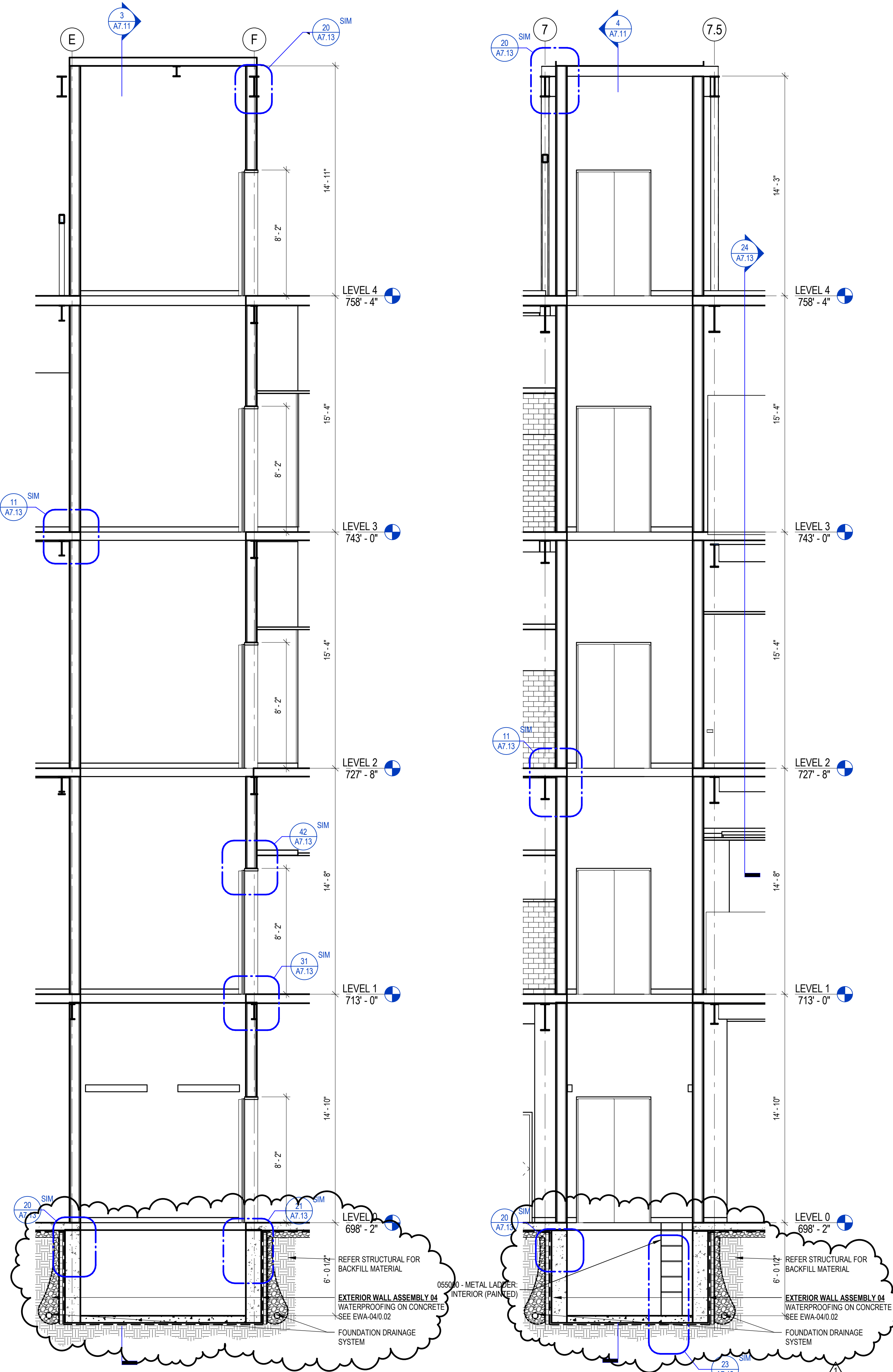
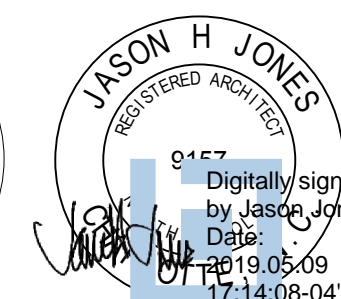
TYPICAL ANCHORAGE AT MOCK-UP PANEL ENDS
 1 1/2" = 1'-0"



PLAN DETAIL AT A-14 (A.4-14 SIM)
 3/4" = 1'-0"

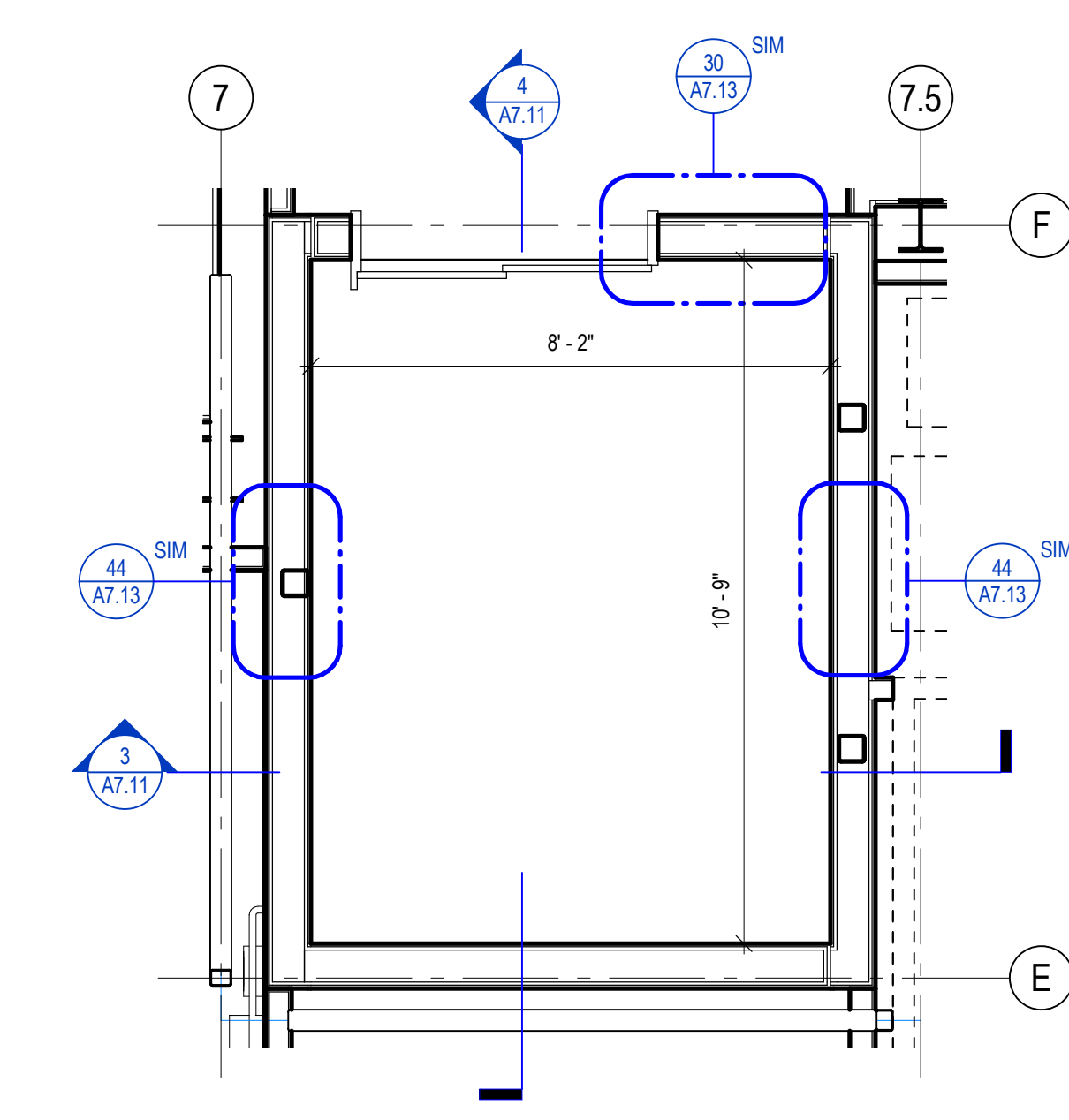




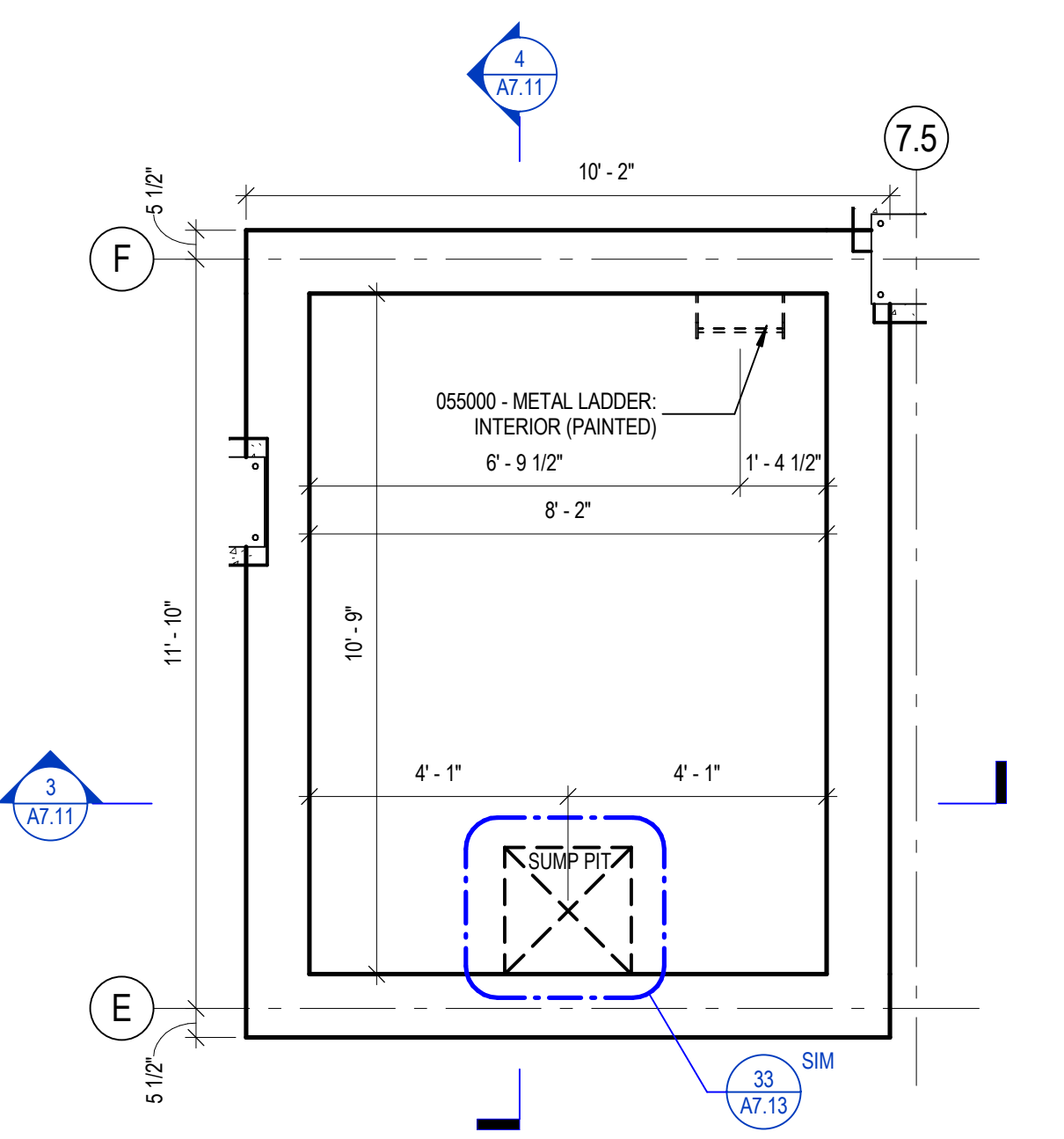


4 ELEVATOR 2 - Section 2
SCALE: 1/4" = 1'-0"

3 ELEVATOR 2 - Section 1
SCALE: 1/4" = 1'-0"



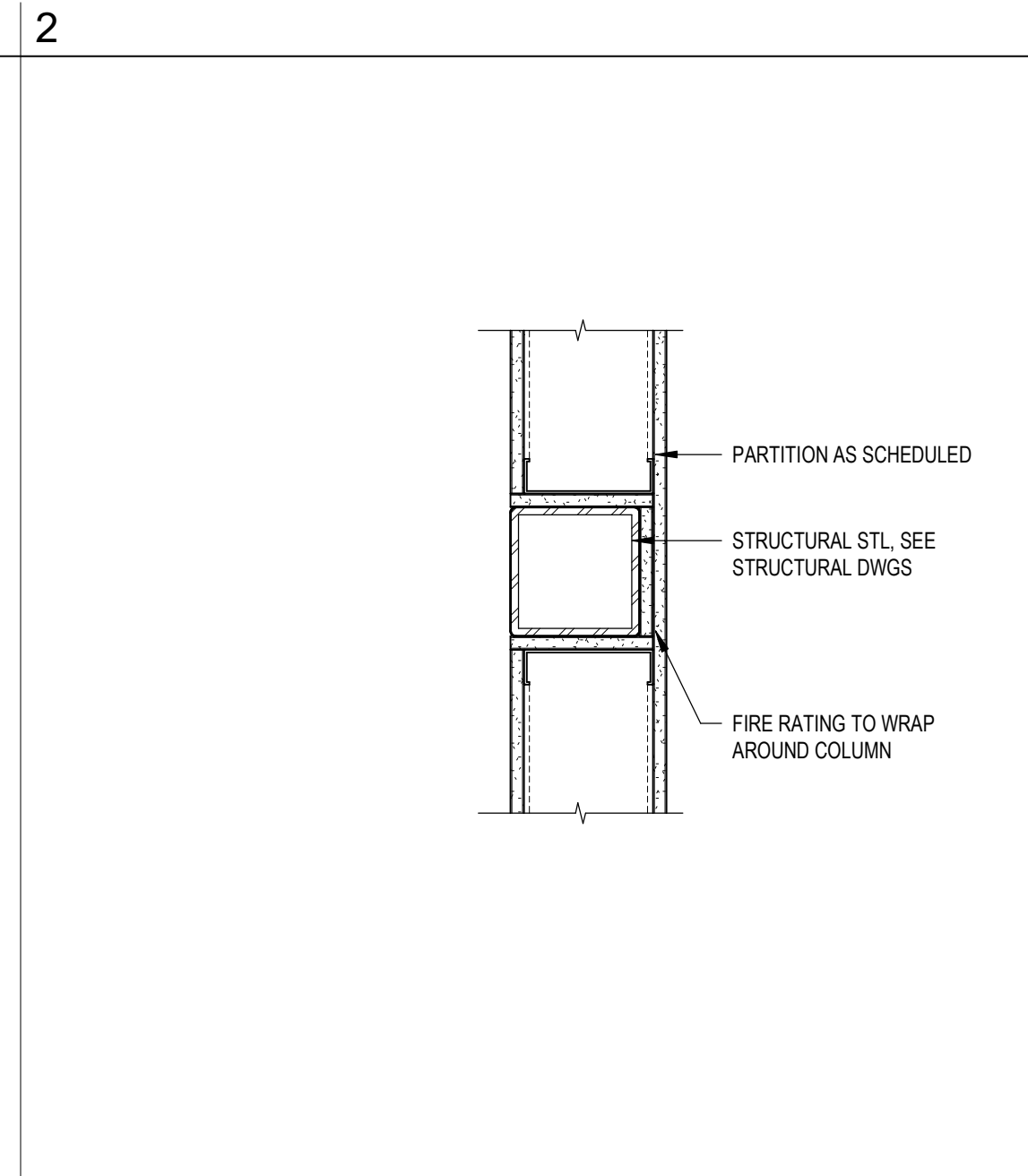
2 ELEVATOR 2 - PLANS 0-4
SCALE: 3/8" = 1'-0"



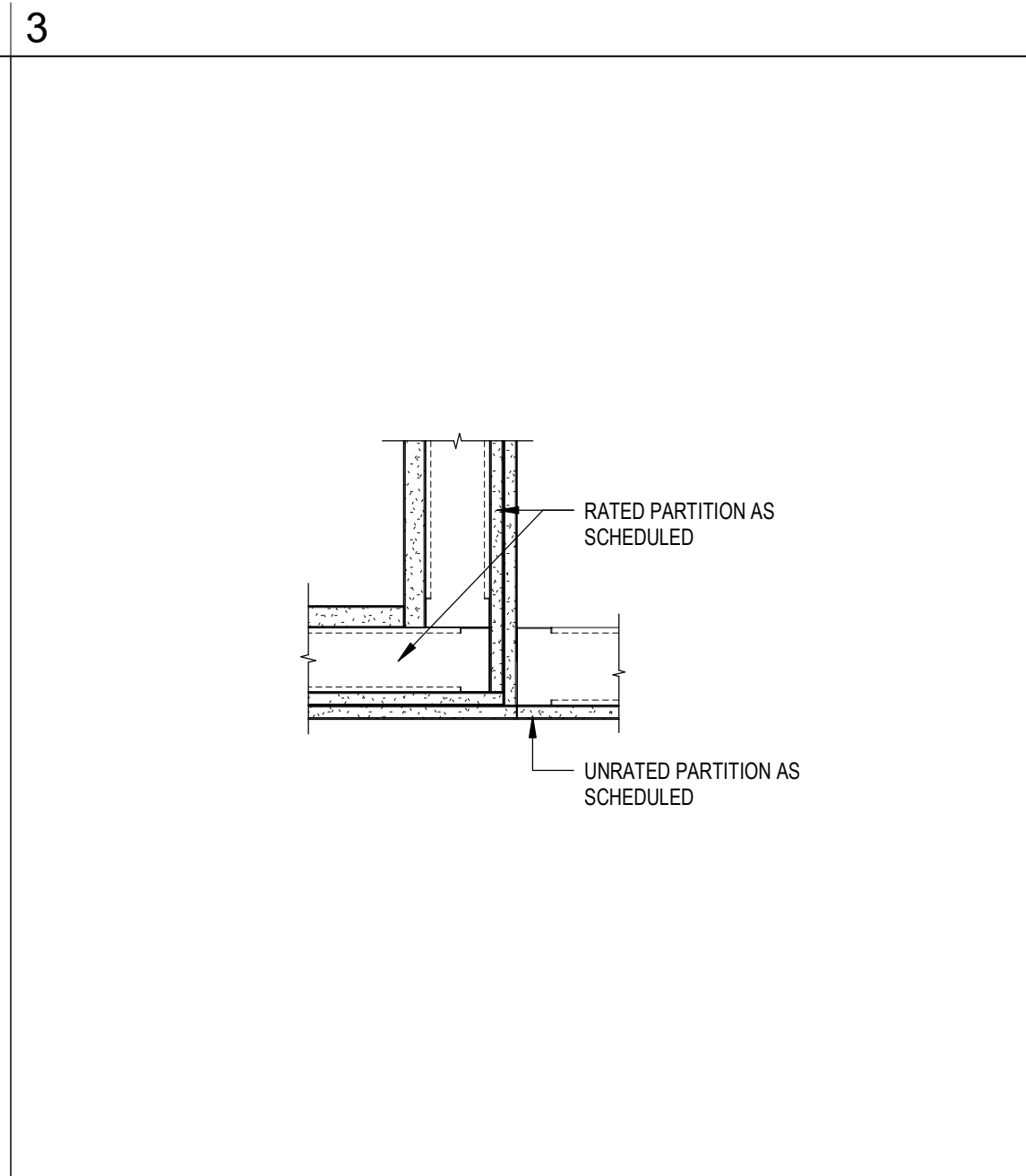
1 ELEVATOR 2 - PIT PLAN
SCALE: 3/8" = 1'-0"

5/6/2019 9:52:45 AM
ASB01/UNC/Charlotte Science/2022_Science Central_A7.13.rvt

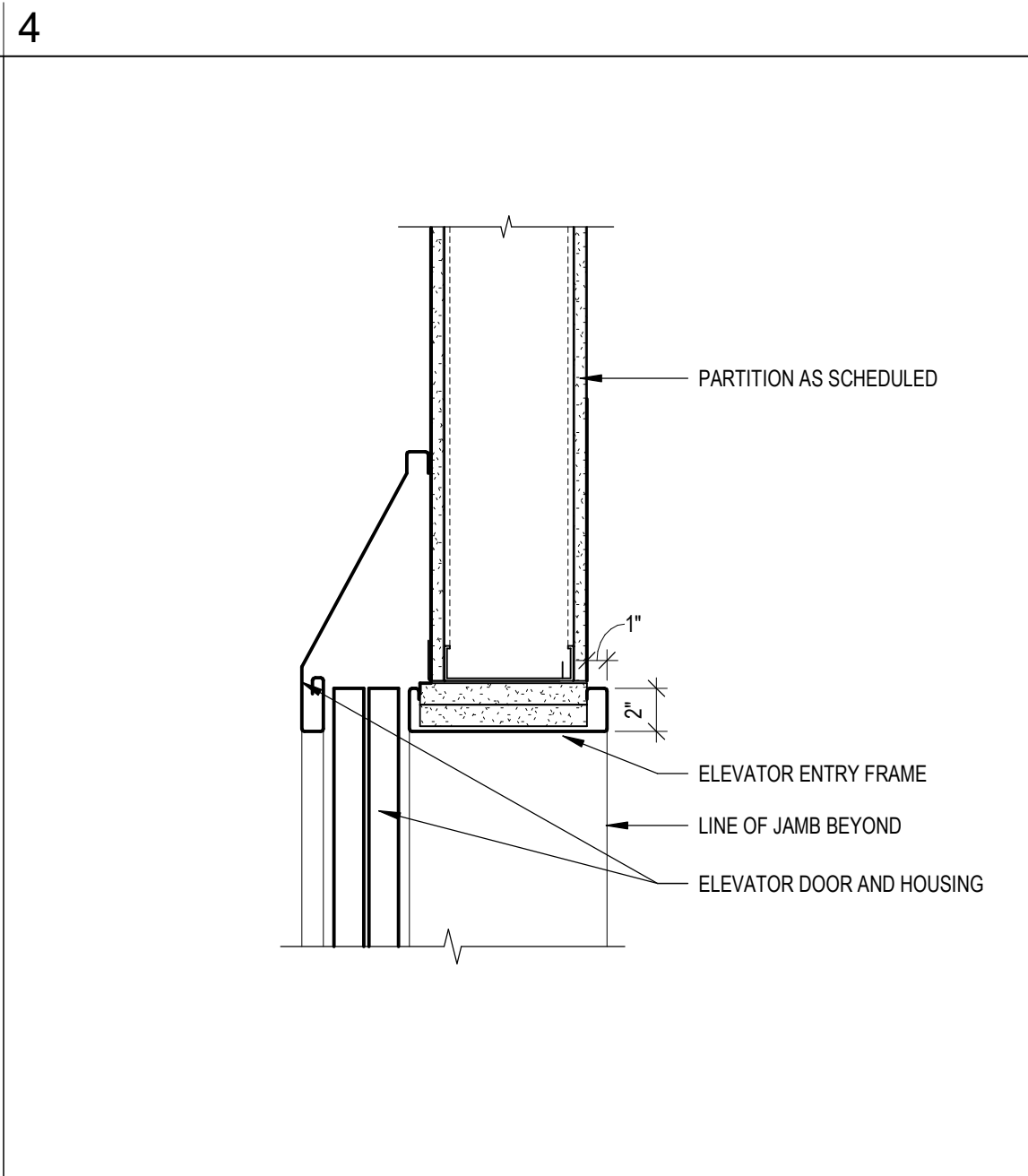
1
E
D
C
B
A



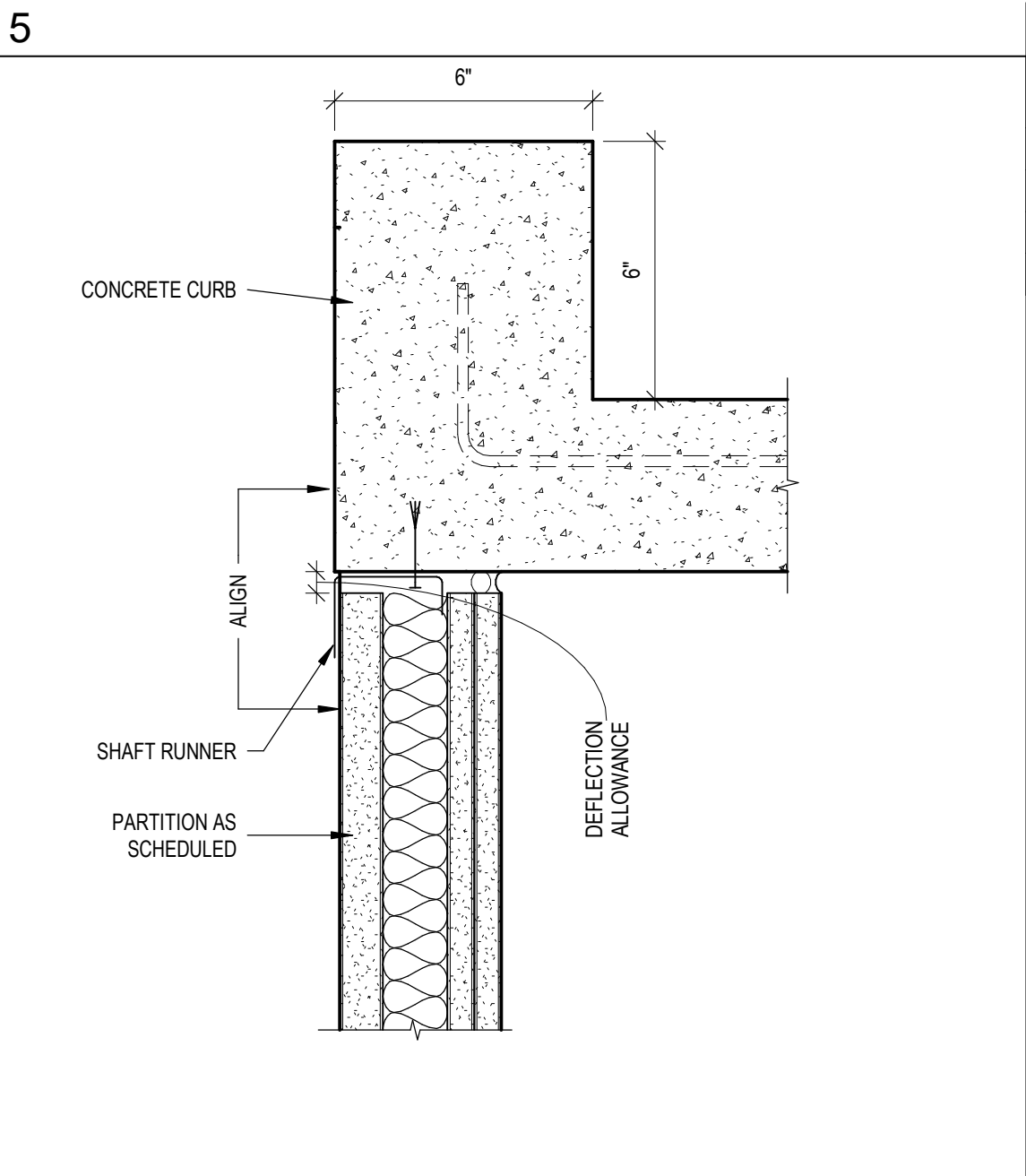
44 PLAN DETAIL - RATED ASSEMBLY AT ELEVATOR SUPPORT STEEL
SCALE: 1 1/2" = 1'-0"



43 INTERIOR DETAIL - TYPICAL RATED SHAFT AT CORNER TRANSITION
SCALE: 1 1/2" = 1'-0"

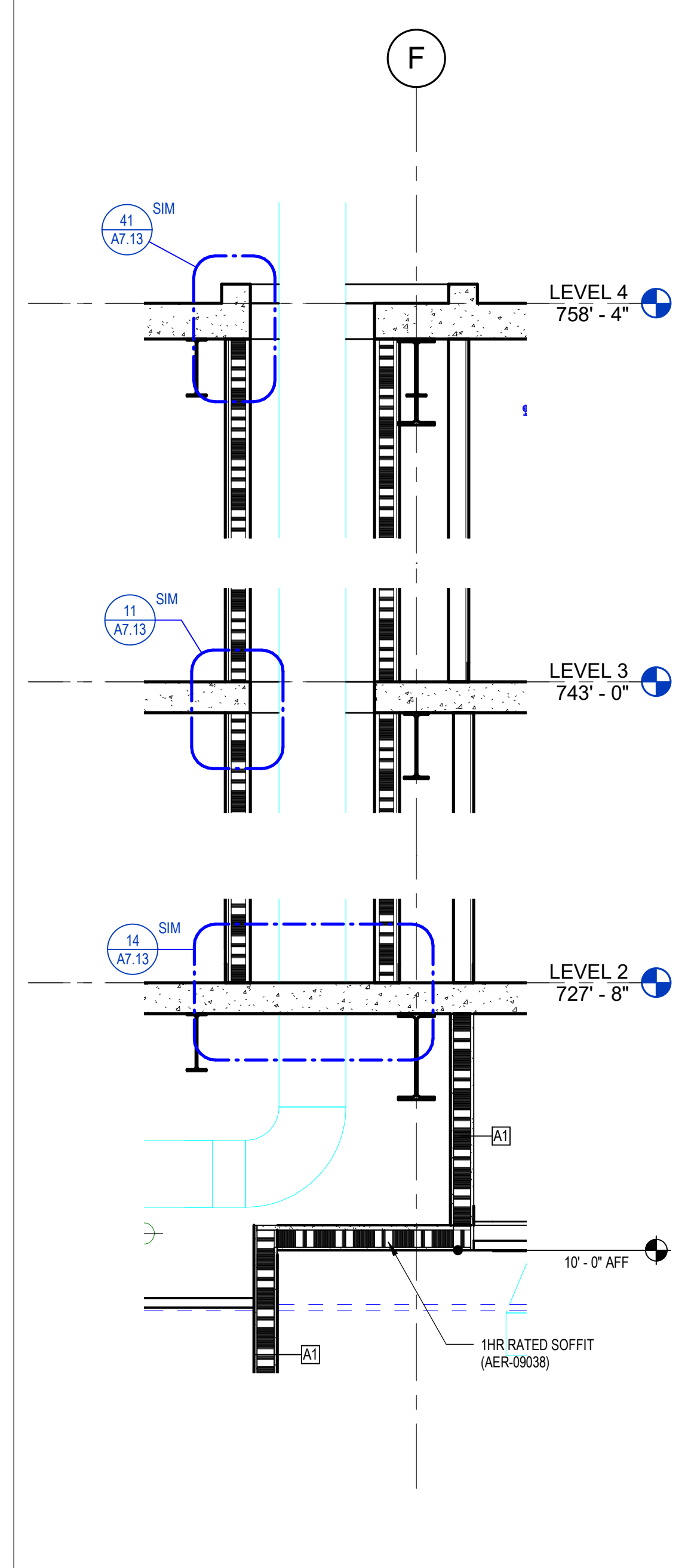


42 ELEVATOR DOOR HEAD DETAIL
INTERIOR DETAILS - SHAFT WALL AT ELEVATOR DOOR HEAD
SCALE: 1 1/2" = 1'-0"

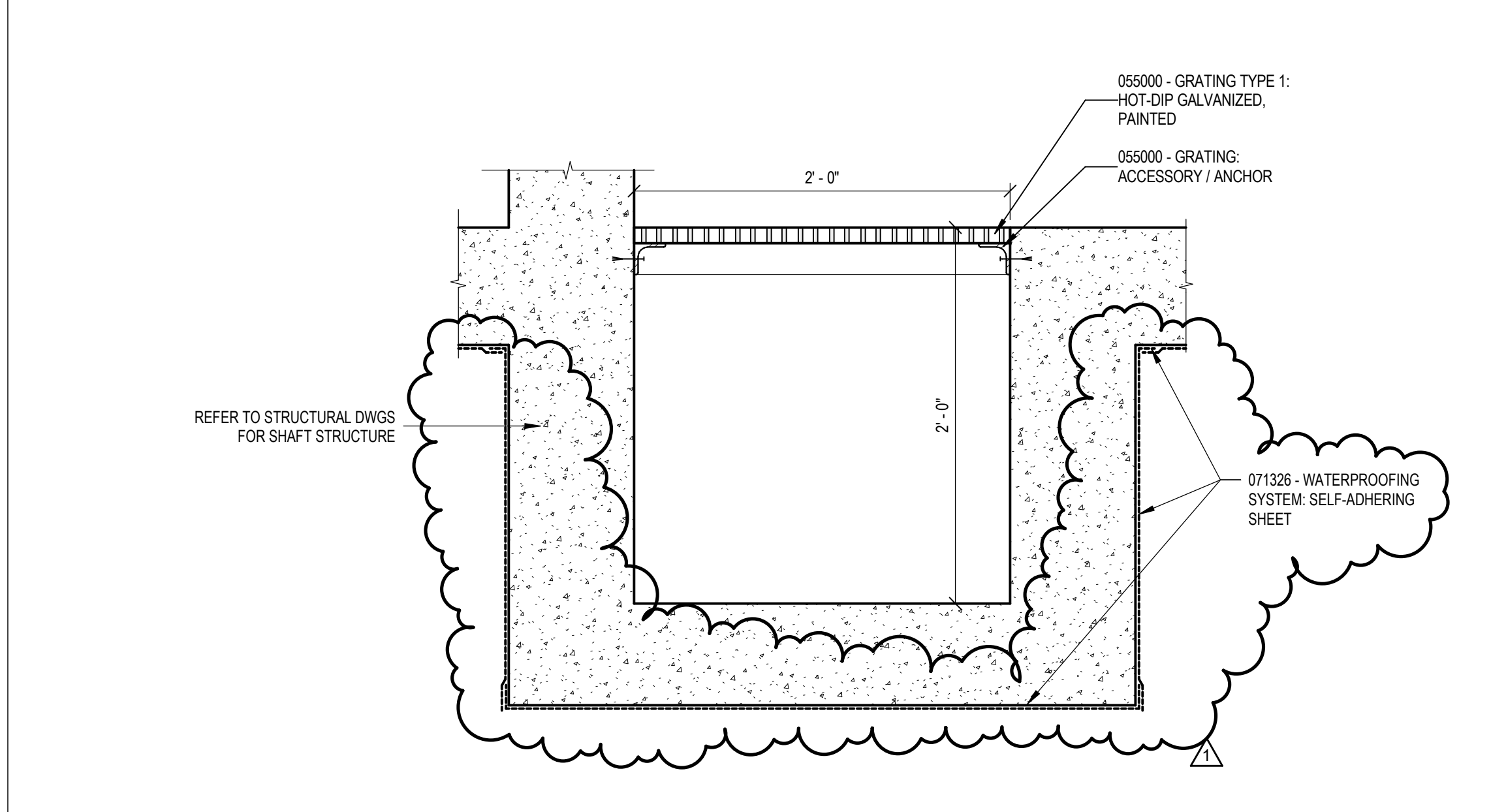


41 GYPSUM BOARD SHAFT DETAIL
INTERIOR DETAILS - TOP OF SHAFT W/ CONCRETE SPILL-CURB
SCALE: 3" = 1'-0"

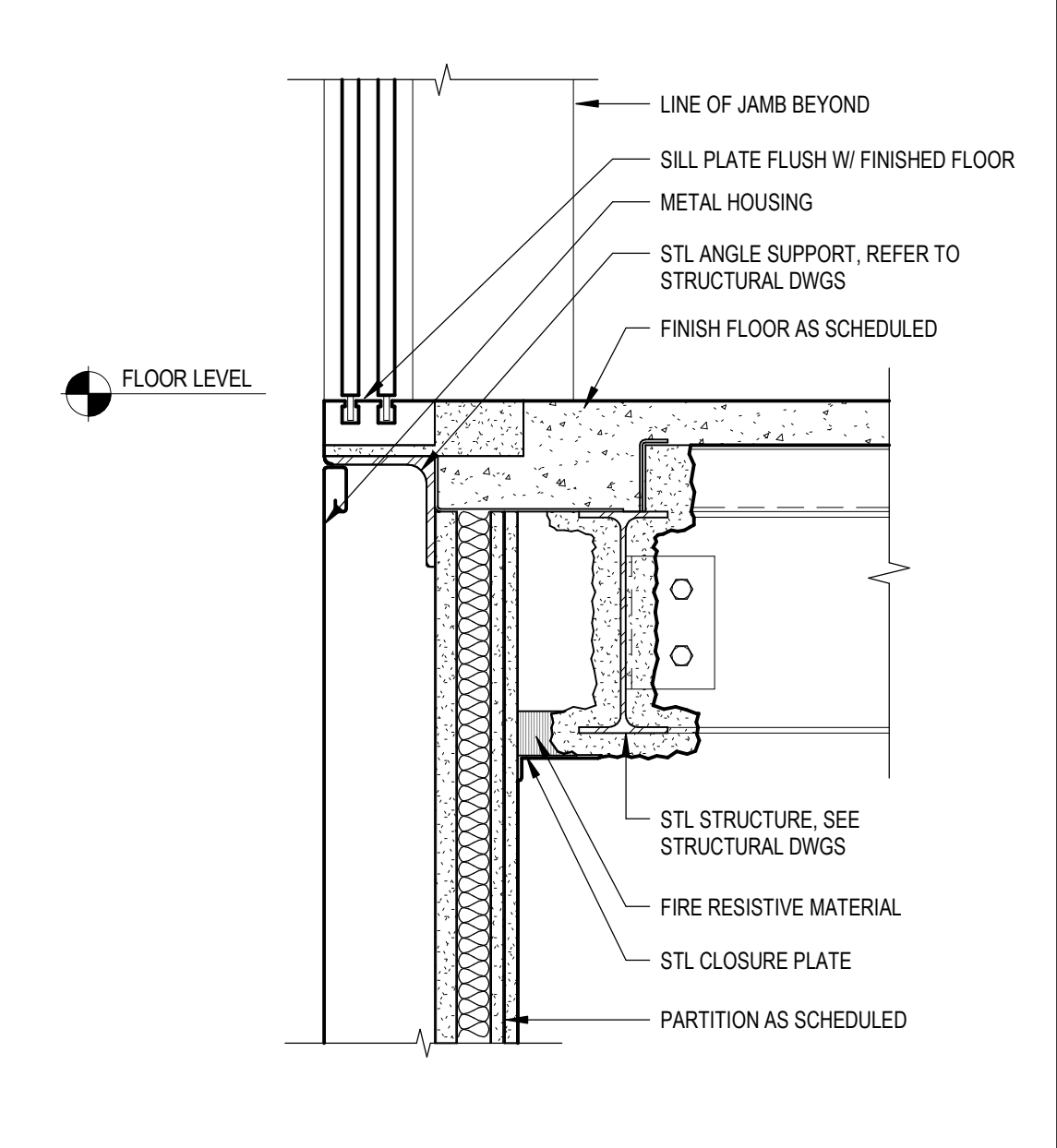
KEYNOTE LEGEND - THIS SHEET	
KEYNOTE	DESCRIPTION
0550D1	055000 - METAL LADDER: INTERIOR (PAINTED)
0550H	055000 - GRATING: ACCESSORY / ANCHOR
0550H1	055000 - GRATING TYPE 1: HOT-DIP GALVANIZED, PAINTED



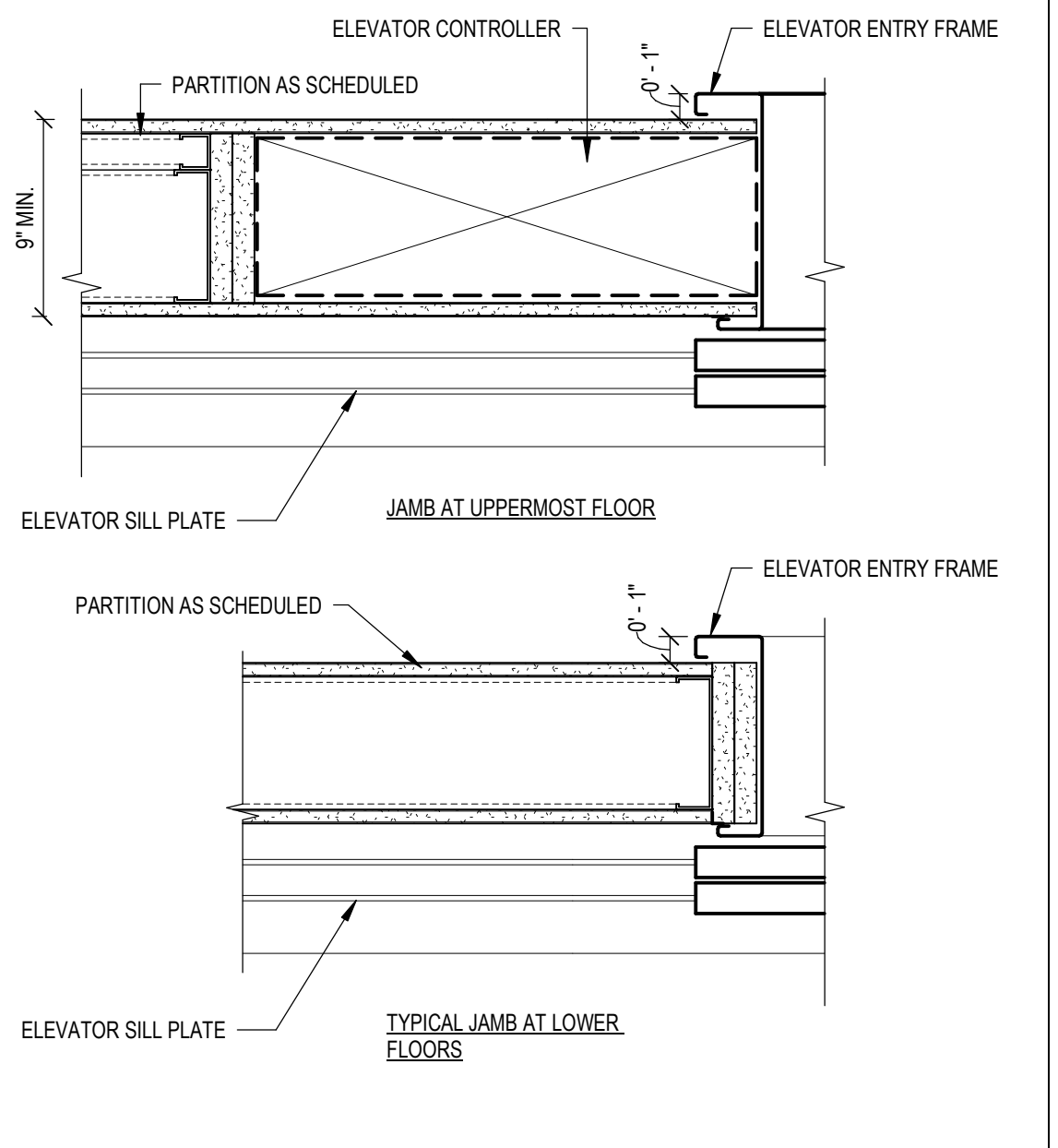
24 SHAFT SECTION - CAFE EXHAUST
SCALE: 1/2" = 1'-0"



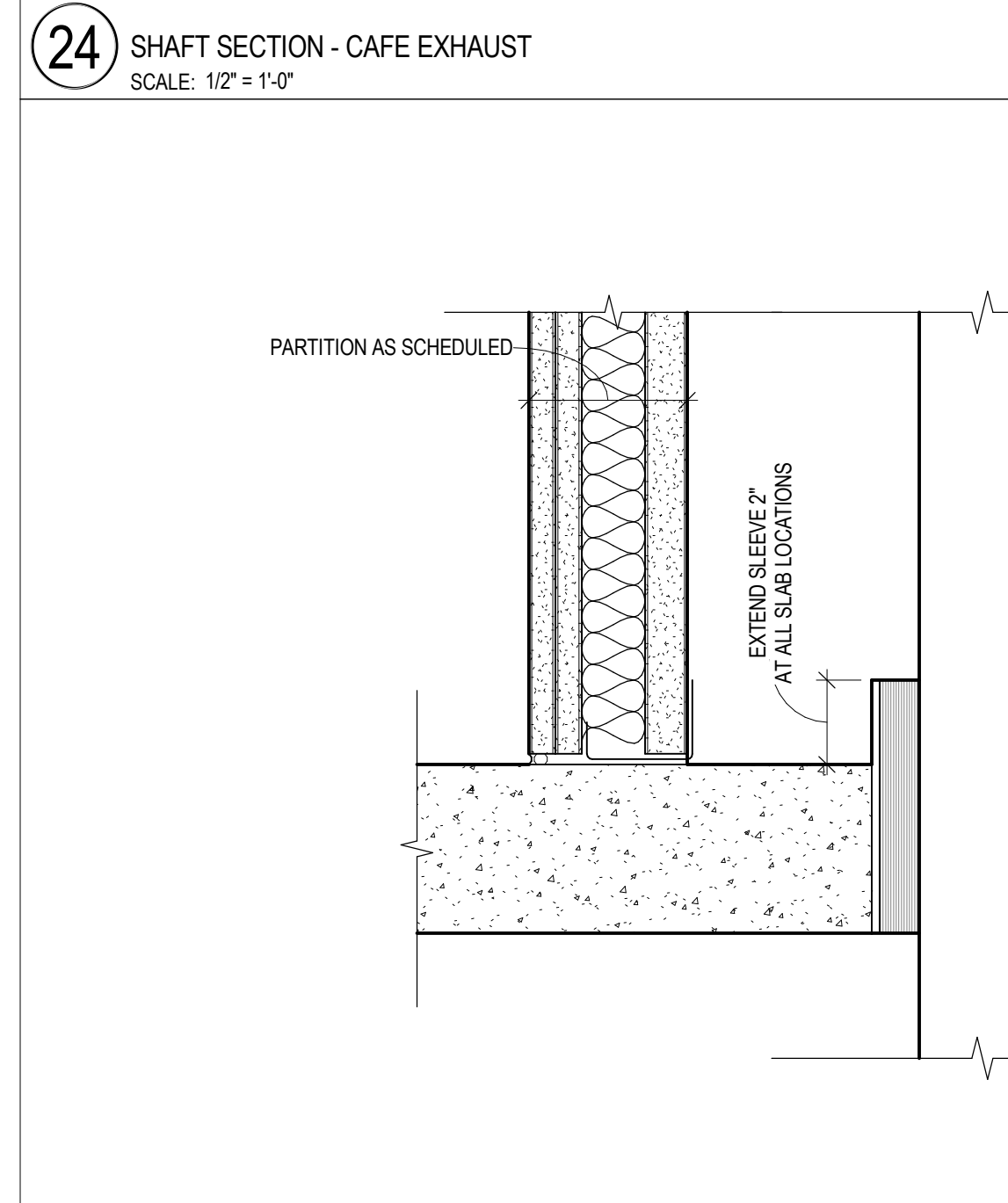
33 INTERIOR DETAIL - ELEVATOR SUMP PIT
SCALE: 1 1/2" = 1'-0"



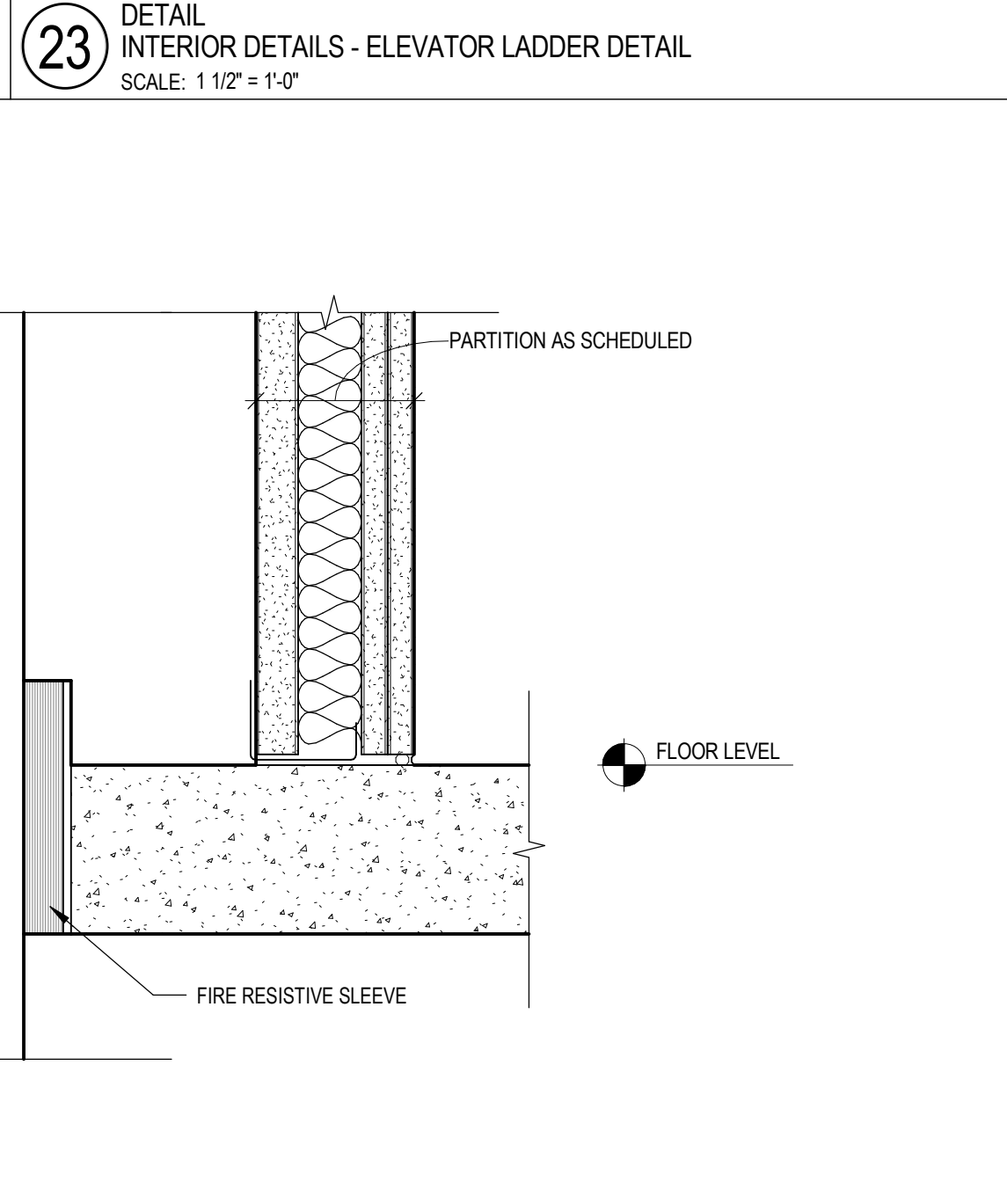
31 GYPSUM BOARD SHAFT DETAIL
INTERIOR DETAILS - SHAFT WALL AT ELEVATOR DOOR
SCALE: 1 1/2" = 1'-0"



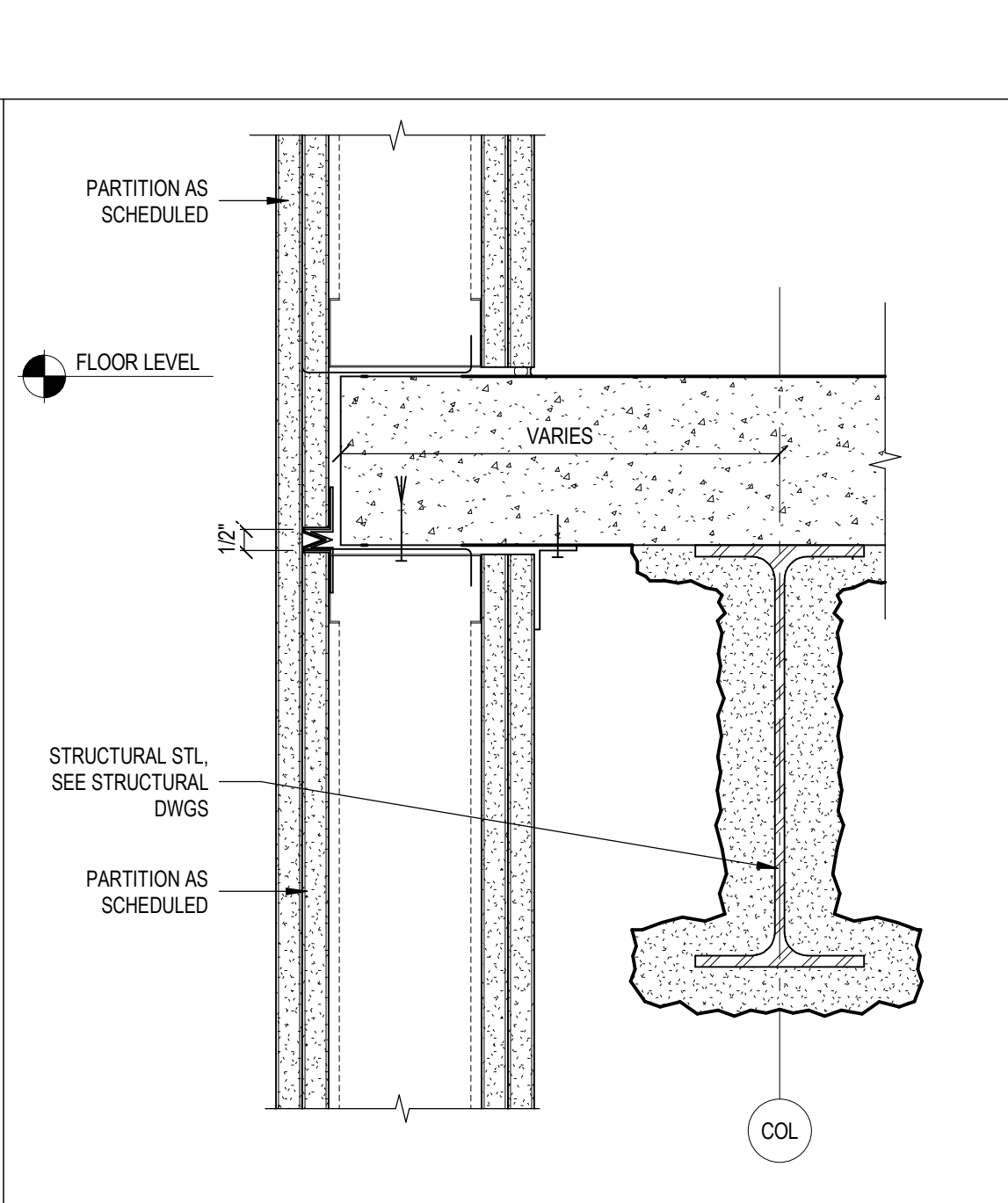
30 ELEVATOR DOOR JAMB DETAIL
INTERIOR DETAILS - TYPICAL JAMB AT ELEVATOR
SCALE: 1 1/2" = 1'-0"



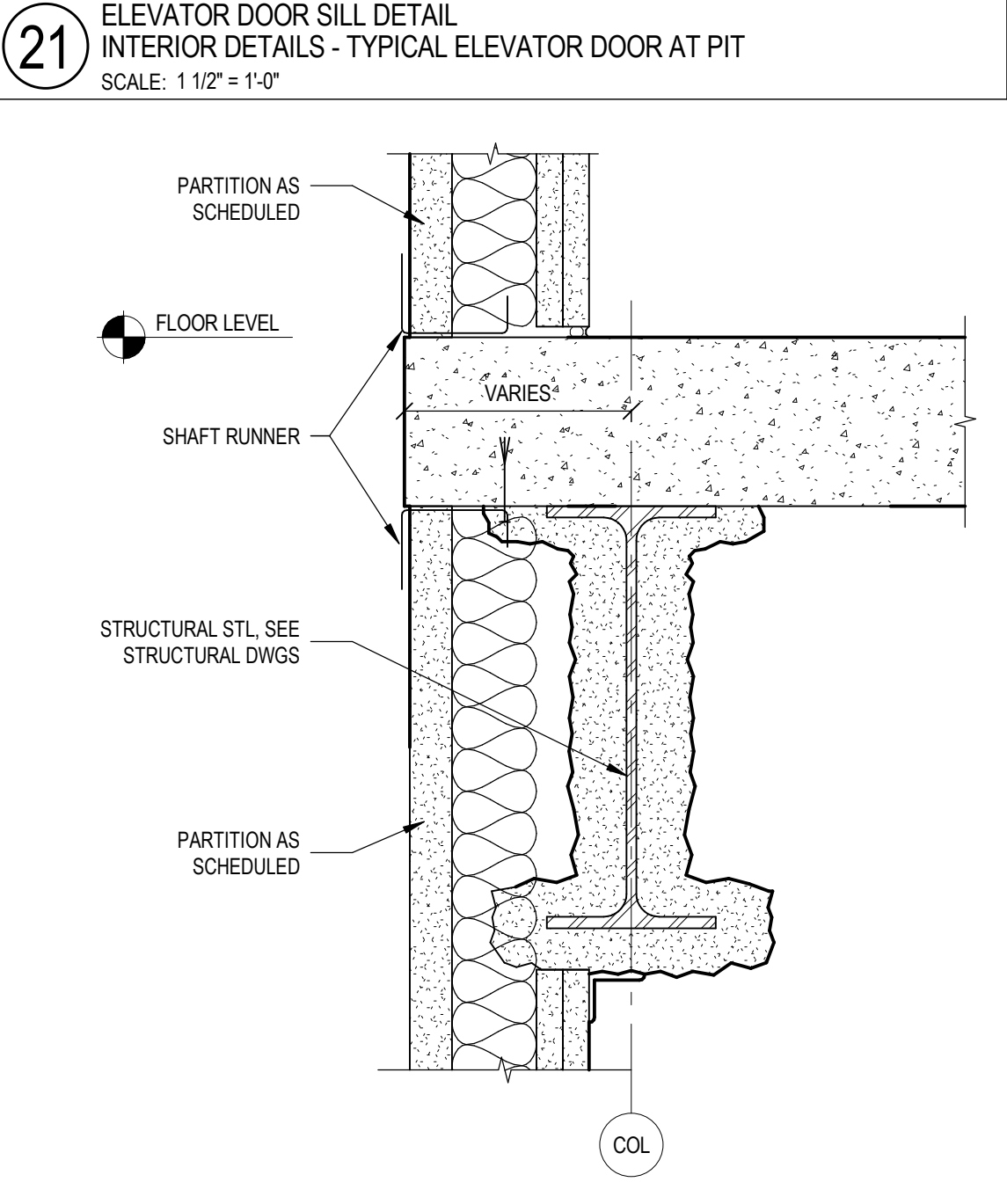
14 GYPSUM BOARD SHAFT DETAIL
INTERIOR DETAILS - MECH PENETRATION AT BASE OF SHAFT
SCALE: 3" = 1'-0"



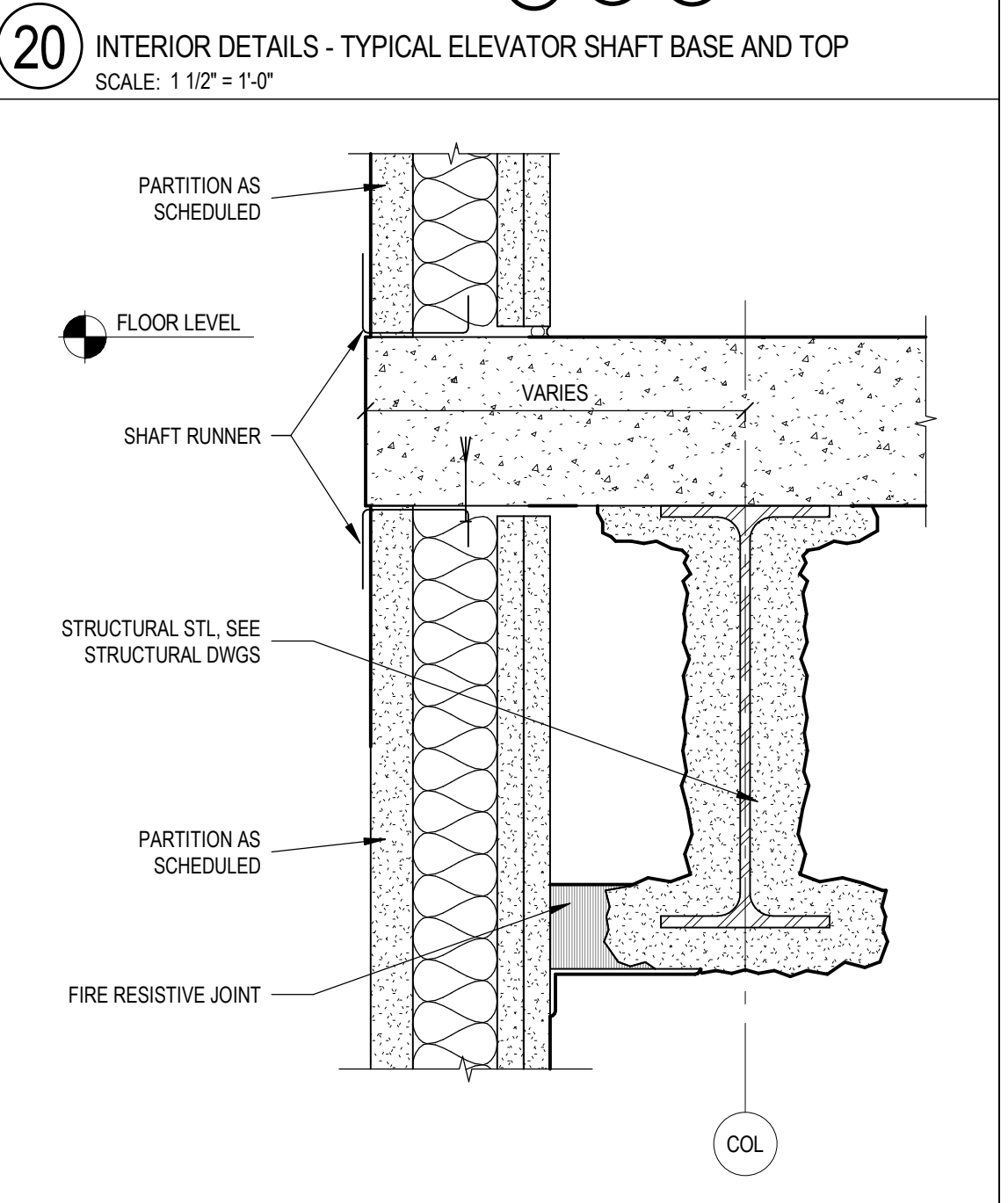
23 DETAIL INTERIOR DETAILS - ELEVATOR LADDER DETAIL
SCALE: 1 1/2" = 1'-0"



12 GYPSUM BOARD SHAFT DETAIL
INTERIOR DETAILS - SLAB EDGE AT STAIR SHAFT WALLS
SCALE: 3" = 1'-0"



21 ELEVATOR DOOR SILL DETAIL
INTERIOR DETAILS - TYPICAL ELEVATOR DOOR AT PIT
SCALE: 1 1/2" = 1'-0"



20 INTERIOR DETAILS - TYPICAL ELEVATOR SHAFT BASE AND TOP
SCALE: 1 1/2" = 1'-0"



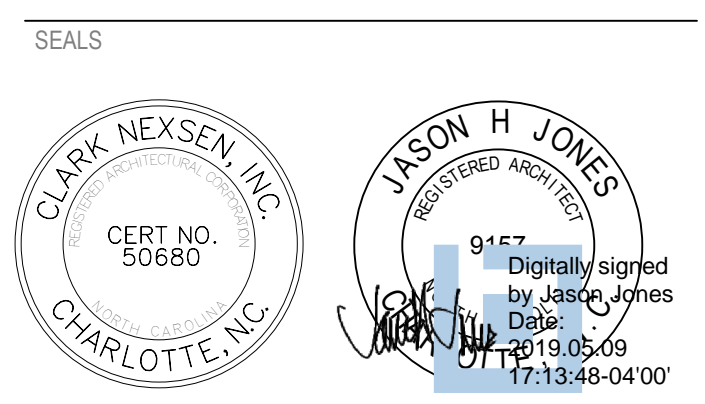
SCO ID Number: 16-14355-02D
CODE: 46626
ITEM: 301

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CLARKNEXSEN LICENSE NUMBER: C-1028
SUBMITTAL
26 APRIL, 2019
BID DOCUMENTS

Issue Date	Description
1	5/10/2019 Addendum 1

KEY PLAN

SHEET
ELEVATOR AND SHAFT DETAILS

SCALE As indicated

A7.13

DESIGN: Designer
DRAWN: Author
REVIEW: Checker
CN 6222

1. DIVISION 23 DESCRIPTION OF ALTERNATES

- ALTERNATE NO. 1
- A. REFER TO ARCHITECTURAL SHEET A0.01 FOR SPACES THAT MAY BE UNFINISHED AS PART OF ALTERNATE 1.
 - B. SEE ASSOCIATED FLOOR PLAN ON THIS SHEET ALL SUPPLY AIR TERMINALS (VAV BOXES OR AIR VALVES) AND ASSOCIATED REHEAT COILS WILL REMAIN AS SHOWN ON THE MECHANICAL SHEETS. ALL RETURN AND EXHAUST AIR TERMINALS WILL LIKEWISE REMAIN AS SHOWN ON THE MECHANICAL SHEETS.
 - C. SUPPLY DUCT WILL EXTEND DOWNSTREAM OF THE REHEAT COIL AND INTO THE SPACE BY AT LEAST 3 FEET. EXHAUST DUCT WILL EXTEND UPSTREAM OF THE EXHAUST TERMINAL AT LEAST 3 FEET INTO THE SPACE. THE OPEN ENDS OF THE SUPPLY AND EXHAUST DUCT WILL BE PROTECTED BY A 1/4" MESH WIRE SCREEN.
 - D. CONTROLS WILL BE ADJUSTED TO MINIMUM VENTILATION SET POINTS OF 0.05 CFM/SQUARE FOOT OF SPACE AND TEMPERATURE SET POINTS OF 60 DEGREES F MINIMUM AND 85 DEGREES F MAXIMUM. OTHER CONTROL ITEMS SHOWN ON THE H8.XX SERIES OF DRAWINGS (HUMIDITY, LACS AIRFLOW OFFSET, PRESSURE, ETC.) SHALL NOT APPLY.
 - E. FOR FULL BUILD OUT OF THESE SPACES REFER TO THE H1.XX THROUGH H8.XX SERIES OF DRAWINGS THAT FOLLOW.

- ALTERNATE NO. 2
- A. REFER TO ARCHITECTURAL SHEET A0.01 FOR SPACES THAT MAY BE UNFINISHED AS PART OF ALTERNATE 2.
 - B. SEE ASSOCIATED FLOOR PLAN ON THIS SHEET ALL SUPPLY AIR TERMINALS (VAV BOXES OR AIR VALVES) AND ASSOCIATED REHEAT COILS WILL REMAIN AS SHOWN ON THE MECHANICAL SHEETS. ALL RETURN AND EXHAUST AIR TERMINALS WILL LIKEWISE REMAIN AS SHOWN ON THE MECHANICAL SHEETS.
 - C. SUPPLY DUCT WILL EXTEND DOWNSTREAM OF THE REHEAT COIL AND INTO THE SPACE BY AT LEAST 3 FEET. EXHAUST DUCT WILL EXTEND UPSTREAM OF THE EXHAUST TERMINAL AT LEAST 3 FEET INTO THE SPACE. THE OPEN ENDS OF THE SUPPLY AND EXHAUST DUCT WILL BE PROTECTED BY A 1/4" MESH WIRE SCREEN.
 - D. CONTROLS WILL BE ADJUSTED TO MINIMUM VENTILATION SET POINTS OF 0.05 CFM/SQUARE FOOT OF SPACE AND TEMPERATURE SET POINTS OF 60 DEGREES F MINIMUM AND 85 DEGREES F MAXIMUM. OTHER CONTROL ITEMS SHOWN ON THE H8.XX SERIES OF DRAWINGS (HUMIDITY, LACS AIRFLOW OFFSET, PRESSURE, ETC.) SHALL NOT APPLY.
 - E. FOR FULL BUILD OUT OF THESE SPACES REFER TO THE H1.XX THROUGH H8.XX SERIES OF DRAWINGS THAT FOLLOW.

- ALTERNATE NO. 3
- A. REFER TO ARCHITECTURAL SHEET A0.01 FOR SPACES THAT MAY BE UNFINISHED AS PART OF ALTERNATE 3.
 - B. SEE ASSOCIATED FLOOR PLAN ON THIS SHEET ALL SUPPLY AIR TERMINALS (VAV BOXES OR AIR VALVES) AND ASSOCIATED REHEAT COILS WILL REMAIN AS SHOWN ON THE MECHANICAL SHEETS. ALL RETURN AND EXHAUST AIR TERMINALS WILL LIKEWISE REMAIN AS SHOWN ON THE MECHANICAL SHEETS.
 - C. SUPPLY DUCT WILL EXTEND DOWNSTREAM OF THE REHEAT COIL AND INTO THE SPACE BY AT LEAST 3 FEET. EXHAUST DUCT WILL EXTEND UPSTREAM OF THE EXHAUST TERMINAL AT LEAST 3 FEET INTO THE SPACE. THE OPEN ENDS OF THE SUPPLY AND EXHAUST DUCT WILL BE PROTECTED BY A 1/4" MESH WIRE SCREEN.
 - D. CONTROLS WILL BE ADJUSTED TO MINIMUM VENTILATION SET POINTS OF 0.05 CFM/SQUARE FOOT OF SPACE AND TEMPERATURE SET POINTS OF 60 DEGREES F MINIMUM AND 85 DEGREES F MAXIMUM. OTHER CONTROL ITEMS SHOWN ON THE H8.XX SERIES OF DRAWINGS (HUMIDITY, LACS AIRFLOW OFFSET, PRESSURE, ETC.) SHALL NOT APPLY.
 - E. FOR FULL BUILD OUT OF THESE SPACES REFER TO THE H1.XX THROUGH H8.XX SERIES OF DRAWINGS THAT FOLLOW.

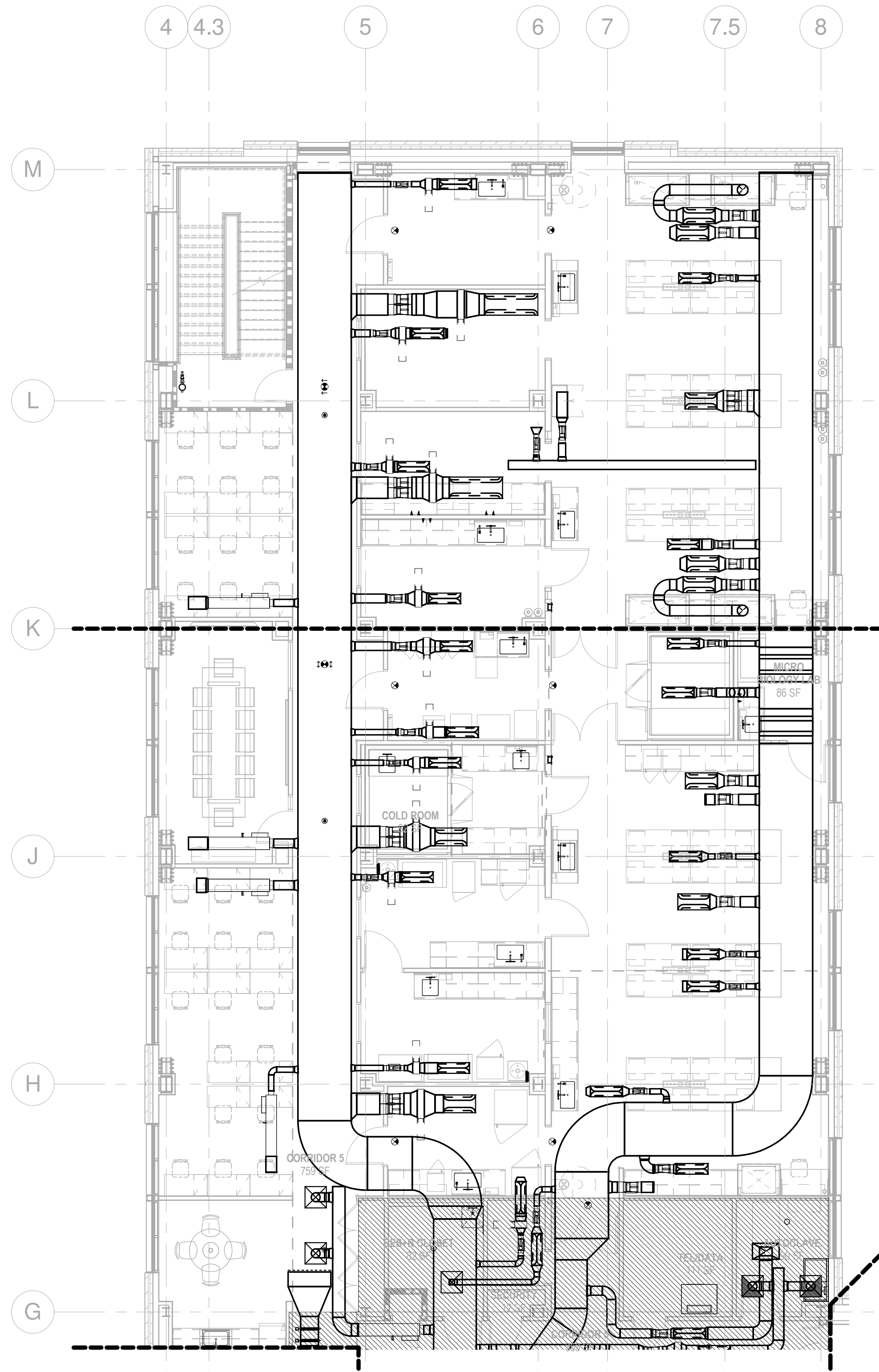
- ALTERNATE NO. 4
- A. REFER TO ARCHITECTURAL SHEET A0.01 FOR SPACES THAT MAY BE UNFINISHED AS PART OF ALTERNATE 4.
 - B. SEE ASSOCIATED FLOOR PLAN ON THIS SHEET ALL SUPPLY AIR TERMINALS (VAV BOXES OR AIR VALVES) AND ASSOCIATED REHEAT COILS WILL REMAIN AS SHOWN ON THE MECHANICAL SHEETS. SELECT DUCT WILL BE CAPPED FOR FUTURE USE. SELECT RETURN/EXHAUST AIR TERMINALS WILL REMAIN AS SHOWN.
 - C. SUPPLY DUCT TO BE UTILIZED WILL EXTEND DOWNSTREAM OF THE REHEAT COIL AND INTO THE SPACE BY AT LEAST 3 FEET. EXHAUST DUCT WILL EXTEND UPSTREAM OF THE EXHAUST TERMINAL AT LEAST 3 FEET INTO THE SPACE. THE OPEN ENDS OF THE SUPPLY AND EXHAUST DUCT WILL BE PROTECTED BY A 1/4" MESH WIRE SCREEN.
 - D. CONTROLS WILL BE ADJUSTED TO MINIMUM VENTILATION SET POINTS OF 0.05 CFM/SQUARE FOOT OF SPACE AND TEMPERATURE SET POINTS OF 60 DEGREES F MINIMUM AND 85 DEGREES F MAXIMUM. OTHER CONTROL ITEMS SHOWN ON THE H8.XX SERIES OF DRAWINGS (HUMIDITY, LACS AIRFLOW OFFSET, PRESSURE, ETC.) SHALL NOT APPLY.
 - E. FOR FULL BUILD OUT OF THESE SPACES REFER TO THE H1.XX THROUGH H8.XX SERIES OF DRAWINGS THAT FOLLOW.

- ALTERNATE NO. 12
- A. BASE BID SCOPE IS THE USE OF MECHANICAL JOINTS IN ACCESSIBLE AREAS AS FOLLOWS:

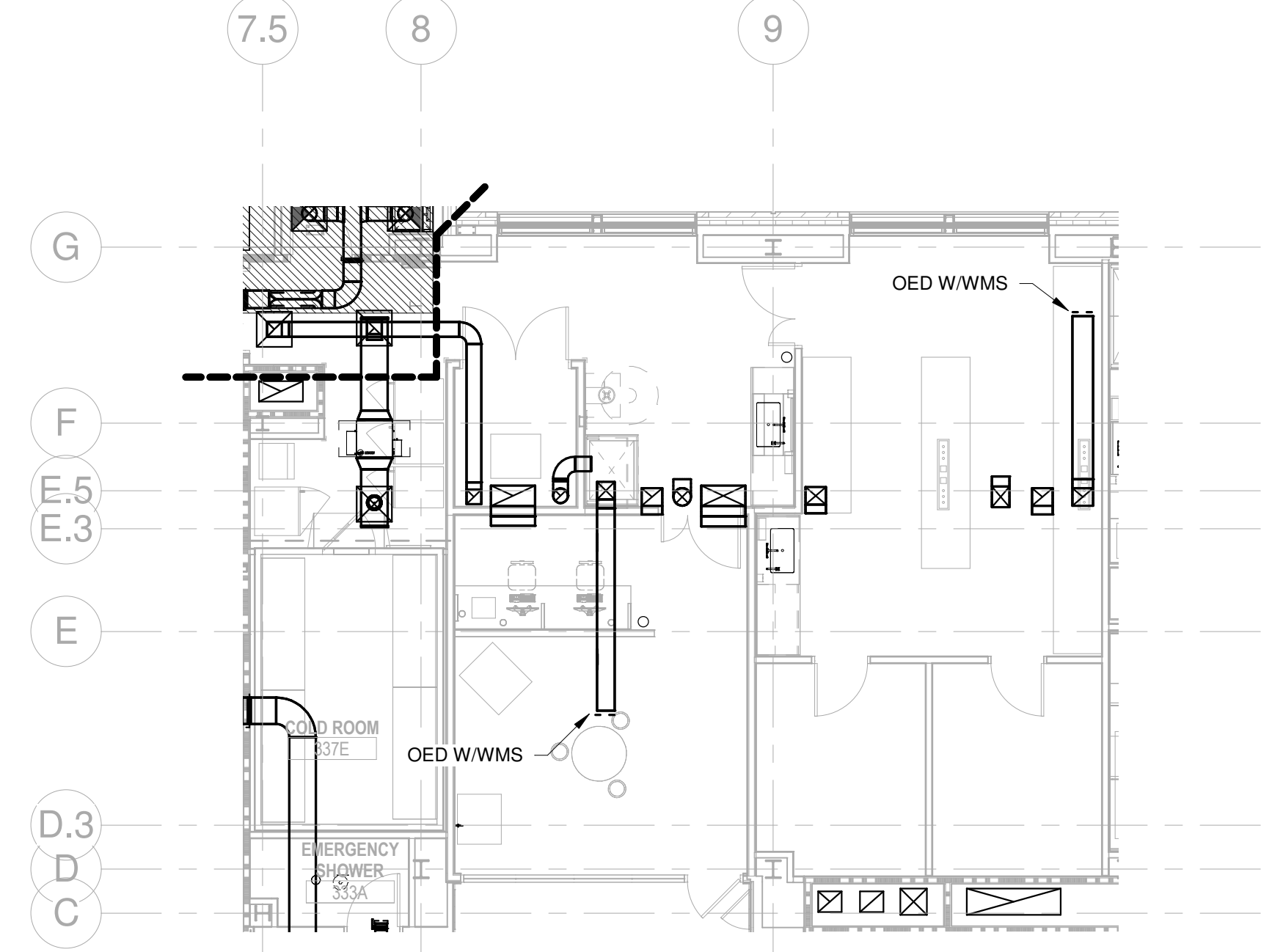
1. STEEL PIPE JOINTS WITH GROOVED PIPE ENDS WITH STEEL FITTING UP TO 12" NPS AS MANUFACTURED BY ANVIL INTERNATIONAL, STAR PIPE PRODUCTS, GRINNELL OR VICTALIC.
 - a. JOINT FITTINGS: ASTM A 536, GRADE 65-45-12 DUCTILE IRON; ASTM A 474 47M, GRADE 32510 MALLEABLE IRON; ASTM A 534 53M, "TYPE F, E, OR S, GRADE B" FABRICATED STEEL; OR ASTM A 106A 106M, GRADE B STEEL. FITTINGS WITH GROOVES OR SHOULDERS CONSTRUCTED TO ACCEPT GROOVED END COUPLINGS, WITH NUTS, BOLTS, LOCKING PIN, LOCKING TOGGLE, OR LUGS TO SECURE GROOVED PIPE AND FITTINGS.
 - b. COUPLINGS: DUCTILE- OR MALLEABLE-IRON HOUSING AND EPDM OR NITRILE GASKET OF CENTRAL CAVITY PRESSURE-RESPONSIVE DESIGN; WITH NUTS, BOLTS, LOCKING PIN, LOCKING TOGGLE, OR LUGS TO SECURE GROOVED PIPE AND FITTINGS.
 - c. ASSEMBLE JOINTS WITH COUPLING AND GASKET, LUBRICANT, AND BOLTS. CUT OR ROLL GROOVES IN ENDS OF PIPE BASED ON PIPE AND COUPLING MANUFACTURER'S WRITTEN INSTRUCTIONS FOR PIPE WALL THICKNESS. USE GROOVED-END FITTINGS AND RIGID, GROOVED-END PIPE COUPLINGS.

2. COPPER PIPE JOINTS WITH PRESSURE SEALED FITTING UP TO 4" NPS AS MANUFACTURED BY VIEGA OR PRO-PRESS.
 - a. HOUSING: COPPER.
 - b. O-RINGS AND PIPE STOPS: EPDM.
 - c. TOOLS: MANUFACTURER'S SPECIAL TOOLS.
 - d. MINIMUM 200-PSIG WORKING-PRESSURE RATING AT 250 DEG F.
 - e. USE MANUFACTURER-RECOMMENDED TOOL AND PROCEDURE TO MAKE JOINTS.
 - f. LEAVE INSERTION MARKS ON PIPE AFTER ASSEMBLY.

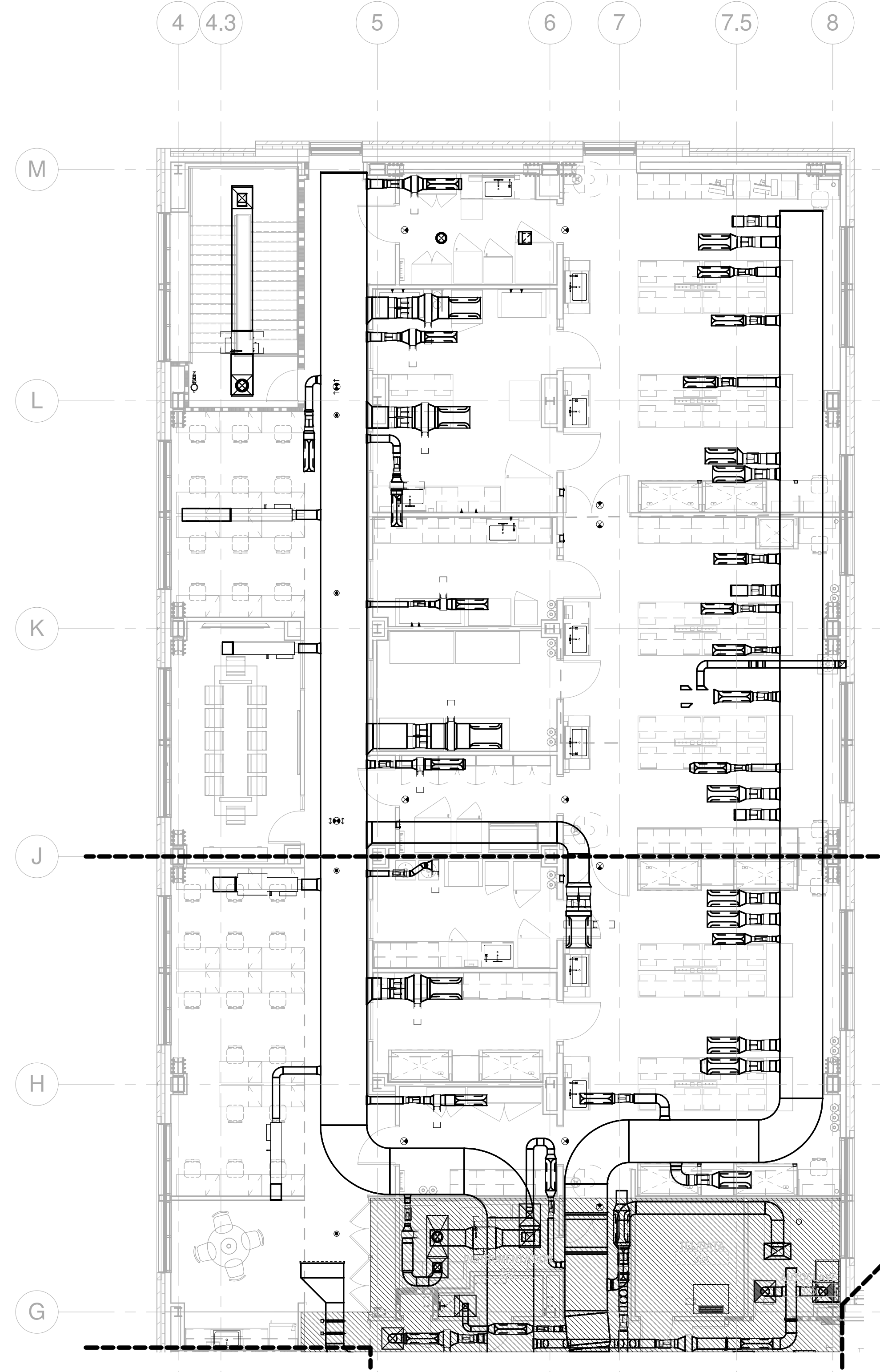
3. FOR PIPE SIZE LARGER THAN INDICATED ABOVE, JOINTS SHALL BE AS SPECIFIED IN SECTION 2321.13 OF THE SPECIFICATIONS.
4. THE JOINTS IN PIPING ROUTED IN INACCESSIBLE AREAS (IN SHAFTS, ABOVE HARD CEILINGS, IN WALLS) SHALL BE AS SPECIFIED IN SECTION 2321.13 OF THE SPECIFICATIONS.



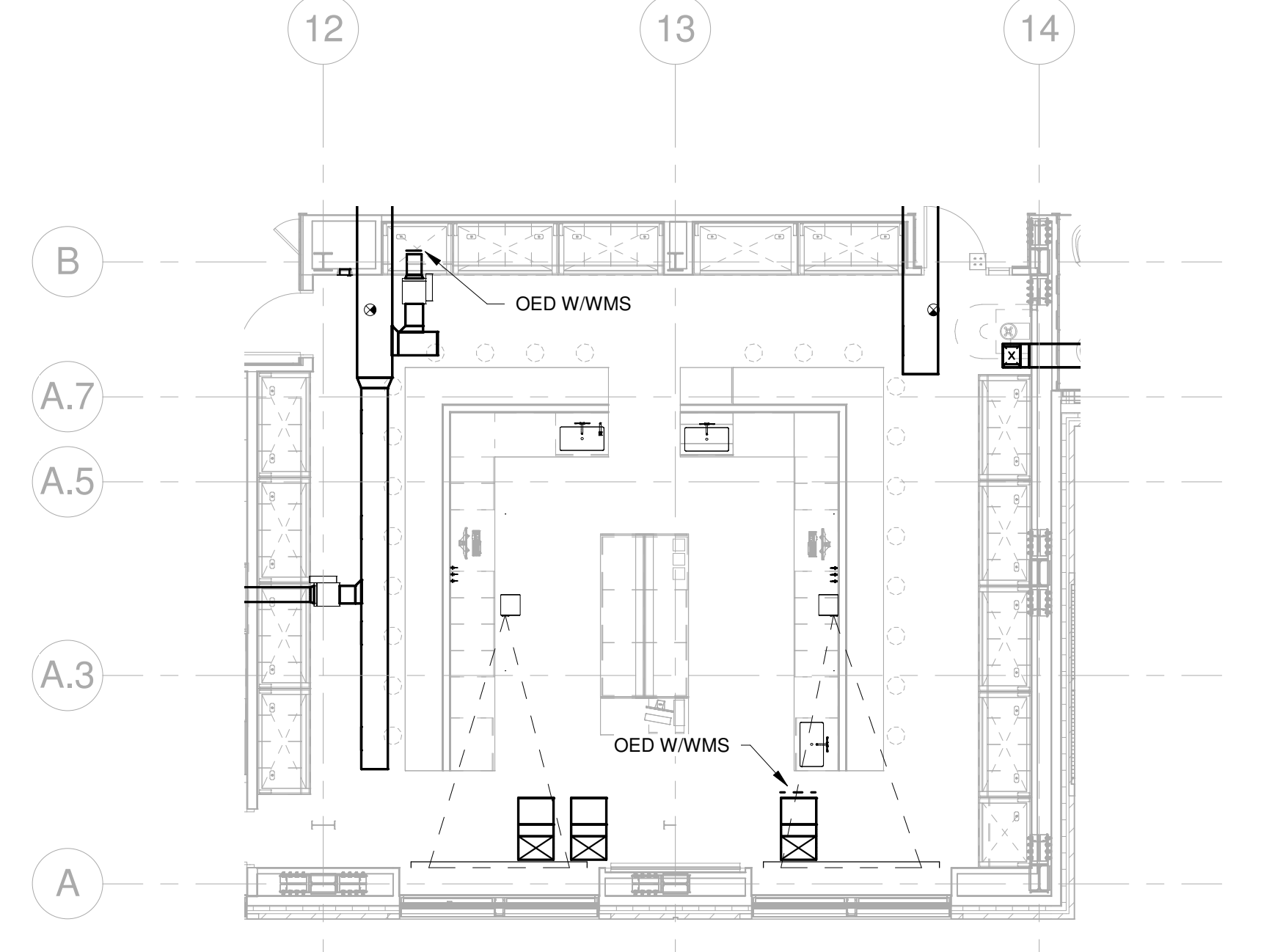
1 ALTERNATE SPACE 1
1/8" = 1'-0"



3 ALTERNATE SPACE 3
1/8" = 1'-0"



2 ALTERNATE SPACE 2
1/8" = 1'-0"



4 ALTERNATE SPACE 4
1/8" = 1'-0"

Revisions		
1	05/09/19	ADDENDUM 1

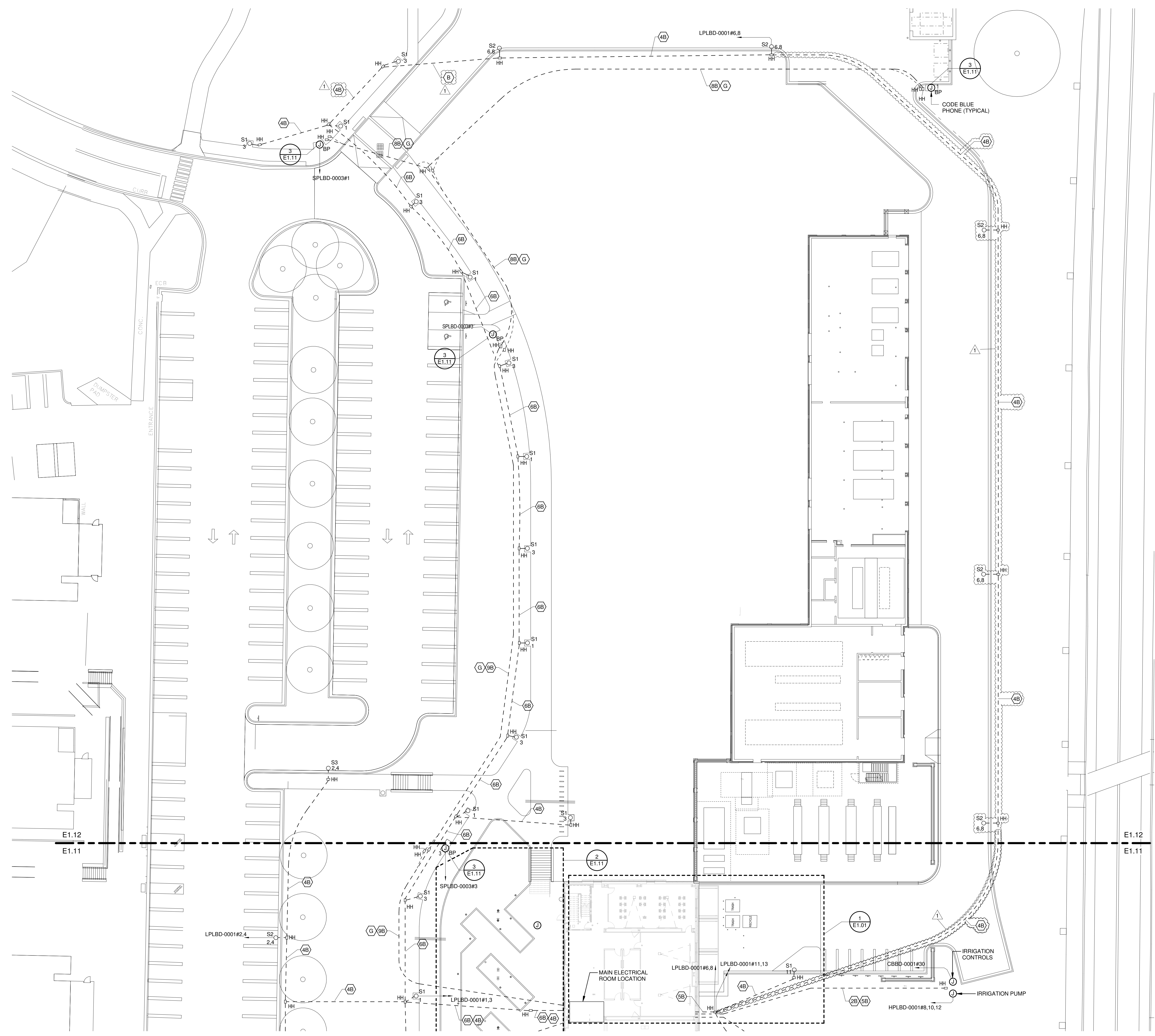
KEY PLAN

SHEET
HVAC BASE DESIGN

SCALE As indicated

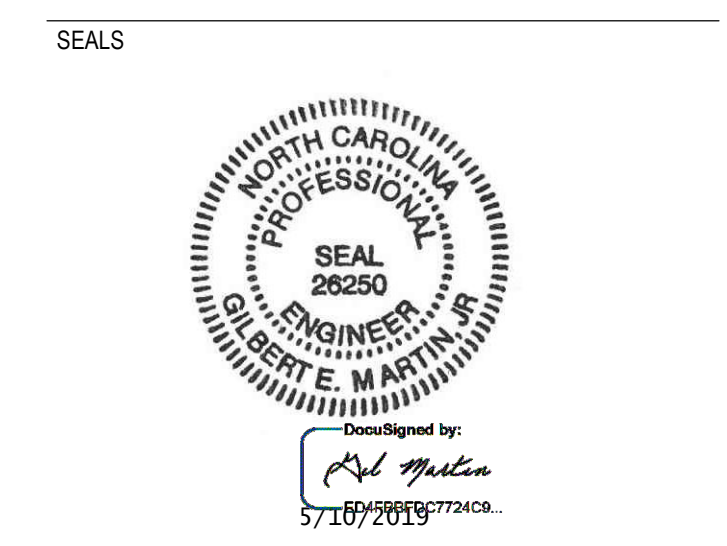
H0.03

DESIGN: NH
DRAWN: NH
REVIEW: RF
CN 6222



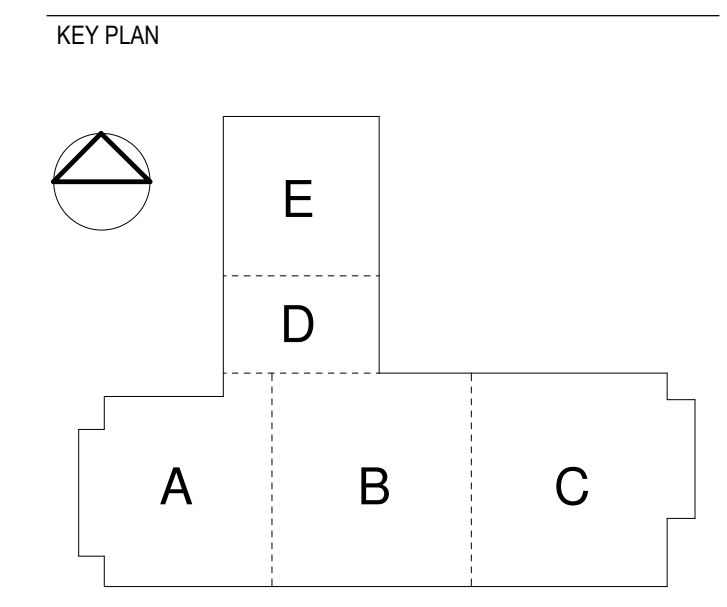
1 ELECTRICAL SITE LIGHTING PLAN NORTH
1" = 20'-0"

GENERAL NOTES	
1	REFER TO DRAWING E7.21 FOR LIGHTING FIXTURE SCHEDULE.
2	SITE LIGHTING CIRCUITS SHALL BE WIRED VIA LIGHTING CONTROL PANEL.
3	FOR SITE CIRCUIT SCHEDULE REFER TO DRAWING E1.11.



Revisions

1	05/09/19	ADDENDUM 1



SECTION 200000 - COMMON MECHANICAL/ELECTRICAL REQUIREMENTS

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.
- B. Some paragraphs in this Section mirror similar paragraphs in Division 01; but those in this section are specific to the mechanical and electrical trades. Contractor shall comply with Division 01 as well as those requirements of this Division that are additional to or more stringent than those in Division 01.
- C. This section shall apply to the following Divisions:
 - 1. Division 21 - Fire Suppression
 - 2. Division 22 - Plumbing
 - 3. Division 23 - Heating, Ventilating, and Air Conditioning (HVAC)
 - 4. Division 25 - Instrumentation and Control for HVAC
 - 5. Division 26 - Electrical
 - 6. Division 27 - Communications
 - 7. Division 28 - Electronic Safety and Security

1.2 SUMMARY

- A. Give notices, file plans, obtain permits and licenses, pay fees and back charges, and obtain necessary approvals from authorities that have jurisdiction.
- B. Schedule the submittals of MEP and Fire Protection information required for the occupancy permit with enough time for resubmittal and approval. The required information is listed in Part 3, paragraph "MEP and Fire Protection Completion Requirements".
- C. Completely coordinate work of this Division with work of others and provide a complete and fully functional installation.
- D. Drawings and Specifications form complimentary requirements. Provide work specified and not shown, work shown and not specified as though explicitly required by both. Although work is not specifically shown or specified, provide supplementary or miscellaneous items, appurtenances, devices and materials for a sound, secure and complete installation
- E. This project is intended to be Green Globes-certified. Refer to Division 01 for specification of work to be performed by mechanical and electrical trade Contractors.

1.3 DEFINITIONS

- A. As used in all Sections covered by Division 20, "provide" means "furnish and install." "Furnish" means "to purchase and deliver to the project site complete with every

necessary appurtenance and support," and "Install" means "to unload at the delivery point at the site and perform every operation necessary to establish secure mounting and correct operation at the proper location in the project. "Architect" means the "Prime Design Consultant." If R.G. Vanderweil Engineers, LLP is not the Prime Design Consultant, the Architect may authorize R.G. Vanderweil Engineers, LLP to act on the Architect's behalf in matters concerning the systems Vanderweil has designed.

- B. The words "Architect" and "Engineer" may be used interchangeably in the mechanical and electrical Division specifications.
- C. The terms "Contractor," "General Contractor," "Construction Manager," and "Design-Builder," may appear in the mechanical and electrical Divisions. Wherever such a term is used, it shall mean the entity that is directing all the construction.
- D. A "substitution" means a product proposed by the Contractor that is from a manufacturer not listed in the individual sections of the Division 20 specifications as an "Acceptable Manufacturer."
- E. "AHJ" means "Authorities Having Jurisdiction."

1.4 CONTRACT DOCUMENTS

- A. The two dimensional drawings govern the construction. They show the design intent and are part of the Contract Documents. BIM models are not part of contract documents. They are developed for convenience only.
- B. Except where modified by a specific notation to the contrary, it shall be understood that the indication and/or description of an item in the drawings or specifications or both, carries with it the instruction to furnish and install the item, regardless of whether or not this instruction is explicitly stated as part of the indication or description.
- C. Items referred to in singular number in Contract Documents shall be provided in quantities necessary to complete work.
- D. Information and components shown on riser diagrams, but not shown on plans, and vice versa, shall apply or be provided as if expressly required on both.
- E. In spaces used by building occupants, but not in mechanical rooms, the architectural drawings shall govern the location of visible mechanical and electrical components. In order to obtain the intended aesthetics in such spaces, prior to installation of visible material and equipment (including access panels), review Architectural Drawings for desired locations and where not definitively indicated, request information from Architect.
- F. Maintain maximum headroom at all locations. All piping, duct, conduit, and associated components to be as tight to underside of structure as possible.
- G. Systems shall be run in a rectilinear fashion.
- H. Requirement for Complete Systems and Coordination Adjustments
 - 1. The two dimensional drawings and the BIM model are diagrammatic, whether furnished electronically or in hard copy. They indicate general arrangements of mechanical systems and other work, and are intended to convey sufficient information for skilled contractors and tradesmen to furnish and install complete systems. They are not intended to be absolutely precise; they are not intended to specify or to show every offset, fitting, and component. The purpose of the

drawings and BIM model is to indicate a systems concept, the main components of the systems, and the approximate geometrical relationships. Based on the systems concept, the main components, and the approximate geometrical relationships, provide all other components and materials to make the systems fully complete, coordinated with other systems and the structure and space available, and operational.

2. The drawings and BIM model are not designed to the level of detail of contractor's or manufacturer's fabrication drawings, shop drawings, sheet metal layout drawings, or coordination drawings.
3. Certain information is specified and is intentionally not included on the drawings and BIM model such as hangers and supports, insulation, and routing of branch circuits. Provide installation in accordance with the specifications.
4. Similarly, the drawings and BIM model do not show all offsets required for coordination nor do they show the exact routings and locations needed to coordinate with structure and other trades in order to avoid interferences and to meet ceiling heights and other Architectural requirements. Establish and provide offsets, changes in direction, and exact routings to coordinate all systems.
5. Where conflicts or potential conflicts exist and engineering guidance is desired, submit a "Request for Information" (RFI).

1.5 DISCREPANCIES IN DOCUMENTS

- A. Where Drawings or Specifications conflict or are unclear, submit clarification request in writing before Award of Contract. Otherwise, Architect's interpretation of Contract Documents shall be final, and no additional compensation shall be permitted due to discrepancies or un-clarities thus resolved.
- B. Where Drawings or Specifications do not coincide with manufacturers' recommendations or with applicable codes and standards, submit clarification request in form of an RFI before installation. Otherwise, make changes in installed work required for compliance with manufacturer instructions or codes and standards within Contract Price.
- C. If the required material, installation, or work can be interpreted differently from drawing to drawing, or between drawings and specs, provide material, installation or work that is of the higher standard.
- D. Provide systems and components that are fully complete and operational and fully suitable for the intended use. Where insufficient information exists in the documents to precisely describe a certain component or subsystem, or the routing of a component or its coordination with other building elements, where notification required by Paragraph (A) above has not been submitted, provide the specific component or subsystem with all parts necessary for the intended use, fully complete and operational, and installed in workmanlike manner either concealed or exposed in accordance with the design intent.
- E. In cases covered by Paragraph (D) above, where the contractor believes engineering guidance is needed, submit an RFI.
- F. Where discrepancies exist between the mechanical, plumbing, fire protection, and electrical drawings in regards to what trade owns disconnects or starters, the discrepancy shall be brought to the Architect's attention in accordance with paragraph

(A) above. If the scope is not resolved prior to the Award of Contract, Division 26 shall provide such items.

1.6 CLASH DETECTION

- A. Coordination drawings are specified in the paragraph titled Coordination Drawings. These are required whether engineering drawings have been produced from 2-D or 3-D models. In the latter case, the Contractor may use a BIM model to perform a clash detection study, and subsequently to work out the significant clashes and update the model, and use this as the basis for coordination drawings. The engineer will provide his BIM model for the contractor's use for this purpose if the contractor so requests and signs the appropriate release.
- B. The great majority of clashes in a BIM model involve non-clashing adjacencies or interferences of small MEP components, like piping 2 inches or less in diameter (excluding insulation). Such clashes shall be worked out by the contractor as part of his coordination effort. If a clash consists of a major routing or other impasse, upon submittal of an RFI, the engineer will provide guidance.

1.7 REQUESTS FOR INFORMATION (RFI'S)

- A. Where an RFI is a request to resolve a conflict or an un-clarity, or a request for additional detail, contractor's RFI shall include a sketch or equivalent description of contractor's proposed solution.
- B. To expedite the processing of RFIs, submit the attached form, or similar form including the same information to the Architect, with a copy to the Engineer. Include Contractor proposed solution, with sketches as required, in the indicated space on the form.
- C. The form and all RFI related documents shall be submitted as one PDF (non-binder) format file, without password protection. If it is impossible to convert some information to PDF, it may be submitted as a second file, not password protected.

RFI FORM

RFI No. _____

Date Submitted _____

Contractor: _____

Date Required: _____

Job Name: _____

Person: _____

Spec. Sec./Dwg. No.: _____

Contr. Fax No.: _____

Vanderweil Fax No.: (617) 423-7401

Arch. Fax No.: _____

Contractor Field Question (Provide narrative and/or sketch):

Contractor Proposed Solution (Provide narrative and/or sketch):

Vanderweil Response:

1.8 COORDINATION DRAWINGS AND COORDINATION MODEL

- A. Coordination drawings are required for all Divisions covered by this Section. These drawings require information on all mechanical and electrical trades. The content and procedures described in Division 01 shall be followed, with the additional requirements specifically for the mechanical and electrical trades as described in this Section. If a BIM model is not used on this project, the below requirements shall be accomplished in CAD.
- B. The main paths of egress and for equipment removal from main mechanical and electrical rooms shall be clearly shown on the coordination drawings.
- C. The initiation of these drawings begins with the Sheet Metal Subcontractor's BIM model and the resultant sheet metal shop drawings.
- D. The Sheet Metal Subcontractor's BIM model shall incorporate the sheet metal as well as structure and other information for spatial coordination. Provide cross sections in congested areas. Access panels shall be shown, as well as all fire walls and smoke partitions, which shall be shown in a different color than the regular partitions and the sheet metal.
- E. Each of the mechanical, electrical and other specialty trades shall electronically add its work to the model in a separate color, with appropriate offsets, elevations and grid dimensions, and showing access panels. Mechanical, electrical, and specialty trade information is required for fan rooms and mechanical rooms, horizontal exits from duct shafts, crossovers, and for spaces in and above ceilings. Drawings shall indicate horizontal and vertical dimensions to avoid interference with structural framing, ceilings, partitions, and other services.
- F. The following shall be submitted to the Engineer for review:
 - 1. The 3-D electronic model showing all trades and color coded by trade.
 - 2. For HVAC review:
 - a. An electronic set of 2-D PDFs of all floor plans and sections, made from the 3-D electronic model showing all trades color coordinated.
 - b. An electronic set of 2-D PDFs of all floor plans, made from the 3-D electronic model, but showing only the HVAC superimposed on the architectural layout.
 - 3. For electrical review:
 - a. An electronic set of 2-D PDFs of all floor plans and sections, made from the 3-D electronic model showing all trades color coordinated.
 - b. An electronic set of 2-D PDFs of all floor plans, made from the 3-D electronic model, but showing only the electrical superimposed on the architectural layout.
 - 4. For plumbing review:
 - a. An electronic set of 2-D PDFs of all floor plans and sections, made from the 3-D electronic model showing all trades color coordinated.

- b. An electronic set of 2-D PDFs of all floor plans, made from the 3-D electronic model, but showing only the plumbing superimposed on the architectural layout.
 - 5. For fire protection review:
 - a. An electronic set of 2-D PDFs of all floor plans and sections, made from the 3-D electronic model showing all trades color coordinated.
 - b. An electronic set of 2-D PDFs of all floor plans, made from the 3-D electronic model, but showing only the fire protection superimposed on the architectural layout.
 - 6. One complete set of 2-D coordination drawings, printed out full size with individual trades superimposed and color coded.
- G. The 2-D PDFs are considered the coordination drawings. The engineering review is based on these, not on the 3-D model, which the engineer may need to refer to for clarification in congested spaces.
- H. Fabrication shall not start until the coordinated model, PDF's, and prints are received by the Engineer and have been reviewed.
- I. Review by Engineer of coordination drawings is limited to confirming that requirements for coordination and preparation of plans have been complied with by the Contractor and shall not diminish responsibility under this Contract for final coordination of installation and maintenance clearances of all systems and equipment with Architectural, Structural, Mechanical, Electrical and other related work.
- J. After Review:
 - 1. The Engineer will provide comments.
 - 2. All changes to reviewed coordination drawings shall be approved in writing by the Architect prior to start of work in affected area.
- K. Coordination Drawings shall include, but are not limited to:
 - 1. Plumbing systems, piping and equipment.
 - 2. HVAC piping, systems and equipment.
 - 3. Control systems.
 - 4. Electrical distribution, systems and equipment.
 - 5. Lighting systems and fixtures.
 - 6. Sheet metal work, components and accessories (e.g. coils, terminal boxes).
 - 7. Fire protection and sprinkler system, piping and heads.
 - 8. Structural.
 - 9. Electrical Equipment Room layouts.
 - 10. Environmental Rooms and associated refrigeration/heating systems.
 - 11. Partition/room layout.
 - 12. Ceiling tile and grid

13. Access panels.
14. Smoke and fire dampers.
15. Roof drain piping.
16. Major electrical conduit runs, panel boards, feeder conduit and racks of branch conduit.
17. Above ceiling miscellaneous metal.
18. Heat tracing of piping.

1.9 ENGINEER'S ELECTRONIC BIM FILES

- A. Electronic BIM files for Fire Protection, Plumbing, HVAC, Electrical, Communication, or Electronic Safety and Security drawings will be furnished by Engineer at contractor's request. These files will be provided on Engineer's FTP site in the software release used by the Engineer. If other media or software version is requested, Engineer will require advance reimbursement of processing costs.
- B. Requests should be made by filling out the following form letter and providing an authorized signature. The requested information will not be released prior to receipt of this letter for the appropriate documents.

[DATE]

R.G. Vanderweil Engineers, LLP
Attn: [NAME]
[ADDRESS]

Re: [JOB NAME]

Dear [NAME]:

We hereby request that you provide us with the following electronic files:

[ELECTRONIC FILE Name, date of file, description]

R.G. Vanderweil Engineers, LLP (“Vanderweil”) agrees to provide the above-referenced electronic files to [] (the “Recipient.”). Recipient recognizes that data recorded on or transmitted as electronic files are subject to undetectable alteration, either intentional or unintentional, due to among other causes, transmission, conversion, media degradation, software error, or human alteration. Accordingly, the electronic files are provided to Recipient for informational purposes only and not as an end product or Contract Document.

Vanderweil makes no warranties, either express or implied, regarding the fitness or suitability of the electronic files. The electronic files are instruments of professional service, and shall not be used, in whole or in part, for any project other than that for which they were created, without the express written consent of Vanderweil Engineers.

Accordingly, Recipient agrees to waive any and all claims against Vanderweil resulting in any way from the use, unauthorized reuse or alteration, or misuse of the electronic files, and to defend, indemnify and hold Vanderweil harmless from any claims, losses, damages, or costs, including attorney’s fees, arising out of the use, reuse, alteration, or misuse of the electronic files.

Further:

1. Recipient agrees that any electronic/model data provided in the Electronic Files is for reference only and does not relieve the contractor and subcontractors from the responsibility for material take offs and cost estimations, coordination of systems, sequencing, and means and methods.
2. Recipient agrees not to sell, assign or lease any rights in the designs, models, drawings, information and depicted works in any form to any person or entity.
3. Recipient agrees not to remove any copyright notices, labels or marks on the designs, drawings, information and depicted works.
4. Under no circumstances shall the transfer of ownership of electronic data, or hard copy thereof, be deemed to be a sale by Vanderweil of tangible goods, and Vanderweil makes no warranties, express or implied, of merchantability or of fitness for a particular purpose.

5. The Electronic Files issued are current as of the date of the last revisions as imbedded in the files. Vanderweil is not responsible or liable for providing any updates or modifications that may or may not have occurred since the revision dates shown in the files. The Electronic Files may also represent only a portion - not a complete set - of the construction documents or model data and, as such, they may be incomplete or inconsistent with the most recent design. Vanderweil makes no representation as to its completeness, currency or accuracy and Vanderweil shall not be responsible to advise the Recipient of any changes which may hereafter be made to the Project plan or configuration or other information contained in the Electronic Files.
6. Recipient acknowledges that the designs, drawings, information and depicted works are protected by copyright laws, and that Vanderweil, or its Consultants, as appropriate, is the author and/or owner of same.
7. Vanderweil , or its Consultants, as appropriate, retains all copyrights to the designs, drawings, information and depicted works on the disk and grants to Recipient a limited license to reproduce such information in connection with Recipient or their contractors' or subcontractors work on the Project, and no other.
8. If specifications are provided, recipient agrees not to modify same.
9. If BIM models are provided, the following shall apply:
 - Contract Documents Govern the Project. Recipient agrees that, notwithstanding the use of BIM technology and the transfer of BIM Data, the specifications, and the 2-dimensional Contract Documents and subsequently issued Change Orders, Change Directives, Bulletins, RFI Responses and the like are the sole source of information regarding the requirements for construction of the Project. Recipient will notify Vanderweil if it becomes aware of discrepancy between the BIM Data and any drawing, specification or other document issued for construction of the Project.
 - BIM (i.e. Revit/Navisworks) models and associated files will only contain elements and content that Vanderweil Engineers deems necessary and as required to produce the two dimensional drawings that govern the project. No specific Level of Detail (LOD) is implied or expected. The Recipient agrees that no Revit families or Revit content shall be removed from the model and/or used for any other purpose than supporting this specific project.
 - The BIM model is for general informational and reference purposes only, and is not to be used by the contractor as an alternative to performing field measurements, preparing coordination drawings, or developing shop drawings. Access to the BIM model does not relieve the contractor of the contractual responsibility to implement the design intent through various means. These means include verifying existing conditions, producing coordination drawings (compiled from various sub-contractors), preparing shop drawings, and controlling means and methods of construction.

Accepted and Agreed:

Authorized signature: _____

Print Name: _____

Title: _____

Company: _____

Date: _____

1.10 RELATED WORK IN OTHER SECTIONS

- A. The following work is not included and shall be performed under other Sections. Coordinate requirements with other Divisions.
1. Excavation and backfill.
 2. Concrete work, including concrete housekeeping pads and other pads and blocks for vibrating and rotating equipment, and cast in place manholes and handholes.
 3. Cutting and patching of masonry, concrete, tile and other parts of structure, with the exception of drilling for hangers and providing holes and openings in metal decks.
 4. Flashing of wall and roof penetrations.
 5. Installation of access panels in floors, walls, furred spaces or above ceilings.
 6. Painting, except as specified herein.
 7. Structural supports necessary to distribute loading from equipment to roof or floor except as specified herein.
 8. Temporary light, power, water, heat, gas and sanitary facilities for use during construction and testing.
 9. Outdoor air intake and exhaust louvers.
 10. Wall and ceiling enclosures and shafts for supply, return and exhaust ductwork as shown on drawings.
- B. Installation of circuit breakers and final electrical panel terminal connections for ATC control power wiring shall be provided by Division 26.
- C. This section further delineates the division of work between the Electrical Contractor, Mechanical Contractor, and Plumbing Contractors.
1. Specific work to be done under Division 26 is hereinafter listed or described. All other work necessary for the operation of Divisions 22 and 23 equipment shall be performed under those Divisions.
 2. All individual motor starters and drives for mechanical equipment (fans, pumps, etc.) shall be furnished and installed under Division 23 unless indicated as a part of a motor control center. Motor starters for mechanical equipment provided in motor control centers shall be furnished under Division 26.
 3. Under Division 26, power wiring shall be provided up to a termination point consisting of a junction box, trough, starter, VFD or disconnect switch. Under Division 26, line side terminations shall be provided. Wiring from the termination point to the mechanical equipment, including final connections, shall be provided under Divisions 22 and 23.
 4. Duct smoke detectors, if required by NCBC, shall be furnished and wired by Division 28, installed by Division 23. Fire alarm AHU shut down defeat switch shall be inside or immediately beside the fire alarm panel. The shutdown defeat circuit shall be wired from the fire alarm control panel to a termination point,

adjacent to the AHU control, under Division 28. AHU control wiring from the termination point to the equipment shall be under Division 23

5. Equipment less than 120 Volt, all relays, actuators, timers, seven-day clocks, alternators, pressure, vacuum, float, flow, pneumatic-electric, and electric-pneumatic switches, aqua-stats, freeze-stats, line and low voltage thermostats, thermals, remote selector switches, remote pushbutton stations, emergency break-glass stations, interlocking, disconnect switches beyond termination point, and other appurtenances inclusive of control system power supplies associated with equipment under Division 23 shall be furnished, installed and wired under Division 23.
6. All wiring required for controls and instrumentation not indicated on the drawings shall be furnished and installed by Divisions 22, ~~and 23,~~ **and 25.**
7. Equipment with built-in disconnects or outlets provided under Divisions 22 or 23 shall be wired under Division 26 to the line side of the disconnect switch, or the outlet. A disconnect switch shall be provided under Division 26 if the equipment is not provided with a built-in disconnect switch. In this case wiring from the switch to the equipment shall be under Divisions 22 or 23. The uilt-in switch for outdoor equipment shall be in minimum NEMA 3R enclosure.
8. The sequence of control for all equipment shall be as indicated on the Division 23 Drawings and specified in Section 23, HVAC Control System.
9. Horsepower for all motors shall be consistently identified on the Division 23 and Division 26 Drawings.
10. Under Division 23, the cable from the load side of the VFD to the driven equipment shall comply with the equipment manufacturer's recommendations.
11. All sprinkler flow and tamper switches shall be furnished and installed under Division 21, and wired under Division 28.
12. Where electrical wiring is required by trades other than covered by Division 26, specifications for that section shall refer to same wiring materials and methods as specified under Division 26. Exception to that is the low-voltage control wiring; the use of the J-Hooks to support the low-voltage control wiring system is acceptable; as outlined in Section 4 of the Telecom STS -1000 Guidelines.
13. For kitchen equipment, Division 26 Contractor shall install wiring from a power source to a termination point, adjacent to the kitchen equipment. Contractor providing kitchen equipment shall wire to the equipment from the termination point.
14. The use of combination starters is recommended over the use of individual starters and disconnect switches. Unless confirmed otherwise with the Mechanical Designer, typical pump and fan applications have variable load profiles where the use of VFD for pump and fan motors five HP and larger is recommended. For non-VFD driven motor applications rated 100 HP or higher, solid-state reduced voltage starting shall be required to reduce voltage drop during motor starting.

15. A diagram clarifying division of work responsibility to provide and install the termination point, such as (trough, VFD, individual starter, disconnect switch, JB, --- etc.) shall be as detailed on the drawings..
16. Disconnects for the elevator and the elevator's car shall be provided and installed by the Electrical Contractor.
17. Reports showing the sizes of the maximum overcurrent protection (MOCP), minimum circuit ampacity (MCA), and overload setting of the devices for all motors; shall be provided by the Contractor providing the equipment to the Electrical Contractor for incorporation into the Electrical Systems Studies to be submitted to the Electrical Engineer for review and approval prior to purchase or installation of any electrical equipment.
18. All electrical work shall be performed by individuals and/or companies who are properly licensed by the NC State Board of Examiners of Electrical Contractors.
19. Exit doors & other doors provided with built-in outlets shall be wired by the Electrical Contractor all the way to the door outlet. Electrical Engineer shall coordinate with the Architect when specifying door shutters and magnetically held doors to ensure all required fire alarm devices are shown and specified.
20. For design-build projects, single prime projects, and Construction Manager at Risk projects, the project manager shall be responsible for coordinating the division of work with approval from Engineer-of-Record.

1.11 SITE VISIT

- A. Before submitting bid, visit and carefully examine site to identify existing conditions and difficulties that will affect work of this Section. No extra payment will be allowed for additional work caused by unfamiliarity with site conditions that are visible or readily construed by an experienced observer.

1.12 EXISTING CONDITIONS AND PREPARATORY WORK

- A. Before starting work in a particular area of the project, visit the location and examine conditions under which work must be performed including preparatory work done under other Sections or other Contracts or by the Owner. Review geometrical constraints, such as ceiling heights, to ensure constructability and access for maintenance. Report conditions that might adversely affect work in writing to the Architect. Do not proceed with work until defects have been corrected and conditions are satisfactory. Commencement of work shall be construed as complete acceptance of existing conditions and preparatory work.
- B. Existing Concrete Slabs. Before coring or other penetration of existing slabs, scan the area where the work is to be performed in order to locate existing in-slab or below-slab utilities, and position the slab penetrations so as to avoid these.

1.13 CODES, STANDARDS, AUTHORITIES AND PERMITS

- A. Perform work in accordance with rules, regulations, standards, codes, ordinances, and laws of local, state, and Federal governments, and other authorities that have legal jurisdiction over the site.

- B. Secure and pay for all permits and inspections required by the Authorities having Jurisdiction. Secure trade permits prior to beginning work.
- C. Materials and equipment shall be manufactured, installed and tested as specified in latest editions of applicable publications, standards, rulings and determinations of:
 - 1. Applicable local and state codes.
 - 2. National Fire Protection Association (NFPA).
 - 3. American Insurance Association (AIA) (formerly National Board of Fire Underwriters).
 - 4. Occupational Safety and Health Act (OSHA).
 - 5. Underwriters Laboratories (UL)
 - 6. Factory Mutual Association (FM)
 - 7. Owner's Insurance Underwriter.
- D. Specific reference is made to the following NFPA standards which contain an exceptionally high quantity of mechanical, electrical, and fire protection requirements. These standards as referenced by the applicable building, fire, and mechanical codes shall apply.
 - 1. No. 13 - Installation of Sprinkler Systems
 - 2. No. 14 - Installation of Standpipe and Hose Systems
 - 3. No. 20 - Installation of Centrifugal Fire Pumps
 - 4. No. 30 - Combustible Liquids
 - 5. No. 45 - Fire Protection for Laboratories Using Chemicals
 - 6. No. 70 - National Electric Code
 - 7. No. 72 - National Fire Alarm Code
 - 8. No. 101 - Life Safety Code
- E. Material and equipment shall be listed and labeled by one of the approved testing agencies recognized as acceptable in accordance with North Carolina General Statute Chapter 66-23 through 66-27.01.
- F. When requirements cited in the various parts of the Contract Documents conflict with each other, most stringent shall govern work. Architect may relax this requirement when relaxation does not violate ruling of AHJ. Approval for relaxation shall be obtained from AHJ in writing.
- G. Unless indicated otherwise, the most recent editions of applicable specifications and publications of the following organizations form part of these Contract Documents. Material and Equipment shall be approved by the relevant organizations for intended service.
 - 1. American Gas Association (AGA).
 - 2. American National Standards Institute (ANSI).
 - 3. American Society of Mechanical Engineers (ASME).

4. National Electric Manufacturers Association (NEMA).
5. American Society for Testing and Materials (ASTM).
6. American Water Works Association (AWWA).
7. American Society for Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
8. Air Moving and Conditioning Association (AMCA).
9. Sheet Metal and Air Conditioning Contractors National Association (SMACNA).
10. Air Conditioning and Refrigeration Institute (ARI).
11. Thermal Insulation Manufacturers Association (TIMA).
12. Institute of Electrical and Electronics Engineers (IEEE).
13. Insulated Cable Engineers Association (ICEA).
14. Manufacturer's Standardization Society of the Valve & Fittings Industry (MSS)

1.14 WARRANTY AND 24 HOUR SERVICE

- A. This Paragraph shall not be interpreted to limit Owner's rights under applicable codes and laws and under this Contract.
- B. Part 2 paragraphs of all specification Sections may specify warranty requirements that exceed those of this Paragraph.
- C. Warranty the Work of this Section in writing for one year following the date of Final Acceptance. If the equipment is used for ventilation, temporary heat, or other use prior to initial beneficial occupancy by the Owner, the bid price shall include an extended period of warranty covering the one-year of beneficial occupancy by the Owner. The warranty shall be to repair or replace defective products, materials, equipment, workmanship and installation that develop within this period promptly and to Architect's satisfaction, and to correct damage caused in making necessary repairs and replacements under warranty within Contract Price.
- D. In addition to warranty requirements of Division 01 and of Paragraph C above, obtain written equipment and material warranties offered in manufacturer's published data, without exclusion or limitation, in Owner's name.
- E. Replace material and equipment that require excessive service during warranty period. Excessive service shall be defined as more than three service calls for the same material or equipment within a 12 month period.
- F. Provide 24-hour service beginning on the date of Final Acceptance and lasting until the termination of the warranty period. Service may be provided by a separate service organization subject to Owner approval. Submit name and a phone number that will be answered on a 24-hour basis each day of the week, for the duration of the service.
- G. Submit copies of equipment and material warranties before final payment.
- H. Use of systems provided under this Section for temporary services and facilities shall NOT constitute Final Acceptance of work nor beneficial use by Owner, and shall not institute warranty period.

- I. Provide manufacturer's engineering and technical staff at site to analyze and rectify problems that develop during warranty period immediately. If problems cannot be rectified immediately to Owner's satisfaction, notify Architect in writing, describe efforts to rectify situation, and provide analysis of cause of problem. Architect will recommend course of action.

1.15 ACCEPTABLE MANUFACTURERS

- A. Acceptable Manufacturers: The Engineer's design for each product is based on the single manufacturer listed in the schedule or shown on the drawings. The cited manufacturers are used to denote the quality standard of product desired and do not restrict bidders to a specific brand, make, manufacturer or specific name; they are used only to set forth and convey to bidders the general style, type, character and quality of product desired; equivalent products will be acceptable. In Part 2 of the individual Specification Sections certain Alternate Manufacturers may be listed as being acceptable. These are acceptable only if, as a minimum, they are in compliance with the following requirements:

1. Meet all performance criteria listed in the schedules and outlined in the specification. For example, to be acceptable, an air handling unit must deliver equal CFM against equal external static pressure using equal or less horsepower as the air handler listed in the schedules.
2. Have identical operating characteristics to those called for in the specification. For example, a reciprocating compressor will not be acceptable if a rotary model is specified.
3. Fit within the available space it was designed for, including space for maintenance and component removal, with no modification to either the space or the product. Clearances to walls, ceilings and other equipment will be at least equal to those shown on the design drawings. The fact that a manufacturer's name appears as acceptable shall not be taken to mean that the Architect has determined that the manufacturer's products will fit within the available space - this determination is solely the responsibility of the contractor.
4. For rooftop mounted equipment and for equipment mounted in areas where structural matters are a consideration, the products must have a weight no greater than the product listed in the schedules or specifications.
5. Products must adhere to all architectural considerations including, but not limited to: being of the same color as the product scheduled or specified, fitting within architectural enclosures and details, and for diffusers and plumbing fixtures - being the same size and of the same physical appearance as scheduled for specified products.

- B. Bidder Proposed Substitutions

1. Bidder proposed substitutions of materials, items, or equipment of equal or equivalent design shall be submitted to the architect or engineer for approval or disapproval; such approval or disapproval shall be made by the architect or engineer prior to the opening of bids.
2. Bidder proposed substitutions shall be submitted no later than 10 days prior to bid date for Designer evaluation and inclusion in the last addenda that may be

issued no later than 7 days prior to bid date. Necessary or required substitutions can occur later when specified products are not available, or would cause late delivery, or have experienced model changes, etc. then substitutions can be made after contract award per usual procedure in the General Conditions of the Contract.

C. Deviations

1. Proposed deviations from Contract Documents shall be requested individually in writing whether deviations result from field conditions, standard shop practice, or other cause. Submit letter with transmittal of Shop Drawings which flags the deviation to the attention of the Architect.
2. Without letters flagging the deviation to the Architect, it is possible that the Architect may not notice such deviation or may not realize its ramifications. Therefore, if such letter are not submitted to the Architect, the Contractor shall hold the Architect and his consultants harmless for any and all adverse consequences resulting from deviations being implemented. This shall apply regardless of whether the Architect has reviewed or approved shop drawings containing the deviation, and will be strictly enforced.
3. Approval of proposed deviations, if any, will be made at discretion of the Architect.

1.16 SUBMITTALS

A. This Paragraph supplements Division 01.

B. Besides shop drawings, which are submitted relatively early in the project, code-required information on life safety and other systems is required to be submitted prior to claiming construction completion and filing for an occupancy permit. Refer to Part 3 of these specifications.

C. Definitions

1. Submittals include product data, shop drawings, coordination drawings, and sheet metal shop drawings. Product data and shop drawings are information prepared to illustrate, in more detail than shown on the contract documents, the fixtures, equipment and other components of the work as proposed by the contractor. These are action submittals.
2. Coordination Drawings are detailed, large-scale layout Shop Drawings showing HVAC, Electrical, Plumbing and Fire Protection work superimposed in order to identify conflicts, ensure inter-coordination of Mechanical, Electrical, Plumbing, Architectural, Structural and other work, and to conform the engineering layouts to best construction practices. Coordination drawings are information submittals.
3. Sheet Metal Shop Drawings are 3/8 inch scale detailed sheet metal layouts showing all offsets, fittings, and hangers and supports, and other appurtenances. These are information submittals.
4. Electronic Copy means copy in a searchable PDF format, and excludes scanned material and faxed material. Scanned material and faxed material shall not be submitted.

D. Submittal Cover Sheet

1. In addition to the information required for all submittals on the project as specified in Division 01, provide the below special cover sheet for submittals falling within Division 20, 21, 22, 23, 26, 27 and 28. Information on the special cover sheet shall be completely filled out. Submit a separate cover sheet with shop drawings for each section of the specifications.
2. Where the section specifies a class of products (for example, plumbing fixtures, wiring devices, insulation) the submission for that section shall either be complete, including all products within that class or it shall contain an index listing all products within that class and designating which ones are included with that submittal. Where the submission covers more than one product, the information required on the cover sheet shall be clearly differentiated by product if it does not apply in common for all included products.

SUBMITTAL COVER SHEET

PROJECT: _____ DATE: _____
DIVISION _____ SECTION _____
NO. _____ NO. _____ PARA. NO. _____

DESCRIPTION: _____

CONTRACTOR: _____

CONTRACT DRAWING REFERENCE _____

NO: _____

EQUIPMENT TAG (From Dwg. _____

Schedules): _____

SUBMISSION (check one): First Second Third Fourth

INFORMATION AND CHECKLIST

1. Direct contact information for product representative or supplier to which questions can be referred (name, address, phone number, and email address).

Name: _____

Address: _____

Phone Number: _____ Email: _____

			<u>Comment</u>
2.	Are all specified or scheduled items included and exactly match scheduled/specified items?	Yes	No
3.	Is this item a substitution or other deviation? If so, follow procedures in Section 012500.	Yes	No
4.	Does equipment fit space shown on construction documents, coordination drawings, and actual field conditions?	Yes	No
5.	Does this material/equipment add expense to other trades or project costs?	Yes	No
6.	Is control interface coordinated?	Yes	No
7.	List electrical characteristics (Voltage/Phase/Hz/Amps)		_____

E. Submittal Contents, Format, Procedures

1. For the submittals covered by Division 20, Contractor review of submittals is intended to ensure that the submittals include the foregoing cover sheet, are in the correct electronic or paper format as specified below, and that the specified item physically fits into the space available. Contractor shall verify that the submittal contains adequate information to verify specification requirements as well as the performance and dimensional requirements shown on the drawings.
2. HVAC controls shall be coordinated with any package controls provided with equipment to ensure that the HVAC controls submittal includes all required sequences.
3. Submittal Contents
 - a. Submittals shall be comprehensive and fully self-contained.
 - b. Submittals shall include page numbers to allow reviewer to identify specific location where comment applies.
 - c. Electronic submittals shall be fully self-contained and shall not contain links to associated websites. The submittal coversheet, transmittal, and document shall be prepared as one searchable PDF (non-binder) format file, without password protection. If it is not possible to convert some material into PDF, it is acceptable to submit this as a second file.
 - d. Submittals shall include all catalog data and physical and performance characteristics and plans and diagrams as necessary to confirm compliance with plans and specifications.
 - e. Submittals shall contain only information relevant to the particular equipment or materials to be furnished. Clearly indicate the piece of equipment or material being provided. Do not submit generic catalog cuts which describe several different items in addition to those specific items being provided, unless all irrelevant information is marked out or relevant information is clearly differentiated. Those items and features that are not being proposed for this project shall be crossed out so as not to imply that they are included.
 - f. Where applicable, equipment Product Data shall include wiring and interlock diagrams using the standard wiring diagrams with all terminals, which have been provided for use by the various Subcontractors clearly indicated. For example, remote start/stop wiring from BMS system to a motor control center shall be clearly identified.
 - g. Provide shop drawing submittals showing details of piping connections to ALL equipment. If connection details are not submitted and connections are installed incorrectly in the field, reinstall within the original contract price.
 - h. Division 23 shop drawings and installation layout drawings for heating, pumping, process piping, and refrigeration systems prepared by the Installer shall note name(s), license number(s), and license expiration dates of the installing firm.

- i. Submit the following for review, including a submittal cover sheet for each product:
 - 1) Electronic copy (see above requirements for electronic copy) for each submittal.

F. Sheet Metal Shop Drawings

1. The Sheet Metal Subcontractor shall prepare a complete electronic background model in a current version of AutoCAD, REVIT, or Navisworks. Request for use of an alternative software shall be submitted to the Architect for approval before preparation of shop drawings. This background shall be used to develop sheet metal shop drawings. Electronic copy of these shall be submitted, containing sufficient plans, elevations, sections, details and schematics to describe work clearly. Plans shall be 3/8 inch = 1 foot-0 inches scale and shall indicate work of other Sections where physical clearances are critical and where interferences are possible. Provide larger scale details to show complete installation. Sheet metal drawings shall show elements of Architect's reflected ceiling plan, exposed ductwork, walls, partitions, diffusers, registers, grilles, fire dampers, sleeves and other aspects of construction for coordination. Show horizontal and vertical offsets and changes of direction. Show all firewalls and smoke partitions. These are action submittals.
2. These shop drawings shall be submitted before the coordination drawings are prepared, and once the Architect's comments are received back shall serve as the starting point for coordination drawings as specified above.

G. Post-Submittal Actions

1. After review, Contractor to receive electronically transmitted response report for all reviewed submittals which includes the following information:
 - a. Submittal status
 - b. List of reviewer's comments
 - c. Copy of returned submittal. All submittals will be returned electronically, with the exception of coordination drawings, which will have one copy returned with comments through overnight mail.
 - d. Re-submittals shall be complete and shall include a cover letter summarizing the corrections made in response to the review comments and the submittal page numbers which were revised.
 - e. Submittal Status: Electronic and paper submittals will be returned notated as illustrated below:

"APPROVED AS NOTED"

"Reviewed and found generally acceptable. Minor deviations may be noted. No further submittal required if notations are complied with."

"REJECTED;

REVISE AND RESUBMIT"

"Submittal contains deviations which shall be corrected and confirmed by a new submittal."

"REJECTED"

Submittal is incorrect to such an extent that material is unacceptable, or is incomplete to such an extent that a complete review cannot be made. Resubmit in accordance with requirements of the Contract Documents."

"NO ACTION"

Submittal not reviewed.

"REVIEWED FOR INFORMATION"

This Submittal is for information only.

2. Where initial submittal is rejected, revised submittal shall be labelled identically to previous submittal and shall include a memo identifying where each comment has been address in the new version.

H. Responsibility

1. Intent of Architect's submittal review is to check for capacity, rating, and certain construction features. Contractor shall ensure that work meets requirements of Contract Documents regarding information that pertains to fabrication processes or means, methods, techniques, sequences and procedures of construction; and for coordination of work of this and other Sections. Work shall comply with submittals marked "APPROVED AS NOTED" to extent that they agree with Contract Documents. Submittal review shall not diminish responsibility under this Contract for dimensional coordination, quantities, installation, wiring, supports and access for service, nor shop drawing errors or deviations from requirements of Contract Documents. Noting of some errors while overlooking others will not excuse proceeding in error. Contract Documents requirements are not limited, waived nor superseded by review.
 2. Inform Subcontractors, Manufacturers and Suppliers of scope and limited nature of review process and enforce compliance with contract documents.
- I. Schedule: Incorporate shop drawing review period into construction schedule so that Work is not delayed. Contractor shall assume full responsibility for delays caused by not incorporating the following shop drawing review time requirements into his project schedule. Working days listed refer to the time in the Engineer's office. It does not include transmittal or review time of others. Unless longer review periods are specified in Division 01, allow at least 10 working days, exclusive of transmittal time, for review each time shop drawing is submitted or resubmitted for Divisions covered by this Section, with the exception that 20 working days, exclusive of transmittal time, are required for the following:
1. HVAC temperature control submittals.
 2. HVAC balancing report.
 3. Coordination Drawings.
 4. Distribution equipment including Panelboards.
 5. Short circuit and coordination study

6. Fire protection fabrication drawings.
7. If more than five shop drawings of a single trade are received in one calendar week.

1.17 RECORD DRAWINGS

- A. As work progresses and for duration of Contract, maintain complete and separate set of prints of Contract Drawings at job site at all times. Record work completed and all changes from original Contract Drawings. Such changes shall include, but not be limited to, those resulting from RFIs, field conditions, and modifications and additions. Include actual locations of MEP/FP systems and existing and new utilities. Record valve tags as they are installed.
- B. Underground and utility work shall be located by distances to landmarks, such as building foundations. Give actual dimensions of everything installed including elevations and elevations at each change in direction.
- C. Drawings shall show record condition of details, sections, riser diagrams, control changes and corrections to schedules. Schedules shall show actual manufacturer and make and model numbers of final equipment installation.
- D. "Record Drawings" are a complete set of drawings containing the information above. If BIM is used to create the record drawings, the model shall incorporate all the above information and be developed to AIA LOD 500.
- E. The installing Contractor shall certify Record Drawings for accuracy. The Architect/Engineer will not certify the accuracy of the record drawings - this is the sole responsibility of the Contractor.
- F. If required by the Authority having jurisdiction, each trade shall submit a set of record drawings for approval by the Authority. Format for submission shall be acceptable to the Authority. Drawing format and size changes, and supplemental information required for the submittal are the responsibility of the installing contractor. Provide copies of submittal to the Construction Manager, General Contractor, Owner, Architect, and Engineer.
- G. At completion of work, prepare a complete set of record drawings with all markups incorporated. Deliver these to the Architect for approval.
- H. After approval, final record drawing deliverable shall be as defined in Division 01. After approval, final record drawings submitted shall be as required by Division 01.

1.18 OPERATING AND MAINTENANCE MANUALS – ELECTRONIC FORMAT

- A. Section 017823 describes requirements for Operating and Maintenance Manuals, and Section 017900 describes requirements for training and operating instructions. This section includes additional requirements specifically for the mechanical and electrical trades.
- B. "Electronic Format" means searchable PDF format. It does not include scanned items, which are considered inappropriate.
- C. Obtain at time of purchase of equipment, electronically formatted versions of operation, lubrication, and maintenance manuals for all items. Assemble this literature along with other information in coordinated electronic manuals with additional information

describing combined operation of field assembled units, including as-built wiring diagrams. Manual shall contain names and addresses of manufacturers and local representatives who stock or furnish repair parts for items or equipment. Divide manuals into three sections or books as follows:

1. Engineering flow diagrams and controls sequences from project mechanical drawings, approved automatic temperature controls submittal, equipment startup procedures and operational instructions. Startup and operational instructions shall list valves, switches, and other devices used to start, stop and control systems. Describe procedure to be followed in case of malfunctions. Include approved valve directory showing each valve number, location of each valve, and equipment or fixture controlled by valve.
 2. Detailed maintenance and troubleshooting manuals containing data furnished by manufacturer for complete maintenance. Include copy of balancing report.
 3. Lubrication instructions detailing type of lubricant, amount, and intervals recommended by manufacturer for each item of equipment. Include additional instructions necessary for implementation of first class lubrication program. Include approved summary of lubrication instructions in chart form, where appropriate.
- D. Submit electronic format version of manual(s) for approval. After approval, submit electronic version and one hard copy for distribution to Owner. Deliver manuals no less than 30 days prior to acceptance of equipment to permit Owner's personnel to become familiar with equipment and operation prior to acceptance.

1.19 OPERATING INSTRUCTION

- A. Upon completion of installation, prior to Owner accepting portions of building and equipment for operational use, instruct Owner's operating personnel in operation of systems and equipment. Instruction shall be performed by equipment and controls vendors' factory-trained personnel. Owner shall determine which systems require additional instruction. Duration of instructions for controls shall take equipment through complete cycle of operation (at least five working days). (Not to be confused with the two-week demonstration of automatic controls operation specified in Part 3.) Make necessary adjustments under operating conditions.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 LIFE SAFETY SYSTEMS CERTIFICATION OF COMPLETION

- A. Definitions
1. Life Safety Systems - Mechanical and electrical systems including:
 - a. Fire Suppression Systems
 - b. Fire Notification (Alarm) and Detection Systems
 - c. Smoke Control Systems and Special Inspections
 - d. Egress Signage and Lighting Systems

- e. Emergency Power Systems
- 2. Complete - For a system to be complete the following shall be true:
 - a. No further work is required to satisfy the requirements specified in the drawings, specifications and applicable codes and standards.
 - b. Systems are fully operational with power to components, valves open, status indicators in "normal" condition and otherwise ready "as-is" to perform required functions.
 - c. Required product data and shop drawing submittals have been submitted and returned with a "Reviewed" status. See Paragraph titled "Submittals" for submittal requirements.
 - d. Test certificates have been submitted and returned with a "Approved as Noted" status. See Paragraph titled "Submittals".
 - e. Project visit report observations and "punch list" items have been addressed and/or corrected.
 - f. "O&M" documentation and "as-built" plans have been submitted and returned with a "Reviewed" status.

B. Notification of Completion

- 1. Notify the Architect in writing that the life safety systems are complete at least five (5) working days prior to requesting final certification of completion ("affidavits") from the Architect. The notification shall be in the form of a single formal document endorsed by an individual charged with management responsibility for all trades associated with the life safety systems.
- 2. Schedule work so life safety systems are complete in advance of other systems. This requirement is to allow the Architect to conduct a final project visit and correction of issues found without affecting issuance of a Certificate of Compliance or a Certificate of Occupancy by the Authorities Having Jurisdiction.
- 3. Operate and maintain systems and equipment until final acceptance by the Owner and AHJ.
- 4. All guarantees and warranties shall not begin until final acceptance of the systems and equipment by the Owner and AHJ. Acceptance requires, at a minimum, completed systems testing and inspections.

3.2 SPECIAL RESPONSIBILITIES

- A. Cooperate and coordinate with work of other Sections in executing work of this Section.
 - 1. Perform work so that progress of entire project including work of other Sections shall not be interfered with or delayed.
 - 2. Provide information requested on items furnished under one Section which shall be installed under other Sections.
 - 3. For equipment provided under any division or section which has connection made under the mechanical or electrical sections, obtain detailed installation and hookup information from the equipment manufacturers.

4. Obtain final roughing dimensions or other information needed for complete installation of items furnished under other Sections or by Owner.
 5. Keep fully informed as to shape, size and position of openings required for material or equipment to be provided under all Sections. Give full information so that openings required by work of this Section may be coordinated with other work and other openings and may be provided for in advance. In case of failure to provide sufficient information in proper time, provide cutting and patching or have same done, at own expense and to full satisfaction of Architect.
 6. Provide information requested as to sizes, number and locations of concrete housekeeping pads necessary for floor-mounted vibrating and rotating equipment provided under this Section.
 7. Notify Architect of location and extent of existing piping, conduit, ductwork and equipment that interferes with new construction. In coordination with and with approval of Architect, relocate piping, ductwork and equipment to permit new work to be provided. Remove non-functioning and abandoned piping, ductwork and equipment. Dispose of or store items.
- B. Building Expansion Joints and Firewalls
1. Ductwork, conduit, cable tray, piping, and other horizontal distribution systems shall be provided with expansion provisions when passing by building expansion joints. Provide copper ground jumper across expansion joints for electrical components. Systems shall be run through rated walls, partitions, and floors via approved fireproofed sleeves.
- C. Installation Shall Provide Access to Systems
1. Installation shall allow clearances for easy access to systems for routine maintenance, for repairs, and for installing new cable in conduit and cable trays.
 2. Access panels shall be installed in ceilings that are not composed of removable tiles. These shall be located where system components exist that have moving parts, motors, or other components requiring periodic maintenance, adjustment, or replacement. Access panels shall be shown on Coordination Drawings and shall be of the type and finish approved by the Architect.
- D. Protection of Work
1. Each contractor shall be responsible for work and equipment until finally inspected, tested, and accepted. Carefully store materials and equipment that is not immediately installed after delivery to site. Close open ends of work with temporary covers or plug during construction to prevent entry of obstructing material. Cover work subject to falling debris with temporary covers.
 2. Provide all materials, equipment and labor to provide adequate protection of all equipment during the course of construction. This includes protection from moisture and foreign material. At completion, all work must be turned over to Owner clean and in new condition.
 3. Protect the work and material of other trades that might be damaged by work or workmen and make good all damage thus caused.
- E. Installation Only Items

1. Where a Contractor is required to install items that it does not purchase, coordinate the delivery and be responsible for their unloading from delivery vehicles and for safe handling and field storage up to the time of installation.
 - a. Provide field assembly and internal connections, as well as mounting in place of the items, including the purchase and installation of dunnage supporting members and fastenings to adapt them to architectural and structural conditions.
 - b. Provide connection to building systems including the purchase and installation of terminating fittings necessary to adapt and connect them to the building systems.
 2. Carefully examine items upon delivery. Claims that items have been received in a condition that their installation will require procedures beyond the scope of work of this contract will be considered only if presented in writing within one week of their date of delivery. Unless claims have been submitted, fully recondition or replace damaged items.
- F. Maintenance of equipment and systems: Maintain equipment and systems until Final Acceptance. Ensure adequate protection of equipment and material during delivery, storage, installation and shutdown and during delays pending final test of systems and equipment because of seasonal conditions. Protect work and equipment from damage and exposure to moisture and outdoor extreme temperature conditions until finally inspected, tested, and accepted. Carefully store materials and equipment that is not immediately installed after delivery to site. Close open ends of work including piping and ductwork with temporary covers or plugs during construction to prevent entry of obstructing material or debris.
- G. Use of premises shall be restricted as follows
1. Remove and dispose of dirt and debris, and keep premises clean. During progress of work, remove unused material and equipment. Maintain building and premises in neat and clean condition, clean and wash required to maintain appearance and operation of equipment.
 2. Store materials in a manner that will maintain an orderly clean appearance. If stored on-site in open or unprotected areas, equipment and material shall be kept off the ground by means of pallets or racks, and covered with tarpaulins.
 3. Do not interfere with function of existing sewers and water and gas mains, electrical, or mechanical systems and services. Extreme care shall be observed to prevent debris from entering pipe, ductwork and equipment.
- H. Surveys and Measurements
1. Base measurements, both horizontal and vertical, on reference points established by Contractor and be responsible for correct lay out of work.
 2. In event of discrepancy between actual measurements and those indicated, notify Architect in writing and do not proceed with work until written instructions have been issued.
- I. Fireproofing
1. Clips, hangers, clamps, supports and other attachments to surfaces to be fireproofed shall be installed, insofar as possible, prior to start of spray fiber work.

2. Ducts, piping and other items that would interfere with proper application of fireproofing shall be installed after completion of spray fiber work.
3. Patching and repairing of fireproofing due to cutting or damaging to fireproofing during course of work specified under this Section shall be performed by installer of fireproofing and paid for by trade responsible for damage and shall not constitute grounds for an extra to Owner.

J. Temporary Utilities

1. Refer to Division 01 for project requirements.
2. Coordinate work under this Section with progress of construction so that permanent heating system will be ready to provide temporary heating if permitted by Owner and Architect as soon as building is closed in.
3. Provide and direct labor required for attendance, operation and final restoration of permanent heating system if used for temporary heating purposes. Continuous direct attendance shall be provided whenever permanent system is in operation prior to acceptance of permanent heating system by Owner.

K. Air Bound Systems

1. If, after systems are operational, piping systems, coils or other apparatus are stratified or air bound (by vacuum or pressure), they shall be repiped with new fittings, air vents, or vacuum breakers at no extra cost. If connections are concealed in furring, floors, or ceilings, installing trade shall bear all expenses of tearing up and refinishing construction and finish, leaving same in as good condition as before it was disturbed.

L. Site Logistics

1. Unload materials and equipment delivered to site. Pay costs for rigging, hoisting, lowering and moving equipment on and around site, in building or on roof.

3.3 CONTINUITY OF SERVICES

- A. Do not interrupt existing services without Owner's approval.
- B. Schedule interruptions in advance, according to Owner's instructions. Submit, in writing, with request for interruption, methods proposed to minimize length of interruption.
- C. Interruptions shall be scheduled at times of day and work so that they have minimal impact on Owner's operations.
- D. Coordinate shutdowns of existing systems as follows:
 1. Give proper notice to Owner when making shutdowns; a minimum of fourteen full days are required.
 2. Minimize shutdowns.
 3. Provide temporary services where required and perform shutdowns and tie ins at a time convenient to Owner.
 4. Complete and file the Owner's shutdown notice questionnaire.

5. Perform required survey and inspection work required by the notice for shutdown.

E. Include premium time work associated with interruptions of services and/or shutdowns to avoid disruption to Owner's operations.

3.4 CLEANING

A. Cleaning shall be performed prior to commissioning. Refer to individual Division 23 Sections for additional requirements.

B. Ductwork

1. Ducts shall be thoroughly cleaned so that no dirt or dust shall be discharged from diffusers, registers or grilles, when system is operated.

2. Provide temporary connections required for cleaning. Provide cheesecloth for openings during cleaning.

3. Replace filters prior to final inspection and testing.

C. Piping

1. Furnish pipe cleaning chemicals, chemical feed equipment, materials and labor necessary to clean piping.

2. Permanently install necessary chemical injection fittings complete with stop valves.

3. After piping systems have been pressure tested and approved for tightness, clean and flush piping as specified and in accordance with applicable codes.

4. Maintain continuous blowdown and make-up during flushing operation.

D. Equipment

1. After completion of project, clean the exterior surface of equipment, including concrete residue, dirt and paint residue.

3.5 MEP AND FIRE PROTECTION COMPLETION REQUIREMENTS

A. Project Punch List Procedure and Representations to Authorities

1. When the contract work is substantially complete, if requested by the Contractor, the Engineer will do an inspection of the relevant work. Prior to the inspection, the Contractor shall submit a punch list of remaining items to be completed as well as the Testing, Adjustment, and Balance report. In the course of the inspection the Engineer will add to the Contractor's punch list any observed remaining work that is not already on it, and provide the modified punch list, in a medium selected at the Engineer's discretion, for the Contractor's convenience in closing out the work.

2. Regardless of what the Engineer observes and does not observe in the inspection, the responsibility for successful completion of the contract in all of its details remains with the Contractor.

3. If, when the Engineer arrives at the site certain areas are not complete and ready for inspection at the final acceptance stage, the Engineer will not review these areas.

4. Confirmation of Punch List Remediation. Once the engineer has submitted the punch list so modified, it shall be the responsibility of the Contractor to confirm that all the listed items have been correctly remedied. Upon receipt of such confirmation, and at the request of the Contractor, the engineer will re-inspect the site to confirm completion.
 5. Contractor shall provide certifications to authorities such as Building Departments if so required. Also, if authorities require from the Engineer certifications, affidavits, or other type of representations, the Contractor shall provide to the Engineer a certified punch list of remaining work for final completion of the project, suitable for the Engineer to attach to the requested representations.
- B. Occupancy Permit
1. Contractor shall prepare and submit the below life-safety related items as a prerequisite for construction completion and occupancy. These shall be submitted to the Engineer prior to filing for the occupancy permit so that the Engineer can provide the completion affidavit to the AHJ in a timely fashion. Provide a copy of all documents to Architect and to Owner. The required Contractor submittals include:
 - a. Signed and sealed (by the Engineer responsible for their preparation) fire protection shop drawings.
 - b. Fire protection As-Builts.
 - c. As-Builts of MEP systems including those aspects of the fire protection system operated by the building controls such as smoke dampers and fan shut down.
 - d. Formal statement of compliance of (a) the fire protection and fire alarm installation with the contract documents, and (b) testing of the fire alarm in accordance with the manufacturer's specifications.
 - e. Certification that acceptance tests of the final fire protection, fire alarm and life safety systems have been successfully completed.
 - f. Contractor's Test and Material Certificates (per NFPA).
 - g. Special Inspector Reports (smoke control system testing).
 - h. Contractor's certified affidavit attesting that MEP systems and Fire Protection have been installed in compliance with the Permit Documents.
 - i. Air and Water Balancing Reports.
 - j. Certification of successful emergency egress lighting test.
 - k. Certification of completion of code-related items on contractor's punch list and supplemental architectural and engineering punch lists.
 - l. Domestic water systems testing, chlorination and water quality documentation.
- C. Startup, Pre-Commissioning, and Commissioning
1. Completion of startup, pre-commissioning, and commissioning shall be accomplished as a prerequisite for final acceptance.

2. Below are minimum requirements for startup and pre-commissioning. Additional requirements may be found in other specifications Sections such as "Commissioning" or "Testing, Adjustment and Balancing."
 3. Testing and balancing of HVAC shall occur after startup and pre-commissioning.
 4. Operate and maintain systems and equipment until final acceptance by the Owner.
 5. All warranties shall not begin until final acceptance of the systems and equipment by the Owner, which does not occur until systems have completed commissioning.
 6. The Owner maintains the right to have access to the entire project site to develop his own operational procedures.
 7. For each of the mechanical and electrical trades, prepare a room by room Startup and Pre-Commissioning Form which lists equipment with moving parts or with combustion or electric heating processes. Lighting controls shall be included in the list. Include equipment name, make and model number, date of Visual Inspection and names and signatures of attendees, date of Startup and names and signatures of attendees, date that the item has been placed into system-wide automatic operation.
 8. Visual Inspection shall be attended by a qualified representative of the manufacturer. Confirm that equipment is installed, mounted and supported per manufacturer's recommendations. Confirm proper direction of rotation.
 9. Startup. Conform to startup and testing procedures outlined in the relevant specification Sections. Startup shall be attended by a qualified representative of the manufacturer. Start each piece of equipment and check its operation in accordance with manufacturer's recommendations. Confirm that equipment operates and cycles appropriately under automatic control. Confirm satisfactory operation in all operating modes (e.g. normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
 10. Leaks, damage and defects discovered or resulting from startup and pre-commissioning shall be repaired or replaced to like-new condition with acceptable materials. Tests shall be continued until system operates without adjustments or repairs.
 11. When all equipment in a system has been started, place entire system in operation under automatic control and confirm system-wide operation.
 12. Submit completed Startup Forms as an Information Submittal.
- D. Demonstration of Successful Operation
1. After components and systems have been commissioned (or, if there is no commissioning, after startup), provide a 2 week, 24 hour per day fully functional automatic operation period of systems simultaneously. This shall be successfully concluded before systems are accepted by Owner.
- E. Project Close-Out Procedure
1. General

- a. The requirements of this Section are in addition to and supplement the requirements outlined in Division 01.
2. Project Close-Out Checklist
 - a. Review requirements of each Section of the specifications and submit for approval to Architect the sign-off forms that shall become the project close-out checklist. Do not group items; provide a separate line item for each required item. The checklist, at a minimum, shall include the information shown below in the Project Close-Out Checklist Example. The Architect and/or Owner may incorporate additional specific items to the following checklist which shall become part of the project requirements.
 - b. Project Close-Out Checklist Example:

PROJECT CLOSE-OUT				
PROJECT:				
DIVISION NO.:				
CONTRACTOR:				
ITEM ¹	DATES			OWNER'S SIGN-OFF
	COMPLETED	RECEIVED BY OWNER		
Permits				
City and County Inspection				
Manufacturer's Warranties				
Contractor's Warranties				
State Fire Rating Data				
Copy of Final Shop Drawings				
List and Possession of Spare Parts				
Pressure Tests				
Equipment Tests Required by Specs				
Startup and Pre-Commissioning Forms				
Testing Adjustment and Balancing Report				
Manufacturer/Vendor Training of Owner's Personnel Required by Specs				
O & M Manuals				
Record Documents				
Coordination Drawings				
Sanitization Reports				
Commissioning Reports/Letters/Forms				
On Site Training Complete				
Protective Device Settings				
Valve Tags and Charts				
Final ATC Installation Drawings				
Insurance Underwriters Approvals				
Final Punch List (Initialed by contractor that items are complete)				
Building Certificate of Occupancy (CO)				
24 Hour Phone No. for Service During Guarantee Period				

END OF SECTION

¹ Provide separate line item for each specified item (do not group items)

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SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Certain requirements common to all the mechanical and electrical trades (Fire Suppression, Plumbing, HVAC, Electrical, and Tele/Data) are specified in Division 20. To avoid repetition, they are not repeated in each relevant Division of the Specifications. However, these requirements are applicable to the work of this Division, and are hereby incorporated by reference.
- B. 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. Equipment labels.
 - 2. Warning signs and labels.
 - 3. Pipe labels.
 - 4. Valve tags.
 - 5. Warning tags.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- D. Valve numbering scheme.
- E. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:

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. Brady Corporation.
 - b. Marking Services, Inc.
 - c. Seton Identification Products.
 2. Material and Thickness: Brass, 0.032-inch stainless steel, 0.025-inch aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 3. Letter Color: Black.
 4. Background Color: White .
 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
 7. Fasteners: Stainless-steel rivets or self-tapping screws.
 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Plastic Labels for Equipment:
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. Brady Corporation.
 - b. Marking Services, Inc.
 - c. Seton Identification Products.
 2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
 3. Letter Color: Black.
 4. Background Color: White.
 5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
 6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger

lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

8. Fasteners: Stainless-steel rivets or self-tapping screws.
 9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.
- D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

- 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. Brady Corporation.
 2. Marking Services Inc.
 3. Seton Identification Products.
- B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
- C. Letter Color: White.
- D. Background Color: Red.
- E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
- H. Fasteners: Stainless-steel rivets or self-tapping screws.
- I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- J. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

- 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. Brady Corporation.
 - 2. Marking Services Inc.
 - 3. Seton Identification Products.
- B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- C. Pretensioned Pipe Labels: Precoiled, semi-rigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: Size letters according to ASME A13.1 for piping At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

2.4 VALVE TAGS

- 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. Brady Corporation.
 - 2. Marking Services Inc.
 - 3. Seton Identification Products.
- B. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
 - 1. Tag Material: Brass, 0.032-inch or stainless steel, 0.025-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2. Fasteners: Brass wire-link chain or beaded chain or S-hook.
- C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 - 1. Valve-tag schedule shall be included in operation and maintenance data.

2.5 WARNING TAGS

- 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. Brady Corporation.
 - 2. Marking Services Inc.
 - 3. Seton Identification Products.
- B. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.
 - 1. Size: Approximately 4 by 7 inches.
 - 2. Fasteners: Reinforced grommet and wire or string.
 - 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 - 4. Color: Safety yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

- A. Piping Color Coding: Painting of piping is specified in Division 09.
- B. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 5. Near major equipment items and other points of origination and termination.
 6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
 8. Mains shall be labeled at points of entrance and exit from mechanical room, adjacent to each valve, on each riser, at each tee fitting, at points of entrance and exit from building, at least once in each room, and at intervals no longer than 20 feet.
- C. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

3.5 PIPE IDENTIFICATION

- A. Provide color-coded pipe identification markers on piping installed under this Section. Pipe markers shall be snap-on laminated plastic protected by clear acrylic coating. Pipe markers shall be applied after Architectural painting where such is required.
- B. Provide arrow marker with each pipe content marker to indicate direction of flow. If flow can be in either direction, use double-headed arrow marker.
- C. In general, 2 inch high legend shall be used for pipe lines 4 inch dia. and larger, and 3/4 inches high legend shall be used for pipe lines 3 inches dia. and smaller.
- D. Color banding shall meet ANSI latest and OSHA requirements.
- E. Markers shall have legends and color coding per the tables below:
- F. Markers are to be applied to all piping, regardless of under jacket colors per the following schedule:

SERVICE	CODE	MARKER LEGEND	LETTERING & BACKGROUND COLOR
Domestic Cold Water	DCW	Potable CW	White on Green
Domestic Hot Water	DHW	Potable HW	White on Green
Domestic Hot Water Return	DHWR	Potable HWR	White on Green
Domestic Hot Water 140 deg F	DHW-140	Potable HW 140 deg F	White on Green
Domestic Hot Water Return	DHWR-140	Potable HWR 140 deg F	White on Green
Main Water Service to Facility	W	City Water	White on Green
Non-Potable Water	NPCW	NPW	Black on Yellow
Trap Primer	TP	Trap Primer Supply	Black on Yellow
Gas (Natural) - low pressure	GGAS	Gas <u> </u> 14 inch WC	Black on Yellow
Gas (Natural) - intermediate pressures	GASG	Gas <u> </u> 2psig	Black on Yellow
Gas (Natural) - high pressure	G	Gas <u> </u> psig	Black on Yellow
Gas Vent	GV	Gas Vent	Black on Yellow
Indirect Waste	IW	Per Service	Black on Yellow
Rainwater	RW	Storm Drain	White on Green
Secondary Rainwater	RW	Storm Drain Overflow	White on Green
Sanitary Waste & Vent	SanAN	San, Waste, Vent	White on Black
Kitchen Waste	KW	Kitchen Waste	White on Black
Kitchen Vent	KV	Kitchen Vent	White on Black
Force Main (Sanitary Or Storm)	FM	FM "Per Service"	White on Black

CHART 2			
Basic Laboratory Plumbing Services			
SERVICE	CODE	MARKER LEGEND	BACKGROUND COLOR
Lab Cold Water	LCW	LCW	White on Green
Lab Hot Water	LHW	LHW	White on Green
Lab Hot Water Return	LHWR	LHWR	White on Green
Tempered Water	TW	Emergency Water	White on Green
Tempered Water Return	TWR	Emergency Water Return	White on Green
Compressed Air 100 psi Label each pressure service	CA-LA 100 psi	Lab Compressed Air 100	White on Blue
Carbon Dioxide	CO ₂	CO ₂	Black on Yellow
Nitrogen	N ₂	N ₂	White on Green
Vacuum (Laboratory)	V AGLV	V AGLV	Black on Yellow
Compressed Air Intake	CAI	CAI	White on Blue
Vacuum Exhaust	VE	VE	Black on Yellow
Force Main (Lab Waste)	LW-FM	Lab Force Main	Black on Yellow
Lab Vent	LV	Lab Vent	Black on Yellow
Lab Waste	LW	Lab Waste	Black on Yellow
RO Pretreatment Water	PTW	Before RO equipment	Black on Yellow
RO Water (S&R)	RO	RO	Black on Yellow
RODI TYPE II (S&R)	RODI-2 RODIR-2	RODI Supply RODI Return	Black on Yellow
RO Reject Water	Re	Re	White on Purple

CHART 3			
Extended Laboratory Plumbing Services			
SERVICE	CODE	MARKER LEGEND	BACKGROUND COLOR
Special Gas (Cylinder) 1 & 2 i.e. non flammable	SG1 SG2	Per the gas service i.e. "Argon, CO ₂ , O ₂ , N ₂ etc.	Black on Yellow
Special Gas (Cylinder) 1 & 2 Flammable or combination	SG1 SG2	Per the gas service i.e. "Ar-Me, etc. Combination Gases	Black on Orange
Special Gas (Cylinder) 1 & 2 Flammable	SG1 SG2	Per the gas service i.e. Hydrogen, Methane, etc.. the label is to indicate Flammable	White on Brown

- G. The Following Areas shall require all insulated piping to be protected along the entire pipe length with PVC **Color Coded** jacketed covers (Ceel-Co or Zeston plastic jacket):

1. Penthouse Mechanical Rooms
2. Plumbing Equipment Rooms
3. Mechanical Rooms
4. Main Pipe Corridor without ceilings
5. All Rainwater Leaders (horizontal) in areas without ceilings
6. Shipping Docks
- 6-7. **Other Areas as Required by Architect**
8. Color pattern and system identification legend shall be as ~~in the above~~ **per the below** schedule ~~for pipe code~~. **Where not shown in below schedule, color pattern and system identification shall be as per the above pipe code chart**

a.

PIPING SYSTEM	PIPE ABBREVIATION	PAINT COLOR (DEVOE)
Acid Waste	ACID	Safety Yellow (DC9400)
Domestic Cold Water	DCW	Medium Green (DC6650)
Non-Potable Cold Water	NPCW	Spruce (DC5323)
Protected (Lab) Cold Water	LCW	Light Green (DC5574)
Domestic Hot Water	DHW	Light Buff (DC1810)
Protected (Lab) Hot Water & Protected (Lab) Hot Water Return	LHW, LHWR	International Orange (DC6900)
Lab Vacuum	LV	Blue
Lab Waste	LW	Black (DC9903/9990)
Tempered Water	TW	Medium Brown (DC1400)
Domestic Hot Water Return	DHWR	Desert Sand (DC1046)
Lab Compressed Air	LA	Plymouth Grey (DC2100)
Nitrogen	N2	Light Grey (DC2973)
Sanitary Drain/Vent	SAN	Match Surrounding
Rainwater	Storm Drain	White on Green

7.

- 8-9. This plastic jacket shall include fitting covers and piping covers.
- 9-10. Piping to be covered with this plastic jacket shall be insulated and finished as herein specified and then the plastic jacket shall be applied.

- H. Furnish and install one coat of primer and two coats of finish paint to all interior gas piping installed per this contract.
 - 1. See Division 09 for paint types for interior piping.
 - 2. Painting shall begin at plumbing side of contract downstream of the utility company gas meter - see exterior painting below for piping exposed to weather.
 - 3. All gas piping shall be painted "Safety Yellow" per ANSI/ASME identification code 13.1.
 - 4. Painting shall include all gas vents from vent origin to termination.
 - 5. Include necessary paint finish touch-up where welding or jointing process has interfered with paint finish
 - 6. Install labels after paint has cured for a minimum of 5 days.
- I. Gas Piping Exposed to Weather or on Roof
 - 1. Furnish and install OSHA Safety Yellow to exterior and roof mounted gas piping commencing at a starting point one (1) foot below roof to gas pipe termination point on roof in the following manner:
 - a. Primer: Epoxy primer/sealer applied at a spreading rate recommended by the manufacturer (2 coats)
 - 1) Moore M36-00/M37 Polyamide Epoxy Clear Sealer Finish
 - 2) PPG 97-14XX Series Pitt Guard DTR Polyamide Epoxy Clear Sealer Finish
 - 3) S-W Heavy Duty Epoxy B67W300 Series
 - b. Intermediate Coat: Epoxy applied at a spreading rate recommended by the manufacturer of 3.0 to 8.0 mils
 - 1) DuPont 25P High Solids Epoxy Mastic
 - 2) S-W Heavy Duty Epoxy B67W300 Series
 - 3) Tnemec Series 66 Hi-Build Epoxoline Polyamidoamine Epoxy
 - c. Topcoat: Semi gloss aliphatic polyurethane enamel applied at a spreading rate recommended by the manufacturer to achieve a dry film thickness of 2.0 - 4.0 mils.
 - 1) Moore M73/M75 Aliphatic Acrylic Urethane Semi Gloss
 - 2) PPG 97-8XXX Series Pitthane High Build Acrylic Aliphatic Urethane
 - 3) S-W Corothane II Low VOC Satin Finish B65W200 Series

2. All finish gas piping shall be painted "Safety Yellow" per ANSI/ASME identification code 13.1.
3. Include necessary paint finish touch-up where welding or jointing process has interfered with paint finish
4. Install labels after paint has cured for a minimum of five (5) days.
5. Do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces or conditions detrimental to formation of a durable paint film. Provide finish coats that are compatible with primers used.

3.6 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
 1. Tags, Valves, Equipment and Instruments
 - a. Upon completion of work, attach engraved laminated plastic tags to all valves, and instrumentation. Equipment shall bear a stamped stainless tag. Tags shall have black characters on white face, consecutively numbered and prefixed with letter P for general valves. Tags shall bear the number used in the P&IDs for those items so marked.
 - b. Embossed or engraved aluminum or brass tags may be substituted if desired. Tags shall be at least 1/8 inch thick.
 - c. Tags shall be at least 1 inch diameter with numerals at least 3/8 inch high and attached by S hooks and chains.
 - d. Nameplates, catalog numbers and rating identifications shall be securely attached to electrical and mechanical equipment with screws or rivets. Adhesives or cements will not be permitted.
 - e. Non-potable water outlets shall be identified with permanently attached yellow color code or 4 inches high triangle tag reading, "water unsafe."
 - f. Coordinate numbering system with existing piping tags as not to duplicate numbers.
 2. Valve-Tag Size and Shape:
 - a. All Plumbing and Piping Services that are part of this contract 1-1/2 inches round.
 3. Valve-Tag Colors:
 - a. Comply with the same colors as indicated for Pipe Labels

4. Letter Colors:
 - a. White.

3.7 WARNING-TAG INSTALLATION

- A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION

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PIPING AND EQUIPMENT.DOC

SECTION 220719 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Certain requirements common to all the mechanical and electrical trades (Fire Suppression, Plumbing, HVAC, Electrical, and Tele/Data) are specified in Division 20. To avoid repetition, they are not repeated in each relevant Division of the Specifications. However, these requirements are applicable to the work of this Division, and are hereby incorporated by reference.
- B. 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 insulating the following plumbing piping services:
 - 1. Insulation materials
 - 2. Accessory materials
 - 3. Factory applied jackets
 - 4. Tapes
 - 5. Securements

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied, if any).
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail attachment and covering of heat tracing inside insulation.
 - 3. Detail insulation application at pipe expansion joints for each type of insulation.
 - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 5. Detail removable insulation at piping specialties, equipment connections, and access panels.
 - 6. Detail application of field-applied jackets.
 - 7. Detail application at linkages of control devices.

- C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:
 - 1. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
 - 2. Jacket Materials for Pipe: 12 inches long by NPS 2.
 - 3. Sheet Jacket Materials: 12 inches square.
 - 4. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- C. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.
- C. Comply with the following applicable standards and other requirements specified for miscellaneous components:
 - 1. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 22.

- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Type A: Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 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. Certain-Teed.
 - b. Johns Manville.
 - c. Owens Corning.
 - d. Pittsburgh Corning Corporation.
 - 2. Molded Fibrous Glass Pipe Insulation: Comply with ASTM C 547, Type 1, Grade A, and ASTM C 585, for sizes required and of a type suitable for installation on piping systems as required. One of the following types shall be used:

3. For indoor systems operating at temperatures from 0 deg F (-18 deg C) to +850 deg F (454 deg C):
 - a. Owens Corning™ Fiberglas™ Insulation with SSL II® Positive Closure System.
 4. For systems operating below ambient (32 deg F (0 deg C) to +65 deg F (18 deg C)) temperature:
 - a. Owens Corning™ VaporWick® Pipe Insulation. (see Plumbing Pipe Insulation – VaporWick® Pipe Insulation)
 5. Block Insulation: ASTM C 552, Type I.
 6. Special-Shaped Insulation: ASTM C 552, Type III.
 7. Preformed Pipe Insulation with Factory-Applied ASJ-SSL: Comply with ASTM C 552, Type II, Class 2.
 8. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
- G. Type B: Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.
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. Aeroflex USA, Inc.
 - b. Armacell LLC.
 - c. K-Flex USA.
 2. Flexible elastomeric in tubular foam. AC/Accoflex, AP/Armaflex, AP/Armaflex SS. This product meets the requirements as defined in ASTM C 534, Grade 1, Type I, "Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
 3. Materials shall have a flame spread index of less than 25 and a smoke developed index of less than 50 when tested in accordance with ASTM E 84, latest revision.
 4. Materials shall have a maximum thermal conductivity of 0.27 Btu-in./h-ft²- deg F at a 75 deg F mean temperature when tested in accordance with ASTM C 177 or ASTM C 518, latest revisions.
 5. Materials shall have a maximum water vapor transmission of 0.08 perm inches when tested in accordance with ASTM E 96, Procedure A, latest revision.
 6. Adhesive shall be the insulation manufacturer's recommended contact adhesive: Armaflex 520, Armaflex 520 BLV. B.
 7. Insulation finish shall be the insulation manufacturer's recommended finish: WB Armaflex Finish. C.
 8. Accessories such as adhesives, mastics and cements shall have the same properties as listed above and shall not detract from any of the system ratings as specified above.

H. Type C: Mineral-Fiber, Preformed Pipe Insulation:

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. Johns Manville; a Berkshire Hathaway company.
 - b. Knauf Insulation.
 - c. Manson Insulation Inc.
 - d. Owens Corning.
2. Perpendicular Oriented Mineral Fiber Insulation: ASTM C1393, Type IIIB, Category 2:
 - a. For piping equal to or larger than 10 in (250 mm) diameter operating at temperatures up to +850 deg F (454 deg C):
 - b. Owens Corning™ Fiberglas™ FLEXWRAP® Insulation.
3. Perpendicular Oriented Mineral Fiber Insulation: ASTM C1393, Type II, Category 1:
 - a. For piping equal to or larger than 10 in (250 mm) diameter operating at temperatures up to +650 deg F (343 deg C):
 - b. Owens Corning™ Fiberglas™ Pipe and Tank Insulation.
4. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

I. Type D: Hydrous Calcium Silicate

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. Johns Manville.
 - b. Industrial Insulation Group (IIG); Thermo-12 Gold.
2. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
3. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
4. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in pre-forming insulation to cover valves, elbows, tees, and flanges.
5. Preformed pipe insulation of rigid, ANSI/ASTM C533; rigid white; asbestos free; "k" value of 0.44 at 300 deg F. Trade name "Cal-Sil" for piping up to 1200 deg F. Johns Manville or equal.

6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
- J. Type E: Phenolic:
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. Kingspan Solar
 - b. Resolco International
 2. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
 3. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
 4. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
 5. Factory-Applied Jacket: None. Requirements are specified in "Factory-Applied Jackets" Article.
- K. Type F Underground Elastomeric
1. For Underground Installation basis of design is Armaflex Tuffcoat
 2. Used only for underslab trap primer piping where copper tube is used as pipe material
- L. Type G: Protective Shielding Pipe Covers,:
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. Engineered Brass Company.
 - b. Insul-Tect Products Co.
 - c. McGuire Manufacturing.
 - d. Plumberex Specialty Products, Inc.
 - e. Truebro.
 - f. Zurn Industries, LLC.
 2. Description: Manufactured plastic wraps for covering plumbing fixture hot-water supply hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.
- M. Type H: Exterior Underground Pre-Engineered Insulated
1. Application: hot or cold water from building to building buried underground
 2. Service limits 40 deg F (5 deg C) to 250 deg F (120 deg C) at 150 psig (1000 KPa)
 3. Completely factory-fabricated, insulated and jacketed copper piping system for the underground distribution. Pipe to be Type "K" copper tube insulated with

rigid, foamed-in-place, polyurethane foam that is encased and sealed in a rugged PVC jacket.

4. Insulation: Foamed-in-place closed-cell polyurethane foam that fills the annular space between the pipe and outer jacket
 - a. Thermal conductivity. Ninety percent closed cell structure provides high resistance to water absorption. Nominal density is 2 LB/FT³ , thermal conductivity ("K" factor) is 0.14 BTU in./ (HR) (sf) (deg F) at 73 deg F
5. PVC Outer Jacket: Type 1, Grade 1 Polyvinyl Chloride flexible vapor barrier to protect both the insulation and pipe. C-resistant and strong enough so the system can withstand H-20 loading with 2 feet of cover with 90 percent backfill compaction
6. Coupling: machined coupling containing two O-ring seals. When two lengths are joined in the coupling the O-rings are compressed to form a watertight connection and also provide separation of pipe ends for expansion and contraction. Expansion loops or expansion joints are not required whereas each coupling acts as an expansion joint, evenly distributing free expansion and contraction along the entire line.
7. End Seal: A latex coating is factory applied to both ends of the pipe insulation to ensure moisture protection at all couplings.
8. Basis of Design: Perma-Pipe/Ricwil Copper-Gard

2.2 ACCESSORY MATERIALS

- A. Accessories: Provide accessories per insulating system manufacturer's recommendations, including the following:
 1. Closure Materials: Butt strips, bands, wires, staples, mastics, adhesives, and pressure-sensitive tapes.
 - a. Mold resistant mastics are recommended for chilled water applications.
 2. Field-Applied Jacketing Materials: Sheet metal, plastic, canvas, fiberglass cloth, insulating cement, PVC fitting covers.
 3. Support Materials: Hanger straps, hanger rods, saddles, support rings, and high density inserts.
- B. Adhesives for Indoor Applications: VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.3 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 1. ASJ: White, Kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with Kraft-paper backing; complying with ASTM C 1136, Type II.

B. Jacket Types

TYPE	STYLE	MATERIALS
Type 1:	All Service Jacket	Vapor Barrier Jackets: Kraft reinforced foil vapor barrier with self-sealing adhesive joints. Jacket shall be heavy duty fire retardant material with glass fiber reinforcing and self-sealing lap. Jacket will be factory applied to the insulation. Jacket shall have neat, white Kraft finish or white vinyl suitable for painting, with bead puncture resistance of 50 units minimum. Vapor barrier shall be .001 inch aluminum foil adhered to the inner surface of the jacket. Permeance shall not exceed 0.02 perms. Jacket shall be Owens-Corning Fiberglass "ASJ-SSL" or Manville flamesafe "AP-T".
Type 2:	PVC Jackets:	Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket One piece, pre-molded type equal to Johns Manville Zeston 2000/300 Series PVC 20 or 30 mil jacketing and PVC fitting covers. All jackets shall follow manufacturers to comply with temperature of service piping. Jackets shall meet USDA compliance standard for all food handling
Type 3:	Color Coded PVC Jacket	Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket Same as type 2 above but color coded generally in rooms without ceilings. Color Jacket to be applied to all pipe, fittings and valves in the specified area in the schedule table below. See Division 20 for identification for specific colors, these colors are to be contiguous on the piping system in the areas scheduled.
Type 4:	Aluminum Jacket:	Aluminum roll stock ready for shop or field cutting. Comply with ASTM B 209/M 3003 alloy, H-14 temper. 0.016 inch thick smooth aluminum jacket with longitudinal ZEE style closures. Jacket shall be secured at both joints with 2 inch wide aluminum straps centered over butt joint of jacket. Provide 1/2 inch wide aluminum bands on 12 inch centers. Fitting covers shall be manufactured for purpose intended and shall be of same material. Acceptable for outdoor installation.
Type 7	Protective Shielding Piping Enclosures for barrier free trap and water piping under fixture	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: Truebro. Zurn Industries, LLC. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements. Furnish protective shielding to all Emergency Eyewash units where water waste and trap are exposed and are exclusively selected for Barrier Free Use.

2.4 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
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. Avery Dennison Corporation, Specialty Tapes Division.
 - b. Compac Corporation.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 - e. Venture Tape.
 2. Width: 3 inches.
 3. Thickness: 11.5 mils.
 4. Adhesion: 90 ounces force/inch in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
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. Avery Dennison Corporation, Specialty Tapes Division.
 - b. Compac Corporation.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 - e. Venture Tape.
 2. Width: 3 inches.
 3. Thickness: 6.5 mils.
 4. Adhesion: 90 ounces force/inch in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch in width.
 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

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. Compac Corporation.
 - b. Ideal Tape Co., Inc., an American Biltrite Company.
 - c. Venture Tape.
 2. Width: 2 inches.
 3. Thickness: 6 mils.
 4. Adhesion: 64 ounces force/inch in width.
 5. Elongation: 500 percent.
 6. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
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. Avery Dennison Corporation, Specialty Tapes Division.
 - b. Compac Corporation.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 - e. Venture Tape.
 2. Width: 2 inches.
 3. Thickness: 3.7 mils.
 4. Adhesion: 100 ounces force/inch in width.
 5. Elongation: 5 percent.
 6. Tensile Strength: 34 lbf/inch in width.

2.5 SECUREMENTS

A. Bands:

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. ITW Insulation Systems; Illinois Tool Works, Inc.
 - b. RPR Products, Inc.
2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch 3/4 inch wide with wing seal or closed seal.

3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.
- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- C. Wire: 0.062-inch soft-annealed, stainless steel.
 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. C & F Wire.

PART 3 - EXECUTION

3.1 PIPING INSULATION SCHEDULE

- A. General Summary Table - Referred Products
 1. Insulating Material

Type	Product	Common Reference Additional
A	Glass Fiber	Fiberglas
B	Flexible Elastomeric Insulation	Armaflex black or white closed cell
C	Mineral Fiber Pre-Formed	Preformed Minwool
D	Hydrous Calcium Silicate	Cal-Sil
E	Phenolic Foam	Solar
F	Buried copper trap primer piping	Armaflex Tuffcoat
G	Package	for Handicap Fixtures waste and water
H	Closed-Cell Polyurethane Foam	Package pre-insulated pipe and insulation - Ricwil

2. Jacket Material

Type	Product	Common Reference Additional
1	All Service Jacket	General White ASJ
2	Protective PVC Jacket	General White PVC
3	Color Coded Protective PVC Jacket	Match color code found in Division 22 for pipe identification
4	Aluminum Jacket	General outdoor
7	Plastic Preformed Barrier Free	For Handicap Fixtures

- B. Schedule

Piping System	Type	Thickness Inches	Jacket	Notes
Water Service Cold, Up To Meter - Water Supply	A C	1 1	Type 2	
All Cold Water Supply, potable and non-potable	A C	1/2	Type 1	Note 4 Note 5
All Hot Water Supply And Return less than 1-1/2 inches, potable and non-potable	A C	1 1	Type 2	Note 4 Note 5
All Hot Water Supply And Return greater than 1-1/2 inches , potable and non-potable	A C	1-1/2 1-1/2	Type 2	Note 4 Note 5
All Industrial cold or ambient Water Piping	A, B C	1/2	Type 1	Note 4 Note 5
All Industrial hot water 105 deg F to 140 deg F	A C	1	Type 1	Note 4 Note 5
Cold Water Supply In Kitchens	B	1/2	Type 2	Below Ceilings
Cold Water Supply In Kitchens	B	1/2	Type 1	Above Ceilings
Hot Water Supply And Return In Kitchens less than 1-1/2 inches	B	1	Type 2	Below Ceilings
Hot Water Supply And Return In Kitchens less than 1-1/2 inches	B	1	Type 1	Above Ceilings
Hot Water Supply And Return In Kitchens greater than 1-1/2 inches	B	1½	Type 2	Below Ceilings
Hot Water Supply And Return In Kitchens greater than 1-1/2 inches	B	1½	Type	Above Ceilings
Emergency Or Tempered Water System less than 1-1/2 inches	A C	1	Type 1	Type 2 When Routed Through Food Service Area Note 5
Emergency Or Tempered Water System greater than 1-1/4 inches	A C	1	Type 1	Type 2 When Routed Through Food Service Area Note 5
All Insulated Piping In Mechanical Rooms, and in Corridors Without Ceilings,	Per This Table	Per This Table	Type 3	Note 5
Roof Drains And Horizontal Rainwater, Including Overflow Drainage System	A C	1/2	Type 1	Note 3 Include Drain Bodies Note 5
Sanitary Force Main Piping	A, B or C	1/2	Type 1	From pump station to gravity trunk line connection

Piping System	Type	Thickness Inches	Jacket	Notes
Floor Drains, Traps, And Sanitary Drain Piping Within 10 Feet Of Drain Receiving Condensate And Equipment Drain Water Below 60 deg F	A B C	1/2	Type 1	Note 3
Hot Service Drains And Vents	A C	1-1/2 1	Type 1	Note 3 Note 5
Piping Exposed To Freezing (Water) less than 2 inch	A C	2	Type 5	
Piping Exposed To Freezing (Water) greater than 2 inch	A C	3	Type 5	See note 2
Piping Exposed To Freezing (Sanitary)	A C	2	Type 5	See note 2
Trap Primer Piping Buried Underslab	F	1/2	none	Armacell Tuffcoat Spec for Interior only
Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, And Stops For Plumbing Fixtures For People With Disabilities	G	1/2	Type 7	Package System Only Includes EW&S Where Designated For Barrier Free Use.
All Kitchen Heat Traced Grease Waste. All Heat Traced Sanitary	A	2	Type 2	Note 5
Supplemental Notes				
<p>Note 1: Two layers of 1 inch with staggered joints. Provide stainless steel 1/2 inch steel bands, 12 inches on center, apply 1 foot hexagonal mesh over insulation and 1/2 inch thick coat of insulating cement troweled smooth. Apply glass cloth jacket and size with one brush coat of lagging adhesive.</p> <p>Note 2: The electrical contractor will furnish and install heat trace tape, prior to insulation installation. Raychem self-regulating Winter Guard Plus 8 watts per foot with failure alarm</p> <p>Note 3: Insulation shall include drain sump body and all horizontal piping to, and including the elbow down to vertical.</p> <p>Note 4: Unless noted otherwise this section pertains to ALL piping in a specified system, including in-chase or in-shaft piping.</p> <p>Note 5: see spec section 220553 subsection 3.5 H where it is stipulated the Areas that require all insulated piping to be protected along the entire pipe length with PVC Color Coded jacketed covers (Ceel-Co oZeston plastic jacket), this applies to exposed piping. If the piping is located above a ceiling, then use white PVC jackets and labels</p>				

3.2 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.3 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that applies to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use de-mineralized water.

3.4 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches OC.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches OC.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above-ambient services, do not install insulation to the following:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.

4. Cleanouts.

3.5 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
 1. Comply with requirements in Division 07 for firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
 1. Pipe: Install insulation continuously through floor penetrations.
 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07.

3.6 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
 3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
 5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.7 INSTALLATION OF CELLULAR-GLASS INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward clinched staples at 6 inches OC.
 4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
- B. Insulation Installation on Pipe Flanges:
1. Install preformed pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.

4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.8 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A. Seal longitudinal seams and end joints with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.9 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward clinched staples at 6 inches OC.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.10 INSTALLATION OF POLYOLEFIN INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:
 - 1. Seal split-tube longitudinal seams and end joints with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Flanges:
 - 1. Install pipe insulation to outer diameter of pipe flange.
 - 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
 - 4. Secure insulation to flanges and seal seams with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Pipe Fittings and Elbows:
 - 1. Install mitered sections of polyolefin pipe insulation.
 - 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Insulation Installation on Valves and Pipe Specialties:
 - 1. Install cut sections of polyolefin pipe and sheet insulation to valve body.
 - 2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - 3. Install insulation to flanges as specified for flange insulation application.
 - 4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.11 FIELD-APPLIED JACKET INSTALLATION

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
 - 1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
 - 2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
 - 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- B. Where FSK jackets are indicated, install as follows:
 - 1. Draw jacket material smooth and tight.
 - 2. Install lap or joint strips with same material as jacket.

3. Secure jacket to insulation with manufacturer's recommended adhesive.
 4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturers recommended adhesive.
1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches OC. and at end joints.

3.12 FINISHES

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09.
1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
1. **Where paint colors are not specified by architect, the piping shall be painted according to the below schedule**

PIPING SYSTEM	PIPE ABBREVIATION	PAINT COLOR (DEVOE)
Acid Waste	ACID	Safety Yellow (DC9400)
Domestic Cold Water	DCW	Medium Green (DC6650)
Non-Potable Cold Water	NPCW	Spruce (DC5323)
Protected (Lab) Cold Water	LCW	Light Green (DC5574)
Domestic Hot Water	DHW	Light Buff (DC1810)
Protected (Lab) Hot Water & Protected (Lab) Hot Water Return	LHW, LHWR	International Orange (DC6900)
Lab Vacuum	LV	Blue
Lab Waste	LW	Black (DC9903/9990)
Tempered Water	TW	Medium Brown (DC1400)
Domestic Hot Water Return	DHWR	Desert Sand (DC1046)
Lab Compressed Air	LA	Plymouth Grey (DC2100)
Nitrogen	N2	Light Grey (DC2973)
Sanitary Drain/Vent	SAN	Match Surrounding
Rainwater	Storm Drain	White on Green

G.

- D. Do not field paint aluminum or stainless-steel jackets.

3.13 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

- B. Perform tests and inspections.

- C. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

- D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.14 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - 1. Drainage piping located in crawl spaces.
 - 2. Underground piping.
 - 3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.15 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed:
 - 1. None.
 - 2. PVC, Color-Coded by System: 30 mils thick.
 - 3. Stainless Steel, Type 304 Smooth 2B Finish: 0.010 inch 0.016 inch thick.
- D. Piping, Exposed:
 - 1. PVC: 30 mils thick.
 - 2. Stainless Steel, Type 304, Smooth 2B Finish with Z-Shaped Locking Seam: 0.020 inch thick.

3.16 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

- A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION

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SECTION 230553 - IDENTIFICATION FOR HVAC PIPING, DUCT AND EQUIPMENT

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. Equipment labels.
 - 2. Pipe labels.
 - 3. Duct stencils.
 - 4. Valve tags.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- D. Valve numbering scheme.
- E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:
 - 1. Material and Thickness: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.

2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel rivets or self-tapping screws.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black.
3. Background Color: White.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

1. Fans shall be stenciled with "EXHAUST" or "SUPPLY" and indicate the area(s) served as indicated on the equipment schedules on the drawings.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

2.3 DUCT STENCILS

PRODUCT DATA SHEET 1 - Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/2 inches for ducts; and minimum letter height of 3/4 inch for access panel and door labels.

1. Stencil Material: Fiberboard or metal.
 2. Stencil Paint: Exterior, gloss, acrylic enamel Paint may be in pressurized spray-can form.
 - a. Color: Black
- B. Contents: Include identification of duct service using designations as follows, duct size, and an arrow indicating flow direction.
1. Duct service designations, coordinate with the drawings for service designations that may not be listed below:
 - a. SUPPLY AIR
 - b. RETURN AIR
 - c. OUTDOOR AIR
 - d. LAB EXHAUST AIR
 - e. RELIEF AIR
 - f. TOILET EXHAUST AIR
 - g. KITCHEN EXHAUST AIR
 2. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.

2.2 VALVE TAGS

- A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 2. Fasteners: Brass wire-link or beaded chain; or S-hook.
- B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

- A. Piping Color-Coding: Painting of piping is specified in Division 09 "Interior Painting"
- B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

- C. Pipe Label Color Schedule: **The colors identified below reference Devoe Paint colors for identification and color match.**

1. Chilled-Water Piping:
 - a. Background Color: ~~Green~~**Safety Blue (DC 9800).**
 - b. Letter Color: White.
2. Heating **Hot** Water Piping:
 - a. Background Color: ~~Yellow~~**Oxide Yellow (DC 8800).**
 - b. Letter Color: Black.
3. ~~Steam and steam condensate~~**Humidifier Supply Water** Piping:

- a. Background Color: ~~Yellow~~**Spruce (DC 5323)**.
- b. Letter Color: Black.

3.4 DUCT STENCIL INSTALLATION

- A. Apply duct stencils on air ducts both level and plumb.
- B. Locate stencils near points where ducts enter into concealed spaces, at changes in direction and at maximum intervals of 25 feet of continuous strait run in each space where ducts are exposed or concealed by removable ceiling system.

3.5 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
 1. Valve-Tag Size and Shape:
 - a. Chilled Water: 1-1/2 inches, round.
 - b. Hot Water: 1-1/2 inches, round.
 - c. Steam and Steam Condensate: 1-1/2 inches, round.
 2. Valve-Tag Color: **The colors identified below reference Devoe Paint colors for identification and color match.**
 - a. Chilled Water: **Safety Blue (DC 9800)**~~Green~~.
 - b. **Heating** Hot Water: **Oxide Yellow (DC 8800)**~~Yellow~~.
 - c. **Humidifier Supply Water**~~Steam and Steam Condensate~~: **Spruce (DC 5323)**~~Yellow~~.
 3. Letter Color:
 - a. Chilled Water: White.
 - b. Hot Water: Black.
 - c. Steam and Steam Condensate: Black.

END OF SECTION

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SECTION 230700 - HVAC INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Certain requirements common to all the mechanical and electrical trades (Fire Suppression, Plumbing, HVAC, Electrical, and Tele/Data) are specified in Division 20. To avoid repetition, they are not repeated in each relevant Division of the Specifications. However, these requirements are applicable to the work of this Division, and are hereby incorporated by reference.
- B. 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 insulating the following duct services:
 - 1. Cooling Only Supply Ducts – Climate Zones 0, 1, 2, 3, 4, 5 and 6
 - 2. Combined Heating and Cooling Ducts – Climate Zones 1, 2, 3 and 4
 - 3. Unconditioned Outside Air Intake Ducts/Plena and Exhaust Relief Duct and Plena Inside the Building Envelope – Climate Zones 2 through 8
 - 4. Unconditioned Outside Air Intake Ducts/Plena and Exhaust/Relief Duct and Plena Outside the Building Envelope – Climate Zones 2 through 8
 - 5. Oven, Dishwash, Warewash and Shower Exhaust Ducts – Climate Zones 0 through 8
 - 6. Concealed, Type 1 (Grease), Commercial, Kitchen Hood Exhaust Duct and Plena – Climate Zones 0 through 8
 - 7. Indoor Concealed and Exposed Ducts Identified as Requiring Fire-Rated Insulation – Climate Zones 0 through 8.
- B. Section includes insulation for breeching, flues and connectors.
- C. Section includes insulating the following HVAC equipment that is not factory insulated:
 - 1. Cooling Coil and Humidifier Drain Pans
 - 2. Cooling System heat exchangers
 - 3. Heating Hot Water heat exchangers
 - 4. Steam Equipment
- D. Section includes insulating the following HVAC piping systems
 - 1. Steam/Steam Condensate Return: 0 psig to 15 psig/201 deg F to 250 deg F
 - 2. Steam Pressure Relief: All Pressures/Temperatures

3. Supply and return piping in Heating Hot Water Systems with a supply temperature in the range of 141 deg F to 200 deg F
4. Supply and return piping in Heating Hot Water Systems with a supply temperature in the range of 85 deg F to 140 deg F
5. Supply and return piping in Cooling Systems with a supply temperature in the range of 40 deg F to 65 deg F
6. Cooling Coil Condensate Piping and Equipment Drain Piping
- E. Section includes insulation for Outdoor, Underground Piping (excluding loose fill insulated piping).
- F. Related Sections:
- G. Referenced Standards:
 1. ASTM International (ASTM)
 2. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE).
 3. North American Insulation Manufacturers Association (NAIMA).

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance, thickness, and jackets (both factory- and field-applied if any).
- B. Sustainable Design Submittals
 1. Adhesives:
 - a. Product Data for adhesives indicating VOC content.
 - b. Laboratory Test Reports for: For adhesives, indicating compliance with requirements for low-emitting materials.
 2. Coatings
 - a. Product Data for coatings indicating VOC content.
 - b. Laboratory Test Reports: For coatings, indicating compliance with requirements for low-emitting materials.
 3. Sealants
 - a. Product Data for sealants indicating VOC content.
 - b. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.
- C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 1. Detail application of field-applied jackets.
 2. Detail application at linkages of control devices.
 3. Detail application of protective duct shields, saddles, and inserts at hangers for each type of insulation and hanger.

4. Detail insulation application at duct elbows, fittings, dampers, specialties and flanges for each type of insulation.
5. Detail attachment and covering of equipment heat tracing inside insulation.
6. Detail removable insulation at equipment connections.
7. Detail field application for each equipment type.
8. Detail application of protective piping shields, saddles, and inserts at hangers for each type of insulation and hanger.
9. Detail attachment and covering of piping heat tracing inside insulation.
10. Detail insulation application at pipe expansion joints for each type of insulation.
11. Detail insulation application at pipe elbows, fittings, flanges, valves, and specialties for each type of insulation.
12. Detail removable insulation at piping specialties.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- C. Coordination Documentation: Written documentation indicating specific sheetmetal and hanger requirements from fire-rated duct insulation system UL Listing.
- D. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 23.
- B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate clearance requirements with equipment Installer for equipment insulation application. Coordinate installation and testing of equipment heat tracing.
- D. Coordinate clearance requirements with piping Installer for piping insulation application. Coordinate installation and testing of piping heat tracing.

1.8 SCHEDULING

- A. Schedule insulation application after pressure and leak testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in Part 3 articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials and Type I for tubular materials. For indoor applications insulation meet ASTM E84 Flame Spread and Smoke Developed ratings of 25/50 for thickness required. For duct applications, color shall be selected by the architect from manufacturer standard color options.

1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Aeroflex USA, Inc.; Aerocel.
 - b. Armacell LLC; AP Armaflex and Armaflex FS.
 - c. K-Flex USA; Insul-Sheet and Insul-Tube.
- G. Mineral-Fiber (Fiberglass) Blanket Duct Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I for insulation without jackets, Type II with factory-applied vinyl jacket, Type III with factory-applied FSK jacket or Type III with factory-applied FSP jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed Corp.; SoftTouch Duct Wrap.
 - b. Johns Manville; Microlite.
 - c. Knauf Insulation; Atmosphere Duct Wrap with ECOSE Technology.
 - d. Manson Insulation Inc.; Alley Wrap.
 - e. Owens Corning; SOFTR All-Service Duct Wrap.
- H. Rigid Mineral-Fiber (Fiberglass) Board Duct Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB.
 1. For duct and plenum applications in mechanical rooms and concealed locations, provide insulation with factory-applied FSK jacket.
 2. For duct and plenum applications exposed in occupied spaces, provide insulation with paintable factory-applied ASJ jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 3. Provide insulation with factory-applied ASJ for equipment. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 4. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed Corp.; Commercial Board.
 - b. Fibrex Insulations Inc.; FBX.
 - c. Johns Manville; 800 Series Spin-Glas.
 - d. Knauf Insulation; Earthwool Insulation Board with ECOSE Technology
 - e. Manson Insulation Inc.; AK Board.
 - f. Owens Corning; Fiberglas 700 Series.
- I. Mineral-Fiber (Fiberglass), Preformed Pipe Insulation

1. Type I, 850 deg F (454 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory and field installed jackets identified in pipe insulation schedules.
 2. Type II, 1200 deg F (649 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, with factory and field installed jackets identified in pipe insulation schedules.
 3. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. Knauf Insulation.
 - c. Manson Insulation Inc.
 - d. Owens Corning.
- J. Semi-Rigid Mineral-Fiber (Fiberglass) Insulation
1. Duct Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semi-rigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Minimum nominal density is 2.5 lb/cu. ft.. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 2. Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semi-rigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Minimum nominal density is 2.5 lb/cu. ft.. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 3. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed Corp.; CrimpWrap.
 - b. Johns Manville; MicroFlex.
 - c. Knauf Insulation; Earthwool Pipe & Tank Insulation with ECOSE Technology.
 - d. Knauf Insulation: Kwik-Flex Pipe & Tank Insulation.
 - e. Manson Insulation Inc.; AK Flex.
 - f. Owens Corning; Fiberglas Pipe and Tank Insulation.
- K. Fire-Rated Insulation Systems
1. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F. Comply with ASTM C 656, Type II, Grade 6. Tested and certified to provide a 1 or 2-hour

fire rating to match penetrated assembly rating by an NRTL acceptable to authorities having jurisdiction.

- a. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Johns Manville; Super Firetemp M.
2. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 1 or 2-hour fire rating to match penetrated assembly rating by an NRTL acceptable to authorities having jurisdiction.
 - a. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) CertainTeed Corp.; FlameChek.
 - 2) Johns Manville; Firetemp Wrap.
 - 3) Nelson Fire Stop Products; Nelson FSB Flameshield Blanket.
 - 4) Thermal Ceramics; FireMaster Duct Wrap.
 - 5) 3M; Fire Barrier Wrap Products.
 - 6) Unifrax Corporation; FyreWrap.

2.2 INSULATING CEMENTS

- A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
 1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Ramco Insulation, Inc.; Super-Stik.
- B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.
 1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Ramco Insulation, Inc.; Thermokote V.
- C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.
 1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
1. Adhesives shall have a VOC content of 250 g/L or less or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 2. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, 9 mcg/cu. m or 7 ppb, whichever is less, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
- B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Aeroflex USA, Inc.; Aeroseal Low VOC.
 - b. Armacell LLC; Armaflex 520BLV Adhesive.
 - c. K-Flex USA; 720-LVOC Contact Adhesive.
 - d. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
- D. ASJ, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
 - d. Mon-Eco Industries, Inc.; 22-25.

- E. PVC Jacket Adhesive: Compatible with PVC jacket.
 - 1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Dow Corning Corporation; 739, Dow Silicone.
 - b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
 - c. P.I.C. Plastics, Inc.; Welding Adhesive.
 - d. Speedline Corporation; Polyco VP Adhesive.
 - 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- F. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-97.
 - b. Eagle Bridges - Marathon Industries; 290.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-27.
 - d. Mon-Eco Industries, Inc.; 22-30.
 - e. Vimasco Corporation; 760.
- G. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.
 - 1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-84.

2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 1. VOC Content: 300 g/L or less.
 - 2. Low-Emitting Materials: Mastic coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method

for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers.” The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, 9 mcg/cu. m or 7 ppb, whichever is less, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.
 - 1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
 - b. Vimasco Corporation; 749.
 - 2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
 - 3. Service Temperature Range: Minus 20 to plus 180 deg F.
 - 4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
 - 5. Color: White.
- C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
 - 1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
 - b. Eagle Bridges - Marathon Industries; 570.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.
 - 2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
 - 3. Service Temperature Range: Minus 50 to plus 220 deg F.
 - 4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
 - 5. Color: White.
- D. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
 - 1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
 - b. Eagle Bridges - Marathon Industries; 550.

- c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
 - d. Mon-Eco Industries, Inc.; 55-50.
 - e. Vimasco Corporation; WC-1/WC-5.
2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
 3. Service Temperature Range: Minus 20 to plus 180 deg F.
 4. Solids Content: 60 percent by volume and 66 percent by weight.
 5. Color: White.

2.5 LAGGING ADHESIVES

- A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
 1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
 - b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
 - c. Vimasco Corporation; 713 and 714.
 2. Adhesives shall have a VOC content of 250 g/L or less.
 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, 9 mcg/cu. m or 7 ppb, whichever is less, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
 4. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
 5. Service Temperature Range: 0 to plus 180 deg F.
 6. Color: White.

2.6 SEALANTS

- A. FSK and Metal Jacket Flashing Sealants:
 1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

- b. Eagle Bridges - Marathon Industries; 405.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
 - d. Mon-Eco Industries, Inc.; 44-05.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
 3. Fire- and water-resistant, flexible, elastomeric sealant.
 4. Service Temperature Range: Minus 40 to plus 250 deg F.
 5. Color: Aluminum.
 6. Sealant shall have a VOC content of 420 g/L or less.
 7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, 9 mcg/cu. m or 7 ppb, whichever is less, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
- B. ASJ Flashing Sealants and PVC Flashing Sealants:
1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
 2. Materials shall be compatible with insulation materials, jackets, and substrates.
 3. Fire- and water-resistant, flexible, elastomeric sealant.
 4. Service Temperature Range: Minus 40 to plus 250 deg F.
 5. Color: White.
- C. Joint Sealants:
1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
 - b. Marathon Industries; 405.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
 - d. Mon-Eco Industries, Inc.; 44-05.
 - e. Pittsburgh Corning Corporation; Pittseal 444.

2.7 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I. Permeance of jacket shall not exceed 0.02 perm.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I. Permeance of jacket shall not exceed 0.02 perm.
 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II. Permeance of jacket shall not exceed 0.02 perm.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering ducts.
1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Chil-Glas No. 5.
- B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for ducts.
1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Mast-A-Fab.
 - b. Vimasco Corporation; Elastafab 894.

2.9 FIELD-APPLIED CLOTHS

- A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..
1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

2.10 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
 - 1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
 - 2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
 - 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- C. Where FSK jackets are indicated, install as follows:
 - 1. Draw jacket material smooth and tight.
 - 2. Install lap or joint strips with same material as jacket.
 - 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 - 4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
 - 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- D. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer recommended adhesive.
 - 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- E. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches OC and at end joints.
- F. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- G. PVC Jacket: 30 Mil, High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 - 1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Johns Manville; Zeston.
 - b. P.I.C. Plastics, Inc.; FG Series.
 - c. Proto Corporation; LoSmoke.
 - d. Speedline Corporation; SmokeSafe.
 - 2. Adhesive: As recommended by jacket material manufacturer.
 - 3. Color: White.
 - 4. Factory-fabricated tank heads and tank side panels.

H. Metal Jacket:

1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
 - b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
 - c. RPR Products, Inc.; Insul-Mate.
2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Factory cut and rolled to size.
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
 - d. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

I. Underground Direct-Buried Piping Jacket: 125-mil- (3.2-mm-) thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Pittsburgh Corning Corporation; Pittwrap.
 - b. Polyguard Products, Inc.; Insulrap No Torch 125.

J. Self-Adhesive Outdoor Jacket: Minimum 12 mil thick, vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; UV resistant, zero permeability with white aluminum-foil facing, impact and tear resistant.

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

- a. Polyguard Products, Inc.; Alumaguard 60.
 - b. Venture Tape Corporation; VentureClad Plus.
2. Subject to compliance with requirements for thickness, UV resistance, tear resistance and permeability, flexible elastomeric insulation manufacturer cladding may be used for outdoor insulation in lieu of field installed jacketing.

2.11 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 428 AWF ASJ.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
 - c. Compac Corporation; 104 and 105.
 - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
 - e. Knauf Insulation; EXPERT Tapes: ASJ+ Tape OR ASJ Tape.
 2. Width: minimum 3 inches.
 3. Thickness: minimum 11.5 mils.
 4. Adhesion: 90 ounces force/inch in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 491 AWF FSK.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
 - c. Compac Corporation; 110 and 111.
 - d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
 - e. Knauf Insulation; EXPERT Tapes: FSK Tape.
 2. Width: minimum 3 inches.
 3. Thickness: minimum 6.5 mils.
 4. Adhesion: 90 ounces force/inch in width.
 5. Elongation: 2 percent.

6. Tensile Strength: 40 lbf/inch in width.
 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 370 White PVC tape.
 - b. Compac Corporation; 130.
 - c. Venture Tape; 1506 CW NS.
 2. Width: 2 inches.
 3. Thickness: 6 mils.
 4. Adhesion: 64 ounces force/inch in width.
 5. Elongation: 500 percent.
 6. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 488 AWF.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
 - c. Compac Corporation; 120.
 - d. Venture Tape; 3520 CW.
 - e. Knauf Insulation; EXPERT Tapes: 2 MIL Foil Tape.
 2. Width: minimum 2 inches.
 3. Thickness: minimum 3.7 mils.
 4. Adhesion: 100 ounces force/inch in width.
 5. Elongation: 5 percent.
 6. Tensile Strength: 34 lbf/inch in width.

2.12 JACKETS AND TAPES FOR INTERIOR USE COLOR CODING

- A. Jackets and tapes shall be color coded in accord with the list below. Colors shall be submitted to the architect for approval. Jackets and tapes may be provided by the manufacturers in the required colors or painted in the field to match the required colors. PVC jackets and tapes shall not be painted in the field, only factory coloring shall be acceptable.**

- B. Metal jackets, underground and outdoor jackets are not required to be color coded.**
- C. Where a specific color is required, a Devoe Paint identification number is shown in the color codes below. This information is for reference and color match only, it is not required that only this paint manufacturer be used or that the jackets be field painted instead of factory coded.**
 - 1. Ductwork: White**
 - 2. Chilled Water: Safety Blue (Devoe DC 9800)**
 - 3. Hot Water (heating): Oxide Yellow (Devoe DC 8800)**
 - 4. Relief valve/air vent piping: Orange**
 - 6-5. Humidifier supply water: Spruce (5323)**

~~2.122.13~~ SECUREMENTS

- A. Bands:
 - 1. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ITW Insulation Systems; Gerrard Strapping and Seals.
 - b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
 - c. Wing seals are primarily used for fastening bands together. Closed seals are occasionally used for large, 84-inch- diameter applications and where fastening bands are used with springs. Wing seals are reusable; closed seals are not.
 - 2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 1/2 inch wide with wing seal.
 - 3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 1/2 inch wide with wing seal.
 - 4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
- B. Insulation Pins and Hangers:
 - 1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- or **0.135-inch-** diameter shank, length to suit depth of insulation indicated.
 - a. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) AGM Industries, Inc.; CWP-1.
 - 2) GEMCO; CD.
 - 3) Midwest Fasteners, Inc.; CD.

- 4) Nelson Stud Welding; TPA, TPC, and TPS.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- or 0.135-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 - a. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) AGM Industries, Inc.; CHP-1.
 - 2) GEMCO; Cupped Head Weld Pin.
 - 3) Midwest Fasteners, Inc.; Cupped Head.
 - 4) Nelson Stud Welding; CHP.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, and securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.
 - 2) GEMCO; Perforated Base.
 - 3) Midwest Fasteners, Inc.; Spindle.
 - b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - c. Spindle: Copper- or zinc-coated, low-carbon steel, or Aluminum, or Stainless steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, and securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) GEMCO; Nylon Hangers.
 - 2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.

- b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
 - c. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, and securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Available Manufacturers: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) AGM Industries, Inc.; Tactoo Self-Adhering Insul-Hangers.
 - 2) GEMCO; Peel and Press.
 - 3) Midwest Fasteners, Inc.; Self Stick.
 - b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - c. Spindle: Copper- or zinc-coated, low-carbon steel, or Aluminum, or Stainless steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
 - d. Adhesive-backed base with a peel-off protective cover.
6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel, or aluminum, or stainless-steel sheet matching hanger materials, with beveled edge sized to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - a. Available Manufacturers: Subject to compliance with requirements,:
 - 1) AGM Industries, Inc.; RC-150.
 - 2) GEMCO; R-150.
 - 3) Midwest Fasteners, Inc.; WA-150.
 - 4) Nelson Stud Welding; Speed Clips.
 - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - a. Available 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) GEMCO.
 - 2) Midwest Fasteners, Inc.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- D. Wire: 0.062-inch soft-annealed, stainless steel.
1. Available 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. C and F Wire.

~~2.132.14~~ 2.132.14 CORNER ANGLES

- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.
- C. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 1. Verify that systems and equipment to be insulated have been tested and are free of defects.
 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Duct Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application including dirt, scale, oil, rust and other foreign matter.
- B. Equipment Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- C. Piping Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- D. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

- E. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Protect insulation from exposure to moisture prior to and after installation. All insulation other than flexible elastomeric that becomes wet shall be replaced at no cost to the project.
- B. Install insulation after systems have been tested, proved tight. Remove dirt, scale, oil, rust and other foreign matter prior to installation of insulation.
- C. Install insulation, mastics, adhesives, coatings, covers, weather-protection and other work in accordance with manufacturer's recommendations. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic. Leakage in vapor barrier or voids in insulation will not be accepted.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied non-self-sealing jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches OC

3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at manufacturer recommended spacing but space no further than 4 inches OC
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
- L. Install insulation with self-sealing factory-applied jackets as follows:
1. Locate all longitudinal pipe insulation jacketing laps in least visible location.
 2. Draw jacket tight and smooth.
 3. For proper sealing, seal lap joints with reasonable pressure being applied with a plastic squeegee or sealing tool.
 4. Vapor seal all circumferential joints with factory furnished matching pressure sensitive butt strips installed with reasonable pressure being applied with a plastic squeegee or sealing tool.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. Insulate flex connections to same thickness as material as adjoining system
- Q. Duct Insulation Requirements:
1. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
 2. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
 3. Insulate standing seams with same material and thickness as duct.
 4. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
 5. Insulate flex connections to same thickness as material as adjoining ductwork.
- R. Equipment Insulation Requirements:
1. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.
 2. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment as specified in insulation system schedules.
 3. For above ambient services, do not install insulation to the following:

- a. Vibration-control devices.
- b. Testing agency labels and stamps.
- c. Nameplates and data plates.
- d. Manholes.
- e. Handholes.
- f. Cleanouts.

S. Piping Insulation Requirements:

1. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
2. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
3. For piping systems operating below 60 deg F, seal ends of pipe insulation onto the jacket and seal insulation onto the pipe with approved fire retardant vapor barrier mastic, at flanges, valves and fittings and at intervals of no more than every fourth section of pre-formed insulation or 20 feet on continuous runs of piping whichever is less.
4. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
5. Insulate flex connections to same thickness as material as adjoining piping.
6. For above ambient services, do not install insulation to the following:
 - a. Vibration-control devices.
 - b. Testing agency labels and stamps.
 - c. Nameplates and data plates.
 - d. Manholes.
 - e. Handholes.
 - f. Cleanouts.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.

4. Seal jacket to roof flashing with flashing sealant.
 - B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
 - C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 4. Seal jacket to wall flashing with flashing sealant.
 - D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire-Rated): Install insulation continuously through walls and partitions.
 - E. Ductwork Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
 1. Comply with requirements in Division 07 for firestopping and fire-resistive joint sealers.
 - F. Duct Insulation Installation at Floor Penetrations:
 1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07.
 - G. Piping Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
 1. Comply with requirements in Division 07 for firestopping and fire-resistive joint sealers.
 - H. Piping Insulation Installation at Floor Penetrations:
 1. Pipe: Install insulation continuously through floor penetrations.
 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07.
- 3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION
- A. Seal longitudinal seams and end joints with manufacturer recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

- B. Insulation Installation on Pipe Flanges:
 - 1. Install pipe insulation to outer diameter of pipe flange.
 - 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
 - 4. Secure insulation to flanges and seal seams with manufacturer recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Pipe Fittings and Elbows:
 - 1. Install mitered sections of pipe insulation.
 - 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Insulation Installation on Valves and Pipe Specialties:
 - 1. Install preformed valve covers manufactured of same material as pipe insulation when available.
 - 2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - 3. Install insulation to flanges as specified for flange insulation application.
- E. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.6 INSTALLATION OF MINERAL-FIBER INSULATION

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
 - 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area recommended by the insulation manufacturer but no less than for 50 percent coverage of duct and plenum surfaces.
 - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 - 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches OC

- b. On duct sides with dimensions larger than 18 inches, place pins 16 inches OC each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not over compress insulation during installation. Maximum allowable compressions shall be as recommended by the insulation manufacturer.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch OC. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 20-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
 5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches OC.
 6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches OC.
- B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area recommended by the insulation manufacturer but no less than for 50 percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

- a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches OC.
 - b. On duct sides with dimensions larger than 18 inches, space pins 16 inches OC each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not over-compress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch OC. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
 5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches OC
- C. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 3. For insulation with factory-applied jackets on above-ambient surfaces, secure using the self-seal system per manufacturer's recommendations or for non-self-seal systems, secure laps with outward-clinched staples at 6 inches OC
 4. For insulation with factory-applied jackets on below-ambient surfaces, secure using the self-seal systems per manufacturer's recommendations, or for non-self-

seal systems, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

D. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

E. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

F. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.

5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- C. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer recommended adhesive.
 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
 - D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches OC and at end joints.
- 3.8 FIRE-RATED INSULATION SYSTEM INSTALLATION
- A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
 - B. Install fire rated insulation systems in accordance with the manufacturer's instructions.
 - C. Insulate duct access panels and doors to achieve same fire rating as duct.
 - D. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Division 07.
- 3.9 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION
- A. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area recommended by the insulation manufacturer but no less than for 50 percent coverage of tank and vessel surfaces.
 2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
 3. Protect exposed corners with secured corner angles.
 4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
 - a. Do not weld anchor pins to ASME-labeled pressure vessels.
 - b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
 - c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches OC in both directions.
 - d. Do not over-compress insulation during installation.
 - e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.

- f. Impale insulation over anchor pins and attach speed washers.
 - g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
 6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch pre-stressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches OC. Install a wire ring around each end and around outer periphery of center openings, and stretch pre-stressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches OC. Use this network for securing insulation with tie wire or bands.
 7. Stagger joints between insulation layers at least 3 inches.
 8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
 9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
 10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.
- B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
1. Apply manufacturer recommended coverage of adhesive but no less than 50% to surface with manufacturer's recommended adhesive.
 2. Seal longitudinal seams and end joints.
- C. Insulation Installation on Pumps:
1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch-diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
 2. Fabricate boxes from galvanized steel for indoor pumps and aluminum or stainless steel, at least 0.050 inch thick.
 3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.10 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers. Installation shall conform to the following:
 - 1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
 - 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
 - 3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
 - 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
 - 5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.11 INSTALLATION OF CALCIUM SILICATE INSULATION

- A. Insulation Installation on Boiler Breechings, Flues and Connectors:
 - 1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation material.
 - 2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
 - 3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.
- B. Insulation Installation on Straight Pipes and Tubes:
 - 1. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.

2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

C. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Finish flange insulation same as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.12 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 for exterior and interior painting.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating. Coating for outdoor insulation shall be UV resistant and waterproof.

- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless-steel jackets.

3.13 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:
 - 1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to two location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
 - 2. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to two location(s) for each type of equipment defined in the Part 3. For large equipment, remove only a portion adequate to determine compliance.
 - 3. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
- D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.14 DUCT INSULATION SCHEDULE GENERAL

- A. Items Not Insulated:
 - 1. Fibrous-glass ducts.
 - 2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA scheduled values below.
 - 3. Factory-insulated flexible ducts.
 - 4. Factory-insulated plenums and casings.
 - 5. Vibration-control devices.
 - 6. Factory-insulated access panels and doors.

3.15 DUCT AND PLENUM INSULATION SCHEDULE

- A. Provide insulation materials and thicknesses identified below. If more than one material is listed for a duct location, selection from materials listed is Division 23 option.

B. Duct Insulation Schedules:

1. Where application of rigid versus blanket insulation on components such as coils and supply fans is to be based on the height of a component, height shall be determined based on the bottom of the component listed. Extend applicable insulation over the entire component before transitioning to alternate material. For ductwork, transition from blanket to rigid insulation shall occur no lower than height listed.
2. Exposed ductwork between air volume terminal or local heating or cooling unit mounted within the space served and associated diffusers or registers does not require external insulation. Where air volume terminal or local heating or cooling unit are mounted outside the space served, insulate ductwork between the air volume terminal or local heating or cooling unit and the wall of the space served.

Cooling Only Supply and Return Ducts Climate Zone 0, 1, 2, 3, 4, 5 and 6						
Duct Location	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Minimum Density (lb/cu.ft)	Factory Applied Jacket	Field Applied Jacket
All ductwork, plena, duct mounted coils and supply fans exterior to building envelope. For rectangular and flat oval ductwork taper top insulation to prevent water accumulation by increasing thickness 1/8" per foot up from minimum listed to high point for drainage.	R-8.0	Rigid Mineral-Fiber Board	2.0	6.0	FSK	Self-Adhesive Outdoor Jacket
		Semi-Rigid Mineral-Fiber Board	2.0	1.5	FSK	
		Flexible Elastomeric	2.0	N/A	N/A	
All concealed ductwork, plena, duct mounted coils and supply fans in unconditioned spaces including shafts, non-plenum return ceiling cavities and crawlspaces (ventilated and non-ventilated) and all exposed ductwork, plena, duct mounted coils and supply fans in mechanical rooms located more than 10 feet above finished floor.	R-6.0	Mineral-Fiber Blanket	2.0	1.0	FSK	N/A
		Semi-Rigid Mineral-Fiber Board	1.5	1.5	FSK	N/A
All exposed ductwork, plena, duct mounted coils and supply fans in mechanical rooms 10 feet or less above finished floor.	R-6.0	Rigid Mineral-Fiber Board	1.5	6.0	FSK	N/A
		Semi-Rigid Mineral-Fiber Board	1.5	1.5	FSK	N/A
Concealed supply ductwork, plena, duct mounted coils and supply fans in indirectly conditioned spaces including return air plenums with or without exposed roofs above.	R-1.9	Mineral-Fiber Blanket	1.5	0.75	FSK	N/A
		Semi-Rigid Mineral-Fiber Board	1.5	1.5	FSK	N/A
		Flexible Elastomeric	0.5	N/A	N/A	N/A
Backs of air outlets and outlet plenums with face area larger than 5 square feet that are exposed to unconditioned and indirectly conditioned spaces.	R-2.0	Mineral-Fiber Blanket	1.5	0.75	FSK	N/A
		Flexible Elastomeric	0.5	N/A	N/A	N/A
All exposed supply ductwork passing through occupied spaces from heating and cooling unit or shaft to the supply air terminal box inlet or wall of space served and ductwork between the terminal box and the wall of space served.	R-1.9	Rigid Mineral-Fiber Board	1.5	3.0	ASJ	N/A
		Semi-Rigid Mineral-Fiber Board	1.5	1.5	ASJ	N/A

		Flexible Elastomeric	0.5	N/A	N/A	N/A
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Combined Heating and Cooling Supply, Return and Heat Recovery System Exhaust Ducts Climate Zone 1, 2, 3 and 4						
Duct Location	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Minimum Density (lb/cu.ft)	Factory Applied Jacket	Field Applied Jacket
All ductwork, plena, duct mounted coils and supply fans exterior to building envelope. For rectangular and flat oval ductwork taper top insulation to prevent water accumulation by increasing thickness 1/8" per foot up from minimum listed to high point for drainage.	R-8.0	Rigid Mineral-Fiber Board	2.0	6.0	FSK	Self-Adhesive Outdoor Jacket
		Semi-Rigid Mineral-Fiber Board	2.0	1.5	FSK	
		Flexible Elastomeric	2.0	N/A	N/A	
All concealed ductwork, plena, duct mounted coils and supply fans in unconditioned spaces including shafts, non-plenum return ceiling cavities and crawlspaces (ventilated and non-ventilated) and all exposed ductwork, plena, duct mounted coils and supply fans in mechanical rooms located more than 10 feet above finished floor.	R-6.0	Mineral-Fiber Blanket	2.0	1.0	FSK	N/A
		Semi-Rigid Mineral-Fiber Board	1.5	1.5	FSK	N/A
All exposed ductwork, plena, duct mounted coils and supply fans in mechanical rooms 10 feet or less above finished floor.	R-6.0	Rigid Mineral-Fiber Board	1.5	6.0	FSK	N/A
		Semi-Rigid Mineral-Fiber Board	1.5	1.5	FSK	N/A
Concealed supply ductwork, plena, duct mounted coils and supply fans in indirectly conditioned spaces including return air plenums with or without exposed roofs above.	R-1.9	Mineral-Fiber Blanket	1.5	0.75	FSK	N/A
		Semi-Rigid Mineral-Fiber Board	1.5	1.5	FSK	N/A
		Flexible Elastomeric	0.5	N/A	N/A	N/A
Backs of air outlets and outlet plenums with face area larger than 5 square feet that are exposed to unconditioned and indirectly conditioned spaces.	R-2.0	Mineral-Fiber Blanket	1.5	0.75	FSK	N/A
		Flexible Elastomeric	0.5	N/A	N/A	N/A
All exposed supply ductwork passing through occupied spaces from heating and cooling unit or shaft to the supply air terminal box inlet or wall of space served and ductwork between the terminal box and the wall of space served.	R-1.9	Rigid Mineral-Fiber Board	1.5	3.0	ASJ	N/A
		Semi-Rigid Mineral-Fiber Board	1.5	1.5	ASJ	N/A

Combined Heating and Cooling Supply, Return and Heat Recovery System Exhaust Ducts Climate Zone 1, 2, 3 and 4						
Duct Location	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Minimum Density (lb/cu.ft)	Factory Applied Jacket	Field Applied Jacket
		Flexible Elastomeric	0.5	N/A	N/A	N/A

Unconditioned Outside Air Intake Ducts/Plena and Exhaust (after heat recovery)/Relief Duct/Plena Inside Building Envelope Climate Zones 2 Through 8						
Duct Location	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Minimum Density (lb/cu.ft)	Factory Applied Jacket	Field Applied Jacket
For outside air intakes, all ductwork and plena between the building envelope and the first system heating coil, cooling coil or air handling unit connection.	R-12.0	Rigid Mineral-Fiber Board	3.0	6.0	FSK	N/A
		Semi-Rigid Mineral-Fiber Board	3.0	1.5	FSK	
For exhaust/relief ducts and plena, all ductwork and plena between the building envelope and first system isolation damper.	R-12.0	Rigid Mineral-Fiber Board	3.0	6.0	FSK	N/A
		Semi-Rigid Mineral-Fiber Board	3.0	1.5	FSK	

Unconditioned Outside Air Intake Ducts/Plena and Exhaust (after heat recovery)/Relief Duct/Plena Outside Building Envelope Climate Zones 2 Through 8						
Duct Location	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Minimum Density (lb/cu.ft)	Factory Applied Jacket	Field Applied Jacket
For outside air intakes where isolation damper between indoors and outdoors is located outdoors, all rectangular ductwork and plena between the isolation damper and building envelope penetration.	R-12.0	Rigid Mineral-Fiber Board	3.0	6.0	FSK	N/A
		Semi-Rigid Mineral-Fiber Board	3.0	1.5	FSK	
For exhaust/ relief ducts and plena where isolation damper between indoors and outdoors is located outdoors, all rectangular ductwork and plena between the isolation damper and the building envelope.	R-12.0	Rigid Mineral-Fiber Board	3.0	6.0	FSK	N/A
		Semi-Rigid Mineral-Fiber Board	3.0	1.5	FSK	

Exhaust Ducts from Cold Rooms and Environmental Rooms Climate Zone 0 and 8						
Duct Location	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Minimum Density (lb/cu.ft)	Factory Applied Jacket	Field Applied Jacket
Between penetration of cold/environmental room envelope and the duct main including air volume control terminal.	R-1.9	Mineral-Fiber Blanket	1.5	0.75	FSK	N/A
		Semi-Rigid Mineral-Fiber Board	1.5	1.5	FSK	N/A
		Flexible Elastomeric	0.5	N/A	N/A	N/A

Oven, Dishwash, Warewash and Shower Exhaust Ducts Climate Zones 0 Through 8						
Duct Location	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Minimum Density (lb/cu.ft)	Factory Applied Jacket	Field Applied Jacket
All ductwork and plena exterior to building envelope. For exterior ductwork taper insulation to prevent water accumulation by increasing thickness from minimum listed to high point for drainage.	R-3.5	Rigid Mineral-Fiber Board	1.0	6.0	FSK	Self-Adhesive Outdoor Jacket
		Semi-Rigid Mineral-Fiber Board	1.5	1.5	FSK	
All ductwork and plena in unconditioned shafts and in mechanical spaces (prior to recovery device or air handling unit return connection only).	R-3.5	Rigid Mineral-Fiber Board	1.0	6.0	FSK	N/A
		Semi-Rigid Mineral-Fiber Board	1.5	1.5	FSK	

3.16 BREECHING, FLUES AND CONNECTORS INSULATION SCHEDULE

A. Breeching, flues and connector insulation shall be one of the following:

1. Calcium Silicate: 4 inches thick.
2. High-Temperature Mineral-Fiber Blanket: 3 inches thick and 3-lb/cu. ft. nominal density.
3. High-Temperature Mineral-Fiber Board: 3 inches thick and 6-lb/cu. ft. nominal density.

3.17 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option. Refer to duct insulation tables for supply fan and duct mounted coils requirements.

B. Insulate indoor and outdoor equipment that is not factory insulated.

Cooling System Equipment Insulation Schedule					
Equipment Type	Insulation Type	Indoor - Minimum Thickness (inch)	Outdoor - Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket – Outdoor Only
Chilled-water pumps	Rigid Mineral-Fiber Board: Minimum Density = 6 lb/cu.ft	1	2	FSK	Self-Adhesive Outdoor Jacket
Chilled-water air-separators	Semi-Rigid Mineral-Fiber Board: Minimum Density = 1.5 lb/cu.ft				
Piping system filter-housings	Flexible Elastomeric			N/A	Glass-Fiber Cloth
Heat-exchanger (water-to-water for cooling service)	Rigid Mineral-Fiber Board: Minimum Density = 6 lb/cu.ft	2	4	FSK	Self-Adhesive Outdoor Jacket
Cooling System Tanks:	Semi-Rigid Mineral-Fiber Board: Minimum Density = 1.5 lb/cu.ft				
	Flexible Elastomeric			N/A	Glass-Fiber Cloth

Heating Hot Water Equipment Insulation Schedule					
Equipment Type	Insulation Type	Indoor - Minimum Thickness (inch)	Outdoor - Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket – Outdoor Only
Heating-hot-water pumps	Rigid Mineral-Fiber Board: Minimum Density = 6 lb/cu.ft	1	2	FSK	Self-Adhesive Outdoor Jacket
Heating-hot-water air-separator	Semi-Rigid Mineral-Fiber Board: Minimum Density = 1.5 lb/cu.ft				
Piping system filter-housing					
Heat-exchanger (water-to-water for heating service)	Rigid Mineral-Fiber Board: Minimum Density = 6 lb/cu.ft	2	4	FSK	Self-Adhesive Outdoor Jacket
Heating-hot-water system tanks,	Semi-Rigid Mineral-Fiber Board: Minimum Density = 1.5 lb/cu.ft				

Steam Equipment Insulation Schedule					
Equipment Type	Insulation Type	Indoor - Minimum Thickness (inch)	Outdoor - Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket – Outdoor Only
Steam condensate pump and boiler feedwater pump	Rigid Mineral-Fiber Board: Minimum Density = 6 lb/cu.ft	2	4	FSK	Self-Adhesive Outdoor Jacket
Steam flash-tank, flash-separator, moisture-separator, and blow-off-tank	Semi-Rigid Mineral-Fiber Board: Minimum Density = 1.5 lb/cu.ft				

3.18 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - 1. Drainage piping located in crawl spaces.
 - 2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.19 PIPING INSULATION SCHEDULE

- A. Provide insulation materials and thicknesses scheduled for each system type and pressure/temperature range. If more than one material is listed for a system, selection from materials listed is Division 23 option.
- B. For dual temperature systems (heating and cooling), provide thickness equal to greater of heating or cooling scheduled value. Dual temperature piping shall also meet all vapor barrier requirements for cooling insulation (perm rating).
- C. Insulation for pre-insulated piping shall meet all specified requirements.
- D. Insulate piping operating at temperatures below 40 deg F and systems operating between 40 deg F to 65 deg F in accordance with NAIMA Guide to Insulating Chilled Water Piping Systems with Mineral Fiber Pipe Insulation. Comply with all recommendations including but not limited to the requirement for vapor dams every fourth section of insulation.
- E. Pipe Insulation Schedules:

Heating Hot Water Systems: Supply temp 141 deg F to 200 deg F. Applies to supply and return piping						
Insulation Conductivity Btu-in/hr-deg F-SF at Mean Temp (deg F)	Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor - Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
0.25 to 0.29 at 125	Mineral Fiber (Fiberglass) Preformed Pipe, Type I or Pipe and Tank Insulation for 14" and Larger Pipe Size	Less than 1	1.0	3.0	ASJ or ASJ-SSL	Indoor: PVC for exposed piping in mechanical rooms when mounted 10 feet or lower above finished floor Outdoor: Aluminum with Moisture Barrier
		1 to Less than 1.5	1.0	3.0		
		1.5 to Less than 4	2.0	4.0		
		4 to Less than 8	2.0	4.0		
		8 and Larger	2.0	4.0		

Heating Hot Water Systems: Supply temp 85 deg F to 140 deg F Applies to supply and return piping						
Insulation Conductivity Btu-in/hr-deg F-SF at Mean Temp (deg F)	Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor - Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
0.22 to 0.28 at 100	Mineral Fiber (Fiberglass) Preformed Pipe, Type I or Pipe and Tank Insulation for 14" and Larger Pipe Size	Less than 1	1.0	2.0	ASJ or ASJ-SSL	Indoor: PVC for exposed piping in mechanical rooms when mounted 10 feet or lower above finished floor Outdoor: Aluminum with Moisture Barrier
		1 to Less than 1.5	1.0	2.0		
		1.5" to Less than 4	2.0	3.0		
		4 to Less than 8	2.0	3.0		
		8 and Larger	2.0	3.0		

Chilled water Systems: Supply temp 40 deg F to 65 deg F Applies to supply and return piping						
Insulation Conductivity Btu-in/hr-deg F-SF at Mean Temp (deg F)	Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor - Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
0.21 to 0.27 at 75	Mineral Fiber (Fiberglass) Preformed Pipe, Type I or Pipe and Tank Insulation for 14" and Larger Pipe Size	Less than 1	1.5	3.0	ASJ or ASJ-SSL	Indoor: PVC for exposed piping in mechanical rooms when mounted 10 feet or lower above finished floor Outdoor: Aluminum with Moisture Barrier
		1 to Less than 1.5	1.5	3.0		
		1.5 to Less than 4	1.5	3.0		
		4 to Less than 8	1.5	3.0		
		8 and Larger	1.5	3.0		

Cooling Coil Condensate Piping, Equipment Drain Piping: All						
Insulation Conductivity Btu-in/hr-deg F-SF at Mean Temp (deg F)	Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor - Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
Mineral Fiber with Conductivity = 0.20 to 0.26 at 50 Flexible Elastomeric with Conductivity = 0.26 at 0 (2013 ASHRAE Fundamentals Handbook)	Mineral Fiber (Fiberglass) Preformed Pipe, Type I or Flexible Elastomeric	Less than 1	0.75	2.0	ASJ or ASJ-SSL for Mineral Fiber	Indoor Mineral Fiber: PVC for exposed piping in mechanical rooms when mounted 10 feet or lower above finished floor.
		1 to Less than 1.5	0.75	2.0		
		1.5 to Less than 4	0.75	2.0		
		4 to Less than 8	0.75	2.0	N/A for Flexible Elastomeric	Indoor Flexible Elastomeric: N/A
		8 and Larger	0.75	2.0		Outdoor Mineral Fiber: Aluminum with Moisture Barrier Outdoor Flexible Elastomeric: Glass-Fiber Cloth

3.20 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

- A. This section does not apply where other Division 23 sections require the installation of loose-fill insulation for underground piping.
- B. Schedule of field installed insulation for underground piping:

System Served	Insulation Type	Minimum Insulation Thickness (inches)
Chilled Water, Condenser Water, Heating Hot Water 200 deg F and Below,	Cellular Glass with Underground Direct- Buried Piping Jacket	2.0

3.21 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

- B. Refer to Duct, Plenum, Equipment and Pipe insulation schedules for outdoor field applied jacketing requirements. If more than one material is listed, selection from materials listed is Contractor's option.
- C. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION

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SECTION 230995 - LABORATORY AIRFLOW CONTROL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

- A. A Laboratory Airflow Control System (LACS) shall be furnished and installed under this section. The LACS shall be capable of operating as a standalone system, integrated with the Building Management System (BMS) or Building Automation System (BAS).

1.2 RELATED DOCUMENTS

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

~~B. Section 230900 – Instrumentation and Control for HVAC~~

B. Division 25 - Instrumentation and Control for HVAC

1.3 REFERENCES.

- A. Abbreviations and Acronyms

1. ATC – Advanced Temperature Control
2. BMS – Building Management System
3. BAS – Building Automation System
4. LACS – Laboratory Airflow Control System
5. UBC – Usage Based Controls
6. VAV – Variable Air Volume
7. TTW – Through The Wall (sensor)
8. ZPS – Zone Presence Sensor
9. PIN – Personal Identification Number

- B. Reference Standards

1. Air Conditioning and Refrigeration Institute
2. ARI 880 Performance Rating of Air Terminals
3. American Society of Heating, Refrigeration, and Air Conditioning Engineers / American National Standards Institute
4. ASHRAE/ANSI Standard 130, Methods for Testing Air Terminal Units
5. American National Standards Institute / American Society of Heating, Refrigeration, and Air Conditioning Engineers
6. ANSI/ASHRAE 135-2012: BACnet® - A Data Communication Protocol for Building Automation Systems (including Standard and all published Addenda)

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination

1. The LACS representative shall coordinate all details of the installation with the successful mechanical contractor. This effort shall include complete coordination of the sheet metal layout drawings to assure that the ductwork layout and sizing is based on the actual sizes of the airflow control valves for this project.

B. Pre-installation Meetings

1. The LACS representative shall review the proper installation of the system with the sheet metal contractor and the building management system (BMS) contractor.
2. Project Installation Phase – The LACS representative shall make periodic visits to the project jobsite to assure that the system is being installed properly to assure optimal performance and that the location and orientation of the control valves is consistent for proper operation and future owner maintenance. Any discrepancies shall first be brought to the attention of the appropriate subcontractor. If no action is taken by said contractor, the representative shall bring these issues to the project manager, engineer or owner's representative for resolution.

1.5 SUBMITTALS

A. General: Submit listed Submittals in accordance with Conditions of the General Contract and Division 1 Submittal Procedures Section. LACS submittals shall contain, at a minimum, the following information:

1. Product Data Sheets
2. Equipment Schedule Sheets containing Room#, Tag#, Min/Max flows, Catalog# and other configuration data as required to provide a fully engineered LACS.
3. Installation Instructions
4. Project-specific Wiring Diagrams
5. Points Lists

1.6 CLOSEOUT SUBMITTALS

A. Operation and maintenance manuals, including as-built wiring diagrams and component lists, shall be provided as closeout submittals.

B. Integration checklists are encouraged; once the integration to the BMS or BAS is completed, it is recommended that the LACS Representative Partner meet with the BMS or BAS contractor to do a final acceptance test of the integration. This testing should include:

1. Testing points to ensure communication
2. Testing setpoints such as temperature, occupancy, room offset, etc
3. Testing various alarms in different parts of the system

4. Testing to ensure that equipment will cycle after a power loss

1.7 QUALITY ASSURANCE

A. Certifications

1. The laboratory airflow system provider shall be an entity that designs, develops, manufactures and sells products and services to control the environment and airflow of critical spaces using a Quality Management System registered to ISO 9001:2008.
2. The Laboratory airflow system provider shall be ROHS compliant in all its products
3. The air flow control valves shall be calibrated using NIST traceable equipment AND NVLAP accredited air stations.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Storage and Handling Requirements

1. Prior to installation, the LACS products shall be stored in dry conditions within an environment complying with LACS product specifications as shown on product data sheets within the submittals.
2. The LACS products shall be handled and transported in a manner consistent trade practices for control systems and instruments.

1.9 SITE CONDITIONS

- A. The ambient environmental conditions during installation and operation shall comply with LACS product specifications as shown on the product data sheets within the submittals.

1.10 WARRANTY

- A. The Warranty shall commence upon the date of shipment and extend for a period of 60 months for all airflow control devices and 36 months for all other control system components.

PART 2 - PRODUCTS

2.1 LABORATORY AIRFLOW CONTROL SYSTEMS

- A. LACS shall be furnished and installed to control the airflow into and out of laboratory rooms. The exhaust flow rate of a laboratory fume hood shall be controlled precisely to maintain a constant average face velocity into the fume hood at either a standard/in-use or standby level based on an operator's presence in front of the fume hood. The laboratory control system shall vary the amount of make-up/supply air into the room to operate the laboratories at the lowest possible airflow rates necessary to maintain temperature control, achieve minimum ventilation rates and maintain laboratory pressurization in relation to adjacent spaces (positive or negative). The LACS shall be

capable of operating as a standalone system or as a system integrated with the Building Management System (BMS).

2.2 ACCEPTABLE MANUFACTURES

A. Manufacturer List

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Accutrol, LLC – AccuValve
 - b. Phoenix Controls – Accel II venturi valve
 - c. Price Industries – Venturi Valve (VV)

B. Substitute Limitations

1. In strict accordance with this specification, alternative LACS and equipment shall only be considered for approval provided that the equipment be equal in every respect to the operational characteristics, capacities and intent of control sequences specified herein. Approval to bid does not relieve the LACS supplier from complying with the minimum requirements or intent of this specification.
2. The engineer and owner shall be the sole judges of quality and equivalence of equipment, materials, methods and life cycle cost.
 - 1) Only those systems specifically named in this specification or by addendum shall be considered for approval. Other systems submitted after the bid opening will be returned without review.

2.3 COMPONENTS

A. EQUIPMENT

1. For variable air volume (VAV) systems, a sash sensor shall be provided to measure the height of each vertically moving fume hood sash. A sash sensor shall also be provided to measure the opening of horizontal overlapping sashes. Control systems employing sidewall-mounted or through the wall (TTW) velocity sensors to control the fume hood exhaust airflow shall be unacceptable. Sidewall-mounted or through the wall (TTW) sensors shall only be used as a reference or to provide a secondary alarm indication relative to operating face velocity.
2. The airflow at the fume hood shall vary in a linear manner between two adjustable minimum and maximum flow set points to maintain a constant face velocity throughout this range. A minimum volume flow shall be set to assure flow through the fume hood even with the sash fully closed.

B. AIRFLOW CONTROL DEVICE - GENERAL

1. The device shall be a pressure independent airflow control valve.
2. The valve assembly manufacturer's Quality Management System shall be registered to ISO 9001:2008.
3. All Components of the valve, its controllers, and wiring shall be ROHS compliant.

4. The airflow control device shall be pressure independent over its specified differential static pressure operating range of 0.6 to 3.0 inches of water column. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change (within product specifications) or quantity of airflow controllers on a manifolded system.
5. The airflow control device shall maintain accuracy within $\pm 5\%$ of signal over an airflow turndown range of no less than:
 - a. 10 to 1 (low pressure all valve sizes)
6. No minimum entrance or exit duct diameters shall be required to ensure accuracy and/or pressure independence.
7. No rotational/axial orientation requirements shall be required to ensure accuracy and/or pressure independence. Devices shall not require factory recalibration due to a change in orientation in the field.
8. The airflow control device shall maintain pressure independence regardless of loss of power.
9. Devices with NVLAP certified laboratory calibrated linear airflow relationship relative to actuator position shall be equipped with differential. Devices utilizing flow measurement for control of airflow shall be equipped with true airflow measuring capability, able to continuously monitor the air flow rate of the duct served and electronically transmitting a signal that is in a linear relationship to air flow rate.
10. Devices must be capable of being utilized with a demand based static pressure reset control scheme as described in ASHRAE Standard 90.1-6.5.3.2.3.
11. The airflow control device shall be constructed of one of the following two types:
 - a. Supply, general exhaust, glass-wash and autoclave valves Class A —the airflow control device for non-corrosive airstreams shall be constructed of 16-gauge aluminum. All internal metal components shall be made of 316 stainless steel. All shaft bearing surfaces shall be made of a PP (polypropylene) or PPS (polyphenylene sulfide) composite or Teflon.
 - b. Sound attenuating devices used in conjunction with general exhaust or supply airflow control devices shall be constructed using 24 gauge galvanized steel or other suitable material used in standard duct construction.
 - c. All fume hood valves Class D — the airflow control device shall be made of 20 gauge 316 stainless steel or Heresite P403 phenolic coated 16 gauge aluminum. All internal metal components shall be made of 316 stainless steel with a Teflon coating. All shaft bearing surfaces shall be made of Teflon or PPS (polyphenylene sulfide) composite.
12. Actuation
 - a. For rooms including fume hoods, high speed electrically actuated VAV operation is required, a CE certified, UL Listed, IP56 rated for dust and water, electronic actuator shall be factory mounted to the valve. Loss of

main power shall cause the valve to position itself in the last commanded position. This position shall be maintained constantly without external influence, regardless of external conditions on the valve (within product specifications).

- b. During normal operation the high speed actuated airflow control device shall initiate valve movement and achieve the commanded airflow value with no more than 5% overshoot or undershoot within 1 second or less.
- c. For rooms with no fume hoods, Standard Speed electrically actuated VAV operation may be used, a CSA certified, UL recognized (IP54 rating and CE certification optional on single valves, standard on dual valves) electronic actuator shall be factory mounted to the valve. The failsafe state for standard speed operation valves shall be fail to last position commanded unless otherwise noted.
- d. During normal operation the standard speed actuated airflow control device shall initiate valve movement and achieve the commanded airflow value with no more than 5% overshoot or undershoot within 60 seconds. Standard speed actuation should not be used for valves that are connected to VAV fume hoods.
- e. Constant volume airflow control devices, as identified on equipment schedules on the drawings shall maintain a constant airflow, independent of duct static pressure within the specified range herein. Airflow setting shall be factory calibrated and manually adjustable in the field for future changes.

13. NVLAP Accreditation (Lab Code 200992-0)

- a. Each airflow control device shall be factory characterized on air stations NVLAP Accredited (a program administered by NIST) to ISO/IEC 17025:2005 standards.
- b. Each airflow control device shall be factory characterized to the job specific airflows as detailed on the plans and specifications using NVLAP Accredited air stations and instrumentation having a combined accuracy of no more than $\pm 1\%$ of signal (5,000 to 250cfm), $\pm 2\%$ of signal (249 to 100cfm) and $\pm 3\%$ of signal (199 to 35cfm). Electronic airflow control devices shall be further characterized and their accuracy verified to $\pm 5\%$ of signal at a minimum of 48 different airflows across the full operating range of the device.
- c. Each airflow control device shall be marked with device-specific factory characterization data. At a minimum, it should include the room number, tag number, serial number, model number, eight-point characterization information (for electronic devices), date of manufacture and quality control inspection numbers. All information shall be stored by the manufacturer for use with as-built documentation. Characterization data shall be stored indefinitely by the manufacturer and backed up off site for catastrophic event recovery.

C. EXHAUST AND SUPPLY AIRFLOW DEVICE CONTROLLER

1. The airflow control device shall be a microprocessor-based design and shall use closed loop control to linearly regulate airflow based on a digital control signal. The device shall generate a digital feedback signal that represents its airflow.
2. During normal operation the airflow control device shall initiate valve movement and achieve the commanded airflow value with no more than 5% overshoot or undershoot within:
 - a. 1 second or less with high speed actuation
 - b. 60 seconds for standard speed actuation
3. The airflow control device shall use industry standard 24 VAC power, provided by the LACS supplier (installed and wired by others).
4. The airflow control device shall have built-in integral input/output connections that address fume hood control, temperature control, humidity control occupancy control, emergency control, and non-network sensors switches and control devices. At a minimum, the airflow controller shall have:
 - a. Three universal inputs capable of accepting 0 to 10 VAC, 4 to 20 mA, 0 to 65 K ohms, or Type 2 or Type 3 10 K ohm @ 25 degree C thermistor temperature sensors.
 - b. One digital input capable of accepting a dry contact or logic level signal input.
 - c. Two analog outputs capable of developing either a 0 to 10 VAC @ 1 mA (10Kohm min) or 4 to 20 mA (500 ohm max) linear control signal.
 - d. One Form C (SPDT) relay output capable of driving up to 1 A @ 24 VAC/VAC.
5. The airflow control device shall meet FCC Part 15 Subpart J Class A, CE, and CSA Listed per file #228219.
6. The airflow control device shall be ROHS compliant

D. FUME HOOD DISPLAY

1. The display screen shall be a 3.2" (diagonal) color LCD resistive touch screen (240 x 320 RGB).
2. The touch screen shall support input configurations for fume hood operational parameters done at the touch panel and at a minimum including:
 - a. Sash Dimensions
 - b. Hood ID
 - c. Hood Certification Reminder
 - d. Hood Occupancy Status
 - e. Stopwatch/Timer
 - f. Message Display
3. Hood configuration for the following properties shall be viewable and editable from the touch display:

- a. Sash Dimensions
 - b. Hood ID
 - c. Hood Certification Reminder
 - d. Hood Occupancy Status
 - e. Stopwatch/Timer
 - f. Message Display
4. The enclosure shall be made from material that is resistant to chemicals that are typically used in the lab for wipe down with non-solvent cleaning agents.
 5. The unit's exposed surfaces shall be chemically resistant to vaporized hydrogen peroxide (VHP), formaldehyde, chloride dioxide (clidox), perchloric acid, sodium hypochloride/hypochlorite 3-6% (bleach), and quaternary ammonium 7% in 1:128 tap water (ammonia).
 6. Two mechanical membrane buttons shall be provided at the front panel of the display to enable users to quickly activate emergency exhaust mode and mute without having to remove protective gloves.
 7. Flush mount or recess mount shall be installation options.
 8. A USB port shall be provided to support firmware and software upgrades and shall be covered to protect against moisture or corrosion.
 9. A timer feature shall be provided to enable users to set specific durations for experiments and provide visual and audible alarms when the set time is expired.
 10. The fume hood display shall have an available I/O at its associated valve controller which may be used to receive a 0 – 10 volt signal from a Through-The-Wall (TTW) sensor. The TTW shall not control the valve but provide a drift alert to indicate when the TTW sensor reading is out of range relative to the sash position face velocity value.
 11. POWER
 - a. The device shall be powered by 24 VAC \pm 15% at 10VA, 50/60 Hz.
 12. CONFIGURATION
 - a. Configuration shall be performed from the touch display and/or manufacturer's software tools.
 - b. The device shall be capable of being added to an existing BACnet communication network.
 - c. The device shall display fume hood performance data based on control logics embedded inside the valve controller.
 13. COMMUNICATION
 - a. The fume hood display unit shall connect to BACnet communication and link directly to a specific valve controller associated with the hood it is mounted on.
 - b. The device shall display fume hood performance data based on sash movements and valve controller performance over BACnet.

14. INFORMATION DISPLAY

- a. The device shall have the ability to indicate when the fume hood face velocity is within the normal operating range as well as energy saving, hood certification, hood ID, timer, and hood occupancy status.
- b. The device shall be configurable to display one of the following measurement units: cubic feet per minute (CFM), meters cubed per hour (m^3/h), liters per second (l/s), feet per minute (fpm), or meters per second (m/s).
- c. The device shall have the ability to display system errors caused by the airflow valve or sash travel.
- d. The device shall have the ability to indicate to users when the hood is due for recertification by stating on the LCD display "Hood Cert. due MM/DD/YYYY".

15. EMERGENCY (PURGE) EXHAUST

- a. The display shall have a mechanical membrane button on the lower portion that when pressed will initiate an emergency (purge) exhaust mode in the attached fume hood valve(s).
 - 1) Button shall be mechanical so that users with rubber, nitrile, vinyl, latex, or other gloves can operate the emergency exhaust button
- b. The emergency (purge) exhaust mode, when initiated, will send the attached fume hood exhaust valve(s) to either the maximum flow of the valve, or another predefined flow (as configured in the fume hood valve)

16. ALARMS

- a. The device shall have the ability to show alarms on the main screen using visual and audible alerts.
- b. The main screen background color shall change to flashing red with text stating the type of alarm.
- c. In alarm state, the visual indication shall remain active until the event that triggered the alarm is removed or fixed.
- d. The audible alarm tone shall be cleared only when the event that triggered the alarm is removed or fixed.
- e. The device shall have an Alarm Muting option, which silences the audible alarm for an adjustable time period when the mute button is pushed. If another alarm is generated during the mute period, the new alarm shall override the mute delay and the alarm shall sound again.
- f. The device shall have the ability to have customizable audible alarms levels and customizable mute duration.
- g. Users shall have the ability to change the volume of the alarm tone to low, medium, or high.
- h. The device shall have the ability to show Diversity alarm.

- a) Diversity alarm shall be generated by the valve or from the BMS system.
- b) No audible tone for diversity alarm shall be generated at the fume hood display.

17. SECURITY

- a. End users shall have the ability to enable a PIN pass code to prevent unauthorized changes to sash heights, air flow settings and other editable parameters.

18. COMPLIANCE

- a. The unit shall be certified as meeting regulatory compliance with CE, CUL, and RoHS.
- b. The unit shall be suitable for use with non-solvent wipe down and is designed to meet IP44 test standards.
- c. The device shall comply with part 15 of the FCC Rules. Operation is subject to the following two conditions:
- d. This device shall not cause harmful interference.
- e. This device shall accept any interference received, including interference that may cause undesired operation.

19. ENVIRONMENT

- a. The operating temperature range shall be between 32 – 122°F (0 – 50°C).

2.4 PERFORMANCE/DESIGN CRITERIA

- A. Each laboratory shall have a dedicated LACS. Each dedicated LACS shall support a minimum of 20 network controlled airflow devices.
- B. The LACS shall maintain specific airflow ($\pm 5\%$ of signal within one second of a change in duct static pressure) regardless of the magnitude of the pressure change, airflow change or quantity of airflow control devices on the manifold (within 0.6" to 3.0" wc).

2.5 OPERATION SEQUENCES

- A. The airflow control devices shall utilize peer-to-peer, distributed control architecture to perform room-level control functions. Master-slave control schemes shall not be acceptable. Control functions shall include, at a minimum, volumetric offset pressurization, temperature, humidity control, as well as respond to hood flow demands, occupancy, and emergency control commands.
- B. The sequences below are general, refer to the drawings for specific sequences of operation.
 - 1. Volumetric Offset Pressurization Control
 - a. The laboratory control system shall control supply and auxiliary exhaust airflow devices in order to maintain a volumetric offset (either positive or

negative). Offset shall be maintained regardless of any change in flow or static pressure (within specified range for medium or low pressure valves). This offset shall be field adjustable and represents the volume of air, which will enter (or exit) the room from the corridor or adjacent spaces.

- b. The pressurization control algorithm shall sum the flow values of all supply and exhaust airflow devices and command appropriate controlled devices to new set points to maintain the desired offset. The offset shall be adjustable as a configurable parameter in the LACS as set by startup technician or BMS/BAS.
 - c. The pressurization control algorithm shall consider both networked devices, as well as:
 - d. Up to three non-networked devices providing a linear analog flow signal.
 - e. Any number of constant volume devices where the total of supply devices and the total of exhaust devices may be factored into the pressurization control algorithm.
 - f. Volumetric offset shall be the only acceptable means of controlling room pressurization. Systems that rely on differential pressure as a means of control shall provide documentation to demonstrate that space pressurization can be maintained if fume hood sashes are changed at the same time a door to the space is opened.
 - g. The volumetric offset control algorithm shall support the ability to regulate the distribution of total supply flow across multiple supply airflow control devices in order to optimize air distribution in the space.
2. Temperature Control
- a. Wall mounted and discharge air temp sensors are provided by this LACS supplier
 - b. Standard Primary Temperature Control
 - 1) The laboratory control system shall regulate the space temperature through a combination of volumetric thermal override and control of reheat coils and/or auxiliary temperature control devices. Separate cooling and heating set points shall be writeable from the BMS, with the option of a local offset adjustment.
 - 2) Temperature control shall be implemented through the use of independent primary cooling and heating control functions. Primary heating shall be provided through modulating control of a properly sized reheat coil. Primary cooling shall be provided as a function of volumetric override or through auxiliary modulating control of a chilled water valve. Volumetric override will command both supply and general exhaust valves to maintain desired offset as a high select zone control. Volumetric cooling override may be staged before or after chilled water control valve.
3. Occupancy Control

- a. Room lighting occupancy sensors and/or CO2 sensors shall be provide by others, but wired into the local LACS for monitoring purposes.
- b. The laboratory control system shall have the ability to change the minimum ventilation and/or temperature control set points, based on the occupied state, in order to reduce energy consumption when the space is not occupied. The occupancy state may be set by either the BMS as a scheduled event or through the use of a local occupancy sensor or switch. The laboratory control system shall support a local occupancy override button that allows a user to override the occupancy mode and set the space to occupied for a predetermined interval. The override interval shall be configurable from one to 1440 minutes. The local occupancy sensor/switch or bypass button shall be given priority over a BMS command.

2.6 INTERFACE TO BUILDING MANAGEMENT SYSTEMS

- A. The LACS network shall have the capability of digitally interfacing with the BMS. The required software interface drivers shall be developed and housed in one or more dedicated interface devices furnished by the LACS supplier.
- B. Room Level Integration
 1. Room Level Integration device shall be a standalone piece of hardware with embedded microprocessor controls will be used for commissioning and configuration of Venturi valves and ancillary components such as Fume Hood Displays,
 2. After the Room Level Interface is commissioned it shall provide a web based user interface for device, network, and platform diagnostics as well as a Test and Balance web application for zone balance and airflow validation. Room Level interface will also provide a means of integrating on an open BACnet network via IP, Ethernet, or MS/TP to be field selectable at time of commissioning.
 3. If the room level integration device drops off the network or loses power, it shall not cause the zone balance, temperature control, or fume hood devices to lose control. The room level valve devices should operate independently of the room level integration device.
 4. Room Level Integrator shall be able to integrate to BAS through BACnet/IP, BACnet/Ethernet, or BACnet MS/TP through on board communication adapters and shall be field configurable/upgradable. LACS provider shall coordinate with BAS provider for integration protocol requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that conditioned power supply is available to control units
- B. Verify that duct-, pipe-, and equipment-mounted devices are installed before proceeding with installation

3.2 INSTALLATION

- A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.
- B. Connect and configure equipment and software to achieve sequence of operation specified.
- C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices as directed by Architect above the floor.
- D. Install guards on thermostats in the following locations:
 - 1. Public areas.
 - 2. Where indicated.
- E. Install labels and nameplates to identify LACS components according to Division 23, Identification for HVAC Piping and Equipment.

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. Install raceways, boxes, and cabinets according to Division 26, Raceways and Boxes for Electrical Systems.
- B. Install building wire and cable according to Division 26, Low-Voltage Electrical Power Conductors and Cables.
- C. Install signal and communication cable according to Division 27, Communications Horizontal Cabling.
 - 1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
 - 2. Install all wiring and cables in raceway.
 - 3. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
 - 4. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
 - 5. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
 - 6. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
- D. Connect manual-reset limit controls independent of manual-control switch positions. .
- E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.
- F. All LACS equipment power shall be powered from the electric panels provided by Division 26. Electrical panels for use by LACS contractor are on emergency power. Circuits available for use for the LACS are to be coordinated with the Electrical Contractor (Division 26) by the LACS provider.

1. It is the responsibility of the LACS Contractor to provide 120V power wiring from the breaker, supplied by the LACS provider and installed by Division 26 in the electrical panels, to the final locations of the LACS equipment.
 2. The power shall be obtained from dedicated circuits in 120V panels and clearly labeled by the LACS Contractor. (Refer to the electrical drawings for panel schedules). LACS contractor shall coordinate with electrical contractor (division 26) to provide accurate panel schedules at project closeout.
 3. All power wiring for the LACS equipment shall be done with a dedicated earth ground by means of copper wire media only, originating at the power service source earth ground. This applies to all controllers.
- G. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- H. Perform the following field tests and inspections and prepare test reports:
1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
 2. Test and adjust controls and safeties.
 3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
 4. Test each point through its full operating range to verify that safety and operating control set points are as required.
 5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
 6. Test each system for compliance with sequence of operation.
 7. Test software and hardware interlocks.
- I. LACS Verification:
1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
 2. Check instruments for proper location and accessibility.
 3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
 4. Check instrument tubing for proper fittings, slope, material, and support.
 5. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
 6. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
 7. Check temperature instruments and material and length of sensing elements.
 8. Check control valves. Verify that they are in correct direction.

9. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
10. Check LACS as follows:
 - a. Verify that controller power supply is from emergency power supply, if applicable.
 - b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
 - c. Verify that spare I/O capacity has been provided.
 - d. Verify that controllers are protected from power supply surges.
- J. Replace damaged or malfunctioning controls and equipment and repeat testing procedures

3.4 ADJUSTING

- A. Calibrating and Adjusting:
 1. Calibrate instruments.
 2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
 3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
 4. Control System Inputs and Outputs:
 - a. Check analog inputs at 0, 50, and 100 percent of span.
 - b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
 - c. Check digital inputs using jumper wire.
 - d. Check digital outputs using ohmmeter to test for contact making or breaking.
 - e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
 5. Flow:
 - a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
 - b. Manually operate flow switches to verify that they make or break contact.
 6. Pressure:
 - a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
 - b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
 7. Temperature:

- a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
 - b. Calibrate temperature switches to make or break contacts.
8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
 9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
 10. Provide diagnostic and test instruments for calibration and adjustment of system.
 11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.
- B. Adjust initial temperature and humidity set points.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 01, Demonstration and Training.
- B. Provide thirty two (32) hours of training divided into four (4) session of eight (8) hours each

END OF SECTION

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SECTION 238219 - FAN COIL UNITS

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.
- B. Division 23, Common Mechanical/Electrical Requirements, applies to this Section.

1.2 SUMMARY

- A. This Section includes fan-coil units and accessories.

1.3 DEFINITIONS

- A. BAS: Building automation system.

1.4 SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
- C. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1. Ceiling suspension components.
 - 2. Structural members to which fan-coil units will be attached.
 - 3. Method of attaching hangers to building structure.
 - 4. Size and location of initial access modules for acoustical tile.
 - 5. Items penetrating finished ceiling, including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - 6. Perimeter moldings for exposed or partially exposed cabinets.
- D. Field quality-control test reports.

- E. Operation and Maintenance Data: For fan-coil units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01, Operation and Maintenance Data, include the following:
 - 1. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.
- F. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- C. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.6 COORDINATION

- A. Coordinate layout and installation of fan-coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.
- B. Coordinate size and location of wall sleeves for fan coil units provided with outdoor-air intake.
- C. Coordinate duct collar size and configuration to conform to the ductwork distribution shown on the plans and mixing box as scheduled.

1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Compressor failure.
 - b. Condenser coil leak.
 - 2. Warranty Period: Five for compressor from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
- B. In the Fan-Coil-Unit Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 FAN COIL UNITS

A. Manufacturers:

1. Multiaqua Inc. (basis of Design)
2. Trane (basis of design)
3. Airtherm
4. EMI
5. Envirotech
6. International Environmental Corporation
7. McQuay International
8. Carrier Corporation
9. York: Johnson Controls

B. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.

C. Unit Construction: All unit chassis shall be fabricated of heavy gauge galvanized steel panels able to meet 125 hour salt spray test per ASTM B-117

D. Unit Configuration: Fan coil unit shall be a Draw through type unit

E. Cabinet: Steel with baked-enamel finish in manufacturer's standard paint color.

1. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with cast-aluminum discharge grilles.

F. Casing Insulation: 1/2-inchthick, foil-covered, closed-cell foam complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916. Maximum thermal conductivity shall be $.24 \text{ (BTU} \cdot \text{in) / (hr} \cdot \text{ft}^2 \cdot \text{°F)}$

1. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84, UL 723 and NFPA 90A.

G. Main Drain Pans: Insulated galvanized steel with plastic liner. Fabricate pans and drain connections to comply with ASHRAE 62.1-2004.

H. Secondary Drain Pan: Provide a secondary drain pan for condensate overflow from the primary drain pan with a condensate leak detector sensor. Drain pan shall be plastic or insulated, galvanized steel with plastic liner. The switch shall be factory wired back to the unit terminal strip to shut down the fan upon leak detection and contacts to alarm DDC system.

I. **Drain pans shall be designed for full access for cleaning. Coil banks with sheet metal bottom panels and weep holes will not be allowed.**

J. Chassis: Galvanized steel where exposed to moisture. Floor-mounting units shall have leveling screws.

- J-K.** Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
1. Pleated Cotton-Polyester Media: 90 percent arrestance and 7 MERV.
- K-L.** Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch, rated for a minimum working pressure of 300 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain valve. All coils shall be ARI 410 certified and tagged with an ARI 410 label.
1. Cooling and heating coils shall be in separate coil casings and have a minimum 2 inch gap between them and 1-1/2 inch of clearance on the entering and leaving air sides to allow access from bottom of unit for cleaning when the drain pan is removed. Common tube sheets and coil casing are not acceptable. Water coils on concealed models shall be field reversible for right, left or opposite side connections.
- L-M.** Sound: Units shall have published sound power level data tested in accordance with ARI Standard 350-2000 (non-ducted equipment), ARI Standard 260-2001 (ducted equipment) and as scheduled on drawings.
- M-N.** Provide condensate pumps as scheduled on drawings and shown on plans. Condensate pump shall be provided integral to the unit with a single point power connection.
- N-O.** Fan Assembly:
1. Unit fan shall be a dynamically balanced, forwardly curved, DWDI centrifugal type constructed of 18 gauge zinc coated galvanized steel for corrosion resistance. Motors shall be high efficiency, permanently lubricated sleeve bearing, permanent split-capacitor type with UL and CSA listed automatic reset thermal overload protection and three separate horsepower taps or ECM motors as scheduled on drawings. Single speed motors are not acceptable.
 2. The fan assembly shall be easily removable for servicing the motor and blower at, or away from the unit. The entire fan assembly shall be able to come out of the unit by removing two screws and unplugging the motor. Plenum unit fan assemblies shall be easily serviced through an access panel provided.
 3. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 23, Common Motor Requirements for HVAC Equipment.
 4. Wiring Termination: Connect motor to chassis wiring with plug connection.
 5. ECM Motors - Motors to be DC and brush-less equal to GE ICM2+. All motors to be complete with and operated by a single phase integrated controller/inverter that operates the wound stator and senses rotor position to electrically commutate the stator. All motors to be designed for synchronous rotation. Motor to be permanent magnet type with near zero rotor losses. Motor to be built in soft start and soft speed change ramps. Motor to be direct coupled lubricated with ball bearings. Sleeve bearings are not acceptable. Motor to be direct coupled to the blower. Motor to maintain minimum efficiency of 70% over its entire operating range. The manufacture of the fan powered boxes to set the fan CFM at the factory. Fan CFM to be constant within $\pm 5\%$ regardless of the change in static whether upstream or down stream of the terminal unit after it is installed. Fan

CFM is to be set with a potentiometer. Provide a variable speed switch to allow field adjustments. Fan CFM to be remotely set at the building DDC system through the dynamic speed control at the ECM motor.

Q.P. Factory, Hydronic Piping Package: ASTM B 88, Type L copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.

1. Two-way, modulating control valve for chilled-water coil.
2. Hose Kits: Minimum 400-psig working pressure, and operating temperatures from 33 to 211 deg F. Tag hose kits to equipment designations.
 - a. Length: 36 inches.
 - b. Minimum Diameter: Equal to scheduled fan coil unit branch pipe size.
3. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.
4. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig working pressure, 250-deg F maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
5. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig working pressure at 250 deg F, with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig.
6. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 hose-end, full-port, ball-type blowdown valve in drain connection.
7. Wrought-Copper Unions: ASME B16.22.
8. Risers: ASTM B 88, Type L copper pipe with hose and ball valve for system flushing.

P.Q. Electrical Connection: Factory wire motors and controls for a single point electrical connection.

Q.R. Control devices and operational sequences are specified in Division ~~2325~~, ~~Instrumentation and Control for HVAC, Sequence of Operations for HVAC Controls,~~ and control sequences on drawings.

R.S. Electrical Connection: Units shall be furnished with single point power connection. Provide an electrical junction box with terminal strip for motor and other electrical terminations. The factory mounted terminal wiring strip consists of a multiple position screw terminal block. Plenum units provide a hinged electrical enclosure in the bottom of the unit for easy access to all electrical components, terminal blocks and wiring.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive fan-coil units for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before fan-coil-unit installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install fan-coil units level and plumb.
- B. Install fan-coil units to comply with NFPA 90A.
- C. Suspend fan-coil units from structure with specified vibration isolation. Vibration isolators are specified in Division 23, Vibration Controls for HVAC Piping and Equipment.
- D. Install new filters in each fan-coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
 - 1. Install piping adjacent to machine to allow service and maintenance.
 - 2. Connect condensate drain to indirect waste.
 - a. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.
 - 3. Secondary Drain Pan – Install secondary drain pan and liquid detector wired back to fan coil unit terminal strip to shut down unit and alarm BAS upon detection.
- B. Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Division 23, Air Duct Accessories. Comply with safety requirements in UL 1995 for duct connections.
- C. Ground equipment according to Division 26, Grounding and Bonding for Electrical Systems.
- D. Connect wiring according to Division 26, Low-Voltage Electrical Power Conductors and Cables.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Occupancy Adjustments: When requested within 12 months of 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.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fan-coil units. Refer to Division 01, Demonstration and Training.
 1. Provide sixteen (16) hours of training divided into two (2) session of eight (8) hours each.

END OF SECTION

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SECTION 250000 - INSTRUMENTATION AND CONTROL 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. ~~section 200000~~**Division 20 for-** mechanical and electrical requirements
 2. ~~section 230500~~**Division 23 for** common work results for hvac
 3. **Division 23 for** ~~section 230513~~ common motor requirements
 4. **Division 23 for** ~~section 230995~~ laboratory air control system
 5. **Division 23 for** ~~section 232500~~ hvac water treatment
 6. **Division 23 for** ~~section 232923~~ variable frequency drives
 7. **Division 23 for** ~~section 233600~~ air terminal units
 8. **Division 23 for** ~~section 235700~~ heat exchangers for hvac
 9. **Division 23 for** ~~section 237313~~ air handling units
 10. **Division 23 for** ~~section 238219~~ fan coil units
 11. **Division 23 for** ~~section 238236~~ finned tube radiation
 12. **Division 23 for** ~~section 238239~~ propeller unit heaters
 13. **Division 23 for** ~~section 238413~~ humidifiers
 14. Sections reference in following article of this section that may not be listed above.

1.2 SUMMARY

- A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.
- B. This section includes the enabling/disabling, monitoring, alarming, set point reset and measure variable signaling of equipment equipped with manufacturer's based controller (OEM Controller).
- C. The instrumentation and control system shall be comprised of Java Application Control Engine (JACE) controllers within the building. The JACE shall connect to the UNCC existing network. Access to the system shall be accomplished through a standard Web browser via the internet and/or local area network. The JACE shall communicate directly with LonMark/LonTalk (IDC), BACnet (IBC), MODBUS or other open or legacy protocol system/devices.

- D. JACEs shall have surge protection and protected via UPS. BACnet and control trunks shall be protected by single pair (two-wire) *V Din Rail Dataline Surge protectors or equal. Electrical meters shall be protected by surge protectors.
- E. JACEs shall be version 4.5.96.28.1 or the current version of the UNCC web supervisor. Confirm with UNCC FIS during commissioning.
- F. The instrumentation and control system shall be based on the Niagara AX Framework (Niagara AX), a Java based framework developed by Tridium.

1.3 DEFINITIONS

- A. DDC: Direct digital control.
- B. I/O: Input/output.
- C. MS/TP: Master slave/token passing.
- D. PC: Personal computer.
- E. PID: Proportional plus integral plus derivative.
- F. RTD: Resistance temperature detector.
- G. BACnet: a building automation and control networking protocol established by ASHRAE as Standard 135.

1.4 SYSTEM PERFORMANCE

- A. Comply with the following performance requirements:
 - 1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
 - 2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
 - 3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
 - 4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
 - 5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
 - 6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
 - 7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
 - 8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
 - a. Water Temperature: Plus or minus 1 deg F.
 - b. Water Flow: Plus or minus 5 percent of full scale.
 - c. Water Pressure: Plus or minus 2 percent of full scale.
 - d. Space Temperature: Plus or minus 1 deg F.
 - e. Ducted Air Temperature: Plus or minus 1 deg F.
 - f. Outside Air Temperature: Plus or minus 2 deg F.

- g. Dew Point Temperature: Plus or minus 3 deg F.
 - h. Temperature Differential: Plus or minus 0.25 deg F.
 - i. Relative Humidity: Plus or minus 5 percent.
 - j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
 - k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
 - l. Airflow (Terminal): Plus or minus 10 percent of full scale.
 - m. Air Pressure (Space): Plus or minus 0.01-inch wg.
 - n. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
 - o. Carbon Monoxide: Plus or minus 5 percent of reading.
 - p. Carbon Dioxide: Plus or minus 50 ppm.
 - q. Electrical: Plus or minus 5 percent of reading.
- B. All BACnet network switches shall be Contemporary Controls Skorpion Switch 10/100/1000 or approved equal. 10BASE-T/100BASE-TX/100BASE-FX compliant 1000BASE-T (GT models) Auto-MDIX on all copper ports Auto-negotiated data rate, duplex and flow control on twisted-pair ports, DIN-rail mountable Full or half-duplex Activity/link and data rate LEDs Industrial environment EMC CE Mark UL 508 Listed, C-UL Listed Industrial Control Equipment. 10-36 VDC or 24 VAC ($\pm 10\%$) 47-63 Hz Power is provided through a quick-disconnect terminal strip.

1.5 SEQUENCE OF OPERATION

- A. Sequences of operation shall be as shown on the drawings.

1.6 ACTION SUBMITTALS

- A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
- 1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
 - 2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
 - 3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- 1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
 - 2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
 - 3. Wiring Diagrams: Power, signal, and control wiring.

4. Wiring layouts showing the order in which equipment is connected
 5. Details of control panel faces, including controls, instruments, and labeling.
 6. Written description of sequence of operation.
 7. Schedule of dampers including size, leakage, and flow characteristics.
 8. Schedule of valves including flow characteristics.
 9. DDC System Hardware:
 - a. Wiring diagrams for control units with termination numbers.
 - b. Schematic diagrams and floor plans for field sensors and control hardware.
 - c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
 10. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
 11. Controlled Systems:
 - a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
 - b. Scaled drawings showing mounting, routing, and wiring of all elements of the control system including instruments, sensors, panels, etc. including bases and special construction.
 - c. Written description of sequence of operation including schematic diagram.
 - d. Points list.
 12. Shop drawings will include and identify any interface and interoperability between the BAS and laboratory air control system, OEM equipment controllers and laboratory equipment monitoring systems.
- C. Samples for Initial Selection: For each color required, of each type of thermostat or sensor cover with factory-applied color finishes.
- D. Samples for Verification: For each color required, of each type of thermostat or sensor cover.
- E. Shop drawings will be reviewed by the Owner prior to acceptance.
- F. Shop drawings shall be submitted in PDF and Visio format.
- 1.7 INFORMATIONAL SUBMITTALS
- A. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135 (BACnet).
 - B. Qualification Data: For Installer and manufacturer.
 - C. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.
 - D. Field quality-control test reports.

1.8 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. Manuals shall be provided in searchable PDF format. In addition to items specified in Division 01, Operation and Maintenance Data, include the following:
 - 1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.
 - 2. Interconnection wiring diagrams with identified and numbered system components and devices.
 - 3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
 - 4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
 - 5. Calibration records and list of set points.
- B. Software and Firmware Operational Documentation: Include the following:
 - 1. Software operating and upgrade manuals.
 - 2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
 - 3. Device address list.
 - 4. Printout of software application and graphic screens.
 - 5. Software license required by and installed for DDC workstations and control systems.

1.9 QUALITY ASSURANCE

- A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with ASHRAE 135 for DDC system components.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.
- B. System Software: Update to latest version of software at Project completion.

1.11 COORDINATION

- A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

- B. Coordinate equipment with Division 28, Digital, Addressable Fire-Alarm System and Division 28, Zoned (DC Loop) Fire-Alarm System to achieve compatibility with equipment that interfaces with that system.
- C. Coordinate supply of conditioned electrical branch circuits for control units
- D. Coordinate equipment with Division 26, Electrical Power Monitoring and Control to achieve compatibility of communication interfaces.
- E. Coordinate equipment with Division 26, Panelboards to achieve compatibility with starter coils and annunciation devices.
- F. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03, Cast-in-Place Concrete.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 CONTROL SYSTEM

- A. Available Manufacturers:
 - 1. Johnson Controls Incorporate Facilities Explorer (JCI FX) using open protocol BACnet.
 - 2. Platinum Building Automation.
 - 3. Schneider Electric Controls Invensys I/A series BACnet. (Owner Preference, see Alternate 07).
- B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.
- C. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.
- D. Controls contractor shall export tag all graphics and join them to the web supervisor. Contactor to bring all utilized points into Fin Stack. Points shall be tagged and renamed to match haystack and UNCC model.

- E. Proposed graphics shall be submitted to UNCC for review and approval prior to acceptance.

2.3 DDC EQUIPMENT

- A. Operator Workstation: Not Required
- B. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.
 - 1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
 - 2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
 - a. Global communications.
 - b. Discrete/digital, analog, and pulse I/O.
 - c. Monitoring, controlling, or addressing data points.
 - d. Software applications, scheduling, and alarm processing.
 - e. Testing and developing control algorithms without disrupting field hardware and controlled environment.
 - 3. Standard Application Programs:
 - a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.
 - b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
 - c. Chiller Control Programs: Control function of condenser-water reset, chilled-water reset, and equipment sequencing.
 - d. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
 - e. Remote communications.
 - f. Maintenance management.
 - g. Units of Measure: Inch-pound and SI (metric).
 - 4. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
 - 5. ASHRAE 135 Compliance (BACnet): Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
- C. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
 2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
 - a. Global communications.
 - b. Discrete/digital, analog, and pulse I/O.
 - c. Monitoring, controlling, or addressing data points.
 3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
 4. ASHRAE 135 Compliance (BACnet): Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
- D. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.
1. Binary Inputs: Allow monitoring of on-off signals without external power.
 2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
 3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
 4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.
 5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.
 6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
 7. Universal I/Os: Provide software selectable binary or analog outputs.
- E. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:
1. Output ripple of 5.0 mV maximum peak to peak.
 2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
 3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.
- F. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:
1. Minimum dielectric strength of 1000 V.
 2. Maximum response time of 10 nanoseconds.
 3. Minimum transverse-mode noise attenuation of 65 dB.
 4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.4 UNINTERRUPTIBLE POWER SUPPLY

- A. Entire BAS network including controllers, input devices, output devices, alarms, safeties, actuators, instrumentation etc. shall be operational on BAS contractor provided online double conversion uninterruptible power supply (UPS). The entire network, control system and sequences of operation described in the documents shall be fully operational (it is understood that some mechanical devices such as fan and pumps may not have power while the BAS is operating on its UPS) while operating on the UPS for at least 15 minutes.
1. Capacity (VA or watts) and quantity of UPS units shall be determined by the contractor
 2. UPS shall be equipped with hard wired terminals, input and output
 3. UPS shall be true on-line, double conversion topology with integral automatic bypass
 4. Input:
 - a. Grounded single phase
 - b. Bypass voltage 96 to 138 VAC (user selectable)
 - c. Input voltage range 80 to 144 VAC
 - d. Input frequency 50/60 HZ auto sensing
 - e. AC frequency range 45 to 65 HZ
 5. Output
 - a. 110 to 127 VAC
 - b. +/- 2% voltage regulation
 - c. Less than 5% THD voltage distortion with non-linear loads
 - d. Less than 3% THD voltage distortion with linear loads
 - e. Frequency regulation of +/- 0.25 HZ while on battery or in free run mode
 - f. Dynamic response +/- 9% maximum from 100% to 20% or from 20% to 100% linear load
 - g. Overload capacity 100% to 125% for at least 60 seconds; 125% to 150% for at least 10 seconds.
 6. Operating temperature range -40 degrees F to 140 degrees F.

2.5 UNITARY CONTROLLERS

- A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.

1. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.
2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform automatic system diagnostics; monitor system and report failures.
3. ASHRAE 135 Compliance (BACnet): Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.
- 4.
5. Enclosure: Dustproof rated for operation at 32 to 120 deg F.
6. Enclosure: Waterproof rated for operation at 40 to 150 deg F.

2.6 ALARM PANELS

- A. Unitized cabinet with suitable brackets for wall or floor mounting. Fabricate of 0.06-inch-thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish.
- B. Indicating light for each alarm point, single horn, acknowledge switch, and test switch, mounted on hinged cover.
 1. Alarm Condition: Indicating light flashes and horn sounds.
 2. Acknowledge Switch: Horn is silent and indicating light is steady.
 3. Second Alarm: Horn sounds and indicating light is steady.
 4. Alarm Condition Cleared: System is reset and indicating light is extinguished.
 5. Contacts in alarm panel allow remote monitoring by independent alarm company.

2.7 ANALOG CONTROLLERS

- A. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.
- B. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 deg F, and single- or double-pole contacts.
- C. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.
 1. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.

2.8 ELECTRONIC SENSORS

- A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.
- B. Thermistor Temperature Sensors and Transmitters:

1. Manufacturers:
 - a. BEC Controls Corporation.
 - b. Ebtron, Inc.
 - c. Heat-Timer Corporation.
 - d. I.T.M. Instruments Inc.
 - e. MAMAC Systems, Inc.
 - f. RDF Corporation.
 2. Accuracy: Plus or minus 0.5 deg F at calibration point.
 3. Wire: Twisted, shielded-pair cable.
 4. Insertion Elements in Ducts: Single point, 18 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft..
 5. Averaging Elements in Ducts: 72 inches long, flexible; use where prone to temperature stratification or where ducts are larger than 10 sq. ft..
 6. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches.
 7. Private Offices and Conference Rooms, Room Sensor Cover Construction shall be manufacturer's standard locking covers
 - a. Display of measured variable
 - b. Adjustment knob in units of measured variable.
 - c. Occupancy override button (momentary contact)
 - d. Color: Ivory
 - e. Orientation: horizontal
 8. Other than Private Offices and Conference rooms, Room Sensor Cover Construction shall be Manufacturer's standard locking covers.
 - a. No display of measure variable
 - b. "warmer/cooler" adjustment knob
 - c. Occupancy override button (momentary contact).
 - d. Color: Ivory.
 - e. Orientation: Horizontal.
 9. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
 10. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.
- C. RTDs and Transmitters:
1. Manufacturers:
 - a. BEC Controls Corporation.
 - b. MAMAC Systems, Inc.
 - c. RDF Corporation.
 2. Accuracy: Plus or minus 0.2 percent at calibration point.
 3. Wire: Twisted, shielded-pair cable.
 4. Insertion Elements in Ducts: Single point, 18 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft..

5. Averaging Elements in Ducts: 48 inches long, rigid; use where prone to temperature stratification or where ducts are larger than 9 sq. ft.; length as required.
 6. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.
 7. Room Sensor Cover Construction: Manufacturer's standard locking covers.
 - a. No display of measure variable
 - b. "warmer/cooler" adjustment knob
 - c. Occupancy override button
 - d. Color: Ivory
 - e. Orientation: Horizontal.
 8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
 9. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.
- D. Humidity Sensors: Bulk polymer sensor element.
1. Manufacturers:
 - a. BEC Controls Corporation.
 - b. General Eastern Instruments.
 - c. MAMAC Systems, Inc.
 - d. ROTRONIC Instrument Corp.
 - e. TCS/Basys Controls.
 - f. Vaisala.
 2. Accuracy: 5 percent full range with linear output.
 3. Room Sensor Range: 20 to 80 percent relative humidity.
 4. Room Sensor Cover Construction: Manufacturer's standard locking covers.
 - a. No display of measure variable
 - b. "higher/lower RH" adjustment knob
 - c. Occupancy override button
 - d. Color: Ivory.
 - e. Orientation: Horizontal.
 5. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.
 6. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of minus 22 to plus 185 deg F.
 7. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.
- E. Pressure Transmitters/Transducers:
1. Manufacturers:
 - a. BEC Controls Corporation.
 - b. General Eastern Instruments.

- c. MAMAC Systems, Inc.
 - d. ROTRONIC Instrument Corp.
 - e. TCS/Basys Controls.
 - f. Vaisala.
2. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
 - a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
 - b. Output: 4 to 20 mA.
 - c. Building Static-Pressure Range: 0- to 0.25-inch wg.
 - d. Duct Static-Pressure Range: 0- to 5-inch wg.
 3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.
 4. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.
 5. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
 6. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

2.9 STATUS SENSORS

- A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.
- B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig, piped across pump.
- C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.
- D. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.
- E. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.
- F. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.
- G. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
- H. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

2.10 GAS DETECTION EQUIPMENT

A. Manufacturers:

1. B. W. Technologies.
2. Ebtron, Inc.
3. Honeywell International Inc.; Home & Building Control.
4. TSI Incorporated.
5. Vaisala.

- B. Carbon Dioxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 23 to 130 deg F and calibrated for 0 to 2 percent, with continuous or averaged reading, 4- to 20-mA output; for wall mounting.

2.11 FLOW MEASURING STATIONS

- A. Duct Airflow Station: Combination of air straightener and multiport, self-averaging pitot tube station.

1. Manufacturers:

- a. Air Monitor Corporation.
- b. Wetmaster Co., Ltd.
- c. Ruskin

2. Casing: Galvanized-steel frame.
3. Flow Straightener: Aluminum honeycomb, 3/4-inch parallel cell, 3 inches deep.
4. Sensing Manifold: Copper manifold with bullet-nosed static pressure sensors positioned on equal area basis.

2.12 HUMIDISTATS

A. Manufacturers:

1. MAMAC Systems, Inc.
2. ROTRONIC Instrument Corp.
3. Honeywell

- B. Duct-Mounting Humidistats: Electric insertion, 2-position type with adjustable, 2 percent throttling range, 20 to 80 percent operating range, and single- or double-pole contacts.

2.13 ACTUATORS

A. Manufacturers shall be limited to

1. Belimo Aircontrols (USA), Inc.

- B. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

1. Comply with requirements in Division 23, Common Motor Requirements for HVAC Equipment.
 2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
 3. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
 4. Spring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.
 5. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
 6. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
- C. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
1. Valves: Size for torque required for valve close off at maximum pump differential pressure.
 2. Dampers: Size for running torque calculated as follows:
 - a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.
 - b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
 - c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft. of damper.
 - d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
 - e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
 - f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.
 3. Coupling: V-bolt and V-shaped, toothed cradle.
 4. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
 5. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
 6. Power Requirements (Two-Position Spring Return): Maximum 10 VA at 24-V ac or 8 W at 24-V dc. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
 7. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
 8. Temperature Rating: Minus 22 to plus 122 deg F.
 9. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F.
 10. Run Time: 12 seconds open, 5 seconds closed.
 11. Inlet-Vane Operators: High pressure, with pilot positioners.

2.14 CONTROL VALVES

- A. Manufacturers, other than valves serving equipment noted below shall be:
1. Danfoss Inc.; Air Conditioning & Refrigeration Div.
 2. Erie Controls.

3. Hayward Industrial Products, Inc.
 4. Magnatrol Valve Corporation.
 5. Neles-Jamesbury.
- B. Manufacturers of 2-way control valves serving air handling units, chilled beams and fan coil units shall be limited to:
1. Belimo Aircontrols Inc. Energy Valves.
- C. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
1. PICCV control valves shall be used for control of all chilled water, heating hot water and energy recovery valves at the air handler coils and service entrance heat exchangers.
 2. Control valves serving heating hot water re-heat coils shall be one of the three options below. Contractor to identify costs associated with each selection.
 - a. PICCV control valves
 - b. Belimo PIQCV valves
 - c. Conventional pressure dependent valves.
- D. Hydronic system globe valves shall have the following characteristics:
1. NPS 2 and Smaller: Class 250 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
 2. NPS 2-1/2 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
 3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.
 - a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
 - b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.
 4. Sizing: 5-psig maximum pressure drop at design flow rate or the following:
 - a. Two Position: Line size.
 - b. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
 - c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.
 5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
 6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

- E. Butterfly Valves: 200-psig, 150-psig maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.
 - 1. Body Style: Lug.
 - 2. Disc Type: Nickel-plated ductile iron.
 - 3. Sizing: 1-psig maximum pressure drop at design flow rate.
- F. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.
 - 1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
 - 2. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.
 - 3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

2.15 DAMPERS

- A. Manufacturers:
 - 1. Air Balance Inc.
 - 2. Ruskin.
 - 3. TAMCO (T. A. Morrison & Co. Inc.).
 - 4. United Eneritech Corp.
 - 5. Vent Products Company, Inc.
- B. Dampers: AMCA-rated, opposed-blade design; 0.108-inch- minimum thick, galvanized-steel or 0.125-inch- minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- thick galvanized steel with maximum blade width of 8 inches and length of 48 inches.
 - 1. Secure blades to 1/2-inch- diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
 - 2. Operating Temperature Range: From minus 40 to plus 200 deg F.
 - 3. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.
 - 4. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4-inch wg when damper is held by torque of 50 in. x lbf; when tested according to AMCA 500D.

2.16 CONTROL CABLE

- A. Electronic and fiber-optic cables for control wiring are specified in Division 27, Communications Horizontal Cabling.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that conditioned power supply is available to control units and operator workstation.
- B. Verify that pneumatic piping and duct-, pipe-, and equipment-mounted devices are installed before proceeding with installation.

3.2 INSTALLATION

- A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.
- B. Connect and configure equipment and software to achieve sequence of operation specified.
- C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices as directed by Architect above the floor.
 - 1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
- D. Install guards on thermostats in the following locations:
 - 1. Entrances.
 - 2. Public areas.
 - 3. Where indicated.
- E. Install automatic dampers according to Division 23, Air Duct Accessories.
- F. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.
- G. Install labels and nameplates to identify control components according to Division 23, Identification for HVAC Piping and Equipment.
- H. Install hydronic instrument wells, valves, and other accessories according to Division 23, Hydronic Piping.

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. Provide raceways, boxes, and cabinets necessary for a complete and functional system according to Division 26, Raceways and Boxes for Electrical Systems.
- B. Provide building wire and cable necessary for a complete and functional system according to Division 26, Low-Voltage Electrical Power Conductors and Cables.
- C. Provide signal and communication cable necessary for a complete and functional system according to Division 27, Communications Horizontal Cabling.
- D. General requirements

1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
 2. Install all wiring and cables in raceway.
 3. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.
 4. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
 5. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
 6. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
- E. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
- F. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.
- G. All power for all products associated with the instrumentation and controls system shall be distributed by the instrumentation and controls contractor. The power shall come from circuits in electric panels provided by Division 26. Circuits for use by instrumentation and controls contractor shall be on emergency power. Circuits available for use are to be coordinated with the electrical contractor (Division 26) by the instrumentation and controls contractor.
1. To accomplish this requirement, the instrumentation and controls contractor shall procure the services of an electrician with the proper credentials and licensed in the jurisdiction of the project.
 - a. At the instrumentation and controls contractor's option, the project electrical (division 26) contractor may be hired by the instrumentation and controls contractor to perform this work or another electrician with the proper credentials and licensed in the jurisdiction of the project may be hired by the instrumentation and controls contractor for these services or, if the instrumentation and control contractor has proper credentials and is licensed in the jurisdiction of the project to perform electrical work, the instrumentation and controls contractor may self-perform the necessary scope.
 2. The instrumentation and controls contractor shall supply the circuit breaker for installation in the designated electrical panel by the Division 26 contractor. Coordinate with the division 26 contractor for the appropriate make and model circuit breaker. Instrumentation and controls contractor shall provide the 120V power distribution wiring and raceways from the circuit breaker to the final locations of the Instrumentation and Controls products necessary for a complete and functional system.
 3. The power shall be obtained from dedicated circuits in 120V panels. Instrumentation and controls contractor shall coordinate with electrical (division 26) contractor to provide accurate panel schedules at project closeout.
 4. All power wiring for the instrumentation and controls products shall be done with a dedicated earth ground by means of copper wire media only, originating at the power service source earth ground. This applies to all products.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
 - 2. Test and adjust controls and safeties.
 - 3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
 - 4. Test each point through its full operating range to verify that safety and operating control set points are as required.
 - 5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
 - 6. Test each system for compliance with sequence of operation.
 - 7. Test software and hardware interlocks.
- C. DDC Verification:
 - 1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
 - 2. Check instruments for proper location and accessibility.
 - 3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
 - 4. Check instrument tubing for proper fittings, slope, material, and support.
 - 5. Check installation of air supply for each instrument.
 - 6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
 - 7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
 - 8. Check temperature instruments and material and length of sensing elements.
 - 9. Check control valves. Verify that they are in correct direction.
 - 10. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
 - 11. Check DDC system as follows:
 - a. Verify that DDC controller power supply is from emergency power supply, if applicable.
 - b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
 - c. Verify that spare I/O capacity has been provided.
 - d. Verify that DDC controllers are protected from power supply surges.
- D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.5 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:
 - a. Check analog inputs at 0, 50, and 100 percent of span.
 - b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
 - c. Check digital inputs using jumper wire.
 - d. Check digital outputs using ohmmeter to test for contact making or breaking.
 - e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
5. Flow:
 - a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
 - b. Manually operate flow switches to verify that they make or break contact.
6. Pressure:
 - a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
 - b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
7. Temperature:
 - a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
 - b. Calibrate temperature switches to make or break contacts.
8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

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

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 01, Demonstration and Training.
 - 1. Provide thirty two (32) hours of training divided into four (4) session of eight (8) hours each.

3.7 OEM CONTROLLER INTEGRATION

- A. This Section specifies the requirements for interfacing to the original equipment manufacturers (OEM) packaged control systems provide with all equipment specified in sections listed in Part 1
- B. The BCS Contractor shall be responsible for the development and application of all necessary programming code and the provision of all necessary hardware to allow the OEM packaged control system and the BCS to communicate with one another.
- C. The BCS Contractor shall, at his option, provide communication systems developed by the OEM, if available, for the purposes set forth here-in.
- D. Requirements for all Equipment:
 - 1. Provide for monitoring, alarming, start/stop and setpoint reset control for all equipment as applicable.
 - 2. Communications from equipment shall provide for real time process variable (temperature pressure, etc.) and status information.
 - 3. The intent is all information available at the OEM controller be communicated to the BCS
- E. Software Installation:
 - 1. The BCS Contractor shall provide all labor necessary to install, initialize, start-up and debug all system software as described in this Section. This includes any operating system software or other third party software necessary for successful operation of the system.

END OF SECTION

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