INVITATION FOR BIDS
GHTD IFB #02-024

HVAC EQUIPMENT REPLACEMENT
(UNION STATION)

GREATER HARTFORD TRANSIT DISTRICT
HARTFORD, CT

November 7, 2023

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NOTICE
GREATER HARTFORD TRANSIT DISTRICT
INVITATION FOR BIDS
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HVAC EQUIPMENT REPLACEMENT (UNION STATION)

The Greater Hartford Transit District (GHTD), Hartford, Connecticut, a municipal corporation formed under Chapter 103a of the Connecticut General Statutes, Revision of 1958, as amended, is seeking bids from qualified firms for a licensed HVAC contractor to provide replacement of the commercial-grade HVAC Equipment, deemed as having met or nearing its useful life, at the Union Station Transportation Center Complex located at One Union Place, Hartford, CT, 06103. All work details are indicated in the Bid Documents. Bid documents including drawings and specifications will be available on or after **Tuesday, November 7, 2023**. Bid documents will be available on the District's website at: https://www.hartfordtransit.org/business-opportunities/ and on the State of Connecticut DAS Contracting Portal at https://portal.ct.gov/DAS/CTSource/CTSource.

Bids shall be submitted to LaShaunda Drake, Greater Hartford Transit District, One Union Place, First Floor North, Hartford, CT. 06103, on or before **10:00 a.m. local time on Thursday, January 4, 2024**. There will be a public bid opening at 10:10 a.m. local time held via zoom. **A Virtual Pre-Bid Conference will be held by the District on Wednesday, November 15, 2023, 11:00 AM local time via Zoom**, to provide an opportunity to outline the requirements the District will expect of the Bidder, as well as to provide the opportunity for questions and explanations. The **Virtual Pre-Bid Conference will be followed by an In-Person Site Visit Walk-Through on Wednesday, November 15, 2023 at 2:00 pm**. at the project site located at One Union Place, Hartford, CT, 06103. **Attendance at the Pre-Bid Conference and In-Person Site Visit Walk-Through is mandatory and a condition for final award.**

Questions concerning the bidding process should be submitted in writing to LaShaunda Drake, Contract and Procurement Specialist, at ldrake@ghtd.org.

Bids received after the deadline will not be considered and will be returned to the bidder unopened. Any changes, or any requests for changes in the specifications, will not be recognized after sealed bids are submitted to the District.

Any contract resulting from this invitation for bids is subject to a financial assistance contract between the District and the Federal Transit Administration and the District and the State of Connecticut. All bidders will be required to certify that they are not on the Comptroller General's list of ineligible contractors. Further, the contractor will be required to comply with all applicable equal employment opportunity laws and regulations.

The GHTD hereby notifies all bidders that in regard to any contract entered into pursuant to this Invitation for Bids, advertisement or solicitation, disadvantaged business enterprises will be afforded full opportunity to submit proposals in response, and will not be subjected to discrimination on the basis of race, color, sex or national origin in consideration for an award.

The GHTD reserves the right to reject any and all bids as submitted by this Invitation for Bids, and to waive informalities and irregularities, as it deems in its best interest.

IFB KEY INFORMATION SUMMARY SHEET

Invitation for Bids:	HVAC Equipment Replacement (Union Station)
Solicitation Number:	IFB #02-024
IFB Issue Date:	November 7, 2023
IFB Issuing Office:	Greater Hartford Transit District
Procurement Officer:	LaShaunda Drake Contract and Procurement Specialist Greater Hartford Transit District One Union Place Hartford, CT 06103 Direct Phone: (860) 380-2012 Email: ldrake@ghtd.org
Proposal to be sent to:	Greater Hartford Transit District One Union Place Hartford, CT 06103 Attn: LaShaunda Drake
Virtual Pre-Bid Conference: ***Participation Is Mandatory***	November 15, 2023 at 11:00 a.m. Local Time Web Meeting via Zoom https://us06web.zoom.us/j/83477258663?pwd=EKZ4JcAmpGKgWvAPKnbL2YXTTaqhs4.1 Meeting ID: 834 7725 8663 Passcode: 088204 To call in by phone: (929) 205 6099
Site Visit: ***Participation Is Mandatory***	November 15, 2023 at 2:00 p.m. Local Time One Union Place Hartford, CT 06103
Approved Equals Request Deadline:	November 28, 2023 at 12:00 p.m. Local Time
Inquiries Deadline:	November 28, 2023 at 12:00 p.m. Local Time
Bid Due Date and Time:	January 4, 2024 at 10:00 a.m. Local Time Bid opening promptly at 10:10 a.m. Local Time Web Meeting via Zoom https://us06web.zoom.us/j/89429014241?pwd=YfJYUApMV5jlkWjojOUwa23WDbXzl4.1 Meeting ID: 894 2901 4241 Passcode: 402710 To call in by phone: (929) 205 6099

SECTION I – GENERAL INFORMATION FOR BIDDERS

1. INTRODUCTION

The Greater Hartford Transit District (the "District") is a quasi-municipal corporation operating under the authority of Chapter 103a of the Connecticut General Statutes. There are currently sixteen-member towns represented by appointees who collectively form the Board of Directors, the policy making body of the District. The District has broad powers to acquire, operate, finance, plan, develop, maintain and otherwise provide all forms of land transportation and related services including the development or renewal of transportation centers and parking facilities.

The District is eligible and authorized under state and local law to request, receive, and manage grant funds and to execute and administer grant-funded projects. The District provides a variety of services in support of public transportation in the Capitol Region of Connecticut. The contract awarded as a result of this quote solicitation will be subject to both State of Connecticut and Federal Contract Clauses.

The District is the owner and operator of Hartford's Historic Union Station Transportation Center Complex, an intermodal hub of transportation that currently serves Amtrak rail, CTrail, intercity and intra city bus service, taxi services, and public parking. The Complex includes the Spruce Street Parking Lot. The District is also the owner of the Greater Hartford Transit District ADA Paratransit Operations and Maintenance Facility (the "Facility") located at 148 Roberts Street in East Hartford, CT.

The District, as the owner and operator of Hartford's Union Station issues this formal Invitation for Bids (IFB) from qualified firms for a licensed HVAC contractor to replace existing HVAC equipment which has met or nearing its useful life, located at One Union Place, Hartford, CT 06103. The scope of work for this project is based on, and is expected to be performed in accordance with, the HVAC equipment replacement plan as developed by the assigned Architectural and Engineering firm, AI Engineers, Inc.

The specifics of the services, and other documents relevant to this IFB, are set forth in the Scope of Services and in the Exhibits attached hereto and made a part hereof.

2. SUBMISSION OF BIDS

In order to respond, the Candidate must supply the required information on and along with the response forms. An officer or explicit agent of your organization must sign the response form and any supplementary proposal document.

a) Date and Location for Submittal

Bids must be submitted to the District on or before **Thursday, January 4, 2024 at 10:00 a.m. local time**. There will be a public bid opening at 10:10 a.m. local time held via Zoom.

To join the meeting:
https://us06web.zoom.us/j/89429014241?pwd=YfJYUApMV5jlkWjojOUwa23WDbXzl4.1
Meeting ID: 894 2901 4241
Passcode: 402710

To call in by phone: (929) 205 6099

Each bid shall be enclosed in a sealed envelope and clearly marked “GHTD IFB #02-024 HVAC EQUIPMENT REPLACEMENT (UNION STATION)” on the front thereon. Bids should be delivered to:

LaShaunda Drake
Contract and Procurement Specialist
Greater Hartford Transit District
One Union Place
Hartford, Connecticut 06103
(860) 380-2012

Late submissions will not be accepted. It is the responsibility of the Respondent to ensure that its Proposal is delivered to the District by the date and time referred to hereinabove. Delivery by facsimile or any other electronic means **will not** be accepted.

All bids received prior to the bid opening date will be kept unopened until the time of the bid opening. The person whose duty it is to open the bids will determine when the time stated for opening has arrived. All bids will be opened in public at the bid opening. Any person present shall have the right to have any part of the bids read aloud. The District reserves the right to postpone the bid opening if it is determined to be in the best interest of the District.

b) Form of Bid

One copy of the bid form shall be completed, signed and submitted. No other form of bid or proposal will be acceptable.

Every designated space on the bid form shall be filled in or otherwise marked to show the bidder’s intention clearly. Interlineations, alterations, erasures or any other change must be clearly initialed by the bidder. All amounts shall be stated in figures. The bid form is to be submitted along with the Certifications and other documents required by this IFB. Any conditional or qualified bid will be rejected.

The bid form must be placed in the front of your bid packet submission prior to sealing in the envelope for ease of navigation for the bid opening.

3. BID INQUIRIES

Communication by any bidder with any agent or employee of the District on the subject of this IFB, or the pending process may result in the bidder being deemed ineligible with regard to this IFB. All questions and requests for clarification regarding this IFB or this process must be submitted in writing to LaShaunda Drake at ldrake@ghtd.org on or before **12:00 p.m. local time on Tuesday, November 28, 2023**. Responses shall be in writing and posted in the form of an addendum and will be distributed to all known recipients of the IFB document.

The bids submitted for the work must be based upon the text of this document including the General Information, Special Instructions, Specifications, all Addenda, and any referenced plans, and no oral or informal statement or representation by any representative or employee of the District or the designer shall be considered an amendment to or waiver of any statements in or requirement of such bidding or proposed contract documents and no claim or right of action shall accrue in favor of any respondent as a result of or founded on such oral or informal statements or representations. The District or its agents shall not be responsible for any oral instructions or interpretations given to a Bidder.

4. PRE-BID CONFERENCE

A Mandatory Virtual Pre-Bid Conference will be held by the District via Zoom on **Wednesday, November 15, 2023 at 11:00 a.m. local time**, for the purpose of outlining the requirements and service standards that the District will expect of the Contractor, as well as to provide the opportunity for questions and explanations. The Bidder may submit any written requests for clarification as well as any questions regarding this solicitation package prior to the pre-bid conference.

To join the meeting:
https://us06web.zoom.us/j/83477258663?pwd=EKZ4JcAmpGKgWvAPKnbL2YXTTaqhs4.1
Meeting ID: 834 7725 8663
Passcode: 088204
To call in by phone: (929) 205 6099

The District reserves the right to issue addenda to this IFB as a result of inquiries received, or to make adjustments to its project schedule if it is deemed in the District's best interest to do so. The District further reserves the right to reject any and all Proposals resulting from this RFP if the District deems that it is in the best interest of the District to do so.

5. SITE VISIT (IN-PERSON)

Information contained in these documents is provided in good faith only that all Proposers may have access to the same information utilized by the District, and is not intended as a substitute for personal investigations, interpretations and judgment of the Proposer.

A Mandatory In-Person Site Visit walk-through will be conducted on **Wednesday, November 25, 2023 at 2:00 pm.** at the project site located at One Union Place, Hartford, CT, 06103. Upon arrival, please check in with security and proceed to the first floor Great Hall to await further instructions.

Attendance at the Pre-Bid Conference and Site Visit is mandatory and is a condition for final award.

Submission of a bid shall be evidence that the Proposer has examined the site, compared it with the drawings and specifications and satisfied itself of the conditions existing at the site, the storage and handling of materials, and all other matters incidental to the work under this contract. No additional compensation will be allowed for difficulties which the Proposer could have discovered or reasonably anticipated prior to bidding.

6. COMMENCEMENT OF SERVICES

It is the intent of the District to execute an agreement with the successful bidder, and for work to commence upon execution of contract. Work under this contractual agreement is expected to be completed within **12 months**. The Contractor is expected to immediately communicate with the District any delays experienced which may impede the anticipated project timeline. The District will consider negotiations on the contract term if needed.

7. FUNDING

Any contract resulting from this Invitation for Bids is subject to a financial assistance contract between the District and the Federal Transit Administration and between the District and the State of Connecticut Department of Transportation. All firms will be required to certify that they are not on the U.S. Department of Transportation's list of ineligible contractors. Further, the contractor will be required to comply with all applicable equal employment opportunity laws and regulations.

No bids will be accepted from, or a Contract awarded to any person, firm, or corporation that is in arrears or is in default to the State of Connecticut upon any debt or contract or that is in default as a surety or in any other manner is in default of any obligation to the State. Additionally, no Contract shall be awarded to any person, firm, or corporation that has failed to perform on any prior or previous contract, agreement, or license with the State. Nor will any Contract be awarded to any firm that is not registered with the Secretary of State's Office to conduct business in the State of Connecticut.

8. FEDERAL GRANT REQUIREMENTS

Exhibit A attached hereto and made a part hereof sets forth federal requirements placed upon vendors who are participating in a project funded in whole or in part with Federal grants. Its provisions are hereby included herein as an integral part of this IFB.

9. STATE OF CONNECTICUT GRANT REQUIREMENTS

Contractor must comply with State Grant Requirements (Exhibit B).

10. PROCUREMENT AND APPEALS PROCESS

The District's procurement procedures and appeals process are contained in Exhibit C attached hereto and made a part hereof.

11. SPECIAL PROVISION

It is the policy of the District that Small Contractor and Small Contractor Minority Business Enterprises ("SBE and MBE") be afforded the maximum opportunity to participate in the performance of all contracts let by the District in accordance with Section 4a-60g of the Connecticut General Statutes as revised. This participation may be in the form of prime contracts, and/or sub-contracts, and/or direct or general overhead items procured from SBE and/or MBEs allocated to the Services.

For the purpose of this "Special Provision", the SBE/MBE named to satisfy this requirement must be certified by the Department of Administrative Services of the State of Connecticut (www.das.state.ct.us) as an SBE/MBE as defined by Section 4a-60g of the Connecticut General Statutes as revised or with the U.S. Small Business Administration.

Proposer will submit a statement indicating its own SBE/MBE status and what subcontracts and/or overhead purchases with amounts thereof under this project it will let. **There is no SBE/MBE contract goal for this contract**, however the District does have an annual SBE goal of **25%**. See attached Certification for SBEs. The use of SBE/MBE subcontractors is encouraged if feasible.

If the Contractor is unable to achieve the specified contract goals for the Special Provision, the Contractor must submit written documentation to the District indicating his/her good faith efforts to satisfy goal requirements.

12. DISADVANTAGED BUSINESS ENTERPRISE

It is the policy of the District that disadvantaged business enterprises ("DBE's") be afforded the maximum opportunity to participate in the performance of all contracts let by the District. This participation may be in the form of prime contracts, and/or sub-contracts, and/or direct or general overhead items procured from DBEs allocated to the Services. The term "disadvantaged business enterprise" means a business enterprise that is at least 51% owned and controlled by one or more socially disadvantaged persons. Such disadvantage may arise from cultural, racial, chronic economic circumstances or background, or other similar cause. Such persons would include but not be limited to citizens of the United States who are: African Americans (not of Hispanic origin); Hispanic Americans; Native Americans; Asian-Pacific Americans; and, women regardless of race and ethnicity. Proposers will submit a statement indicating its own DBE status and what subcontracts and/or overhead purchases with amounts thereof under this project it will get to comply with the District's DBE goal of **7%.** DBEs must be certified with the CTDOT.

If the Contractor is unable to achieve the specified contract goals, the Contractor must submit written documentation to the District indicating his/her good faith efforts to satisfy goal requirements. The bidder must present information on DBEs proposed to meet the goal as part of bid responsiveness (provided at the time of bid) or no later than five (5) calendar days after bid opening as a matter of responsibility**.** An example of a good faith effort includes whether the contractor provided written notice to a reasonable number of DBEs with potential interest in the contract and with sufficient time to allow participation. It is important to note that DBEs are certified to perform certain types of work. To receive credit for good faith efforts and to count towards goal attainment, named DBEs must be certified to do the scopes of work that they are contacted/contracted to perform.

The District is a part of the State of Connecticut Department of Transportation Unified Certification Program ("UCP") and any contractor and/or sub-contractor and/or vendor utilized to meet the DBE Participation requirements must be certified through that UCP. A list of CTDOT Certified DBE vendors can be found at: http://www.biznet.ct.gov/dot_dbe/dbesearch.aspx. Upon request, the District will provide information related to the state certification process.

13. VALIDITY OF PROPOSALS

Bidders agree that their proposals remain valid for a period of one hundred eighty (180) days after the above cited due date for submission of bids and may be extended beyond that time by mutual agreement.

By responding to this IFB, the bidder implicitly states that the bid is not made in connection with any competing firm submitting a separate response to this IFB, and is in all respects fair and without collusion or fraud. It is further implied that the bidder did not participate in the District's IFB development process, had no knowledge of the specific contents of this IFB prior to its issuance, and that no employee of the District participated directly or indirectly in the firm's bid preparation.

Please note that the costs associated with the preparation of a Bid are the sole responsibility of the applicable Bidder. Bidder shall not include any such expenses as part of the price proposed in response to the IFB.

14. INFORMATION TO BIDDERS

(a) Discrepancy in Bid Documents

If a bidder becomes aware of any discrepancy, ambiguity, error or omission in this solicitation package, he or she shall report it to the District's representative, LaShaunda Drake, ldrake@ghtd.org, Greater Hartford Transit District, One Union Place, Hartford, CT 06103. The District will determine the necessity for clarification and may issue addenda as a result.

Any interpretation, change, clarification or correction in the bid documents will be made only by written instrument(s) issued by the District. Copies of such instrument(s) will be emailed or delivered to each person, firm or corporation which has received this IFB document.

(b) Brand Names

If present, brand, manufacturer or product names are indicated on the plans or in the specifications only for the purpose of establishing identification and a general description of the item(s) sought. Items of equal quality, not bearing such names, may be submitted in the bid, provided however that prior approval for the item is obtained from the District.

(c) Requests for Clarification

Requests for clarification of plans or specifications and any protest thereof must be received by the District, in writing, to LaShaunda Drake at ldrake@ghtd.org on or before **12:00 p.m. local time on Tuesday, November 28, 2023.** Responses shall be in writing and posted in the form of an addendum and will be distributed to all known recipients of the IFB document.

Requests for Approved Equal Status

In all cases, materials must be furnished as specified. Where brand names or specific items are used in the plans or specifications, consider the term "or approved equal" to follow.

Any unapproved deviations, exceptions, substitutions, alternates or conditional qualifications contained in a proposal may be cause for its rejection. If contractors believe that their product is an equal to the product specified, they must submit a written request to District in triplicate and this request will be approved or rejected by the District at least fifteen (15) calendar days prior to the scheduled opening of the bids. Requests for approved equals must be received by the District in writing by **12:00 p.m. local time on Tuesday, November 28, 2023**.

Any request for an approved equal must be fully supported with catalog information, specifications and illustrations or other pertinent information as evidence that the substitute offered is equal to or better than the specification. Where an approved equal is requested, the contractor must clearly demonstrate the equality of this product to the District to determine whether the proposer's product is or is not equal to that specified.

An Approved Equal Form is included in Exhibit E. Further changes in the specifications will be made by addendum.

(d) Obligations of the Proposer

At the time of the opening of proposals, each Proposer will be presumed to be thoroughly familiar with the IFB requirements, and the objectives for each element of the project, item, or service. A plea of mistake in the accepted response shall not be available to the Proposer for the recovery of the bid surety or as a defense to any action based upon an accepted response.

(e) Omission of Details

No advantage shall be taken by the Proposer in the omission of any part or detail which is required to make the project complete and ready for service, even though such part of detail is not mentioned explicitly in the specifications. All units or parts not herein specified shall be manufacturer's standard units and shall conform to the highest standard in the industry.

(f) Qualification of Bidders

Contractor shall submit documentation of Qualifications to perform the work of this contract. Qualifications at a minimum will include CT license, list of projects of similar scope (subject and cost) for last five (5) years, references from past Owners for this kind of work, and any other materials that will provide assurance that Contractor has qualifications for the work. The District may make such investigations as deemed necessary to determine the ability of the Candidate to perform the work and the degree to which any Candidate meets the criteria for award listed herein. A Statement of Bidders Qualification is included in Exhibit E.

(f) Determination of Successful Bidder

In determining the successful bidder, consideration will be given to price, financial responsibility of the bidder, responsiveness to the specifications, warranty, suitability of the product offered for use, past experience, financial ability to meet the contract, facilities and equipment, availability of labor, delivery promise, terms of payment, and other objective and accountable factors which are reasonable.

Award of any contract from this Invitation for Bids shall be made to the bidder quoting the lowest total computed base bid items and/or add/deduct items, including delivery charges, and payment terms, as described in the Bid (where applicable), provided the bid is responsive in all respects to the procurement requirements.

All materials, parts and equipment furnished by the contractor shall be new, high grade and free from defects. Materials and workmanship not conforming to the requirements of the specifications shall be considered defective and will be subject to rejection.

If the contractor fails to replace any defective or damaged work or materials after reasonable notice, the District may cause such work or materials to be replaced. The replacement expenses shall be deducted from the amount to be paid to the contractor.

The District may inspect all material and workmanship at any time during the progress of the work and shall have the right to reject all materials and workmanship which does not conform to the specifications or which is not considered to be of adequate quality.

(g) Disqualification of Bidders

Proposers may be disqualified and bids may be rejected for any of, but not limited to, the following causes:

- Failure to use Bid Proposal Form furnished by the District
- Lack of signature by an authorized representative on the Bid Proposal Form
- Failure to properly complete the Bid Proposal form
- Evidence of collusion among bidders
- Unauthorized alteration of Bid Proposal Form
- Failure to submit signed required certifications

The District reserves the right to waive any minor informality or irregularity.

15. QUANTITIES AND/OR USAGES

Quantities and/or usages are estimates only and in no way represent a commitment and/or intent to purchase the estimated amount. Actual quantities and delivery locations may vary. The District reserves the right to order all quantities that may be needed, at the contract price, during the contract term regardless of the estimates provided in this IFB.

16. SAMPLES

Samples are furnished free of charge and may be held for comparison with deliveries. Proposers must arrange for their return if desired. Samples are assumed to meet, at a minimum, District specifications for quality. All deliveries shall have at least the same quality as the accepted proposal sample. Latent deficiencies will be remedied by the contractor at no additional cost, or loss of service, to the District.

17. PAYMENT OF PREVAILING WAGES/DAVIS BACON WAGE RATES

The Proposer agrees that the contractor's laborers and mechanics and any subcontractor's, of any tier, laborers and mechanics who work on this project and who fall within any job classification established and published by the Connecticut Department of Labor shall be paid, at a minimum, the prevailing wage rates as certified by said Department. Each contractor and subcontractor of any tier performing work on this project shall post on the project the applicable prevailing wage rates and hourly basic rates of pay for the County or area within which the project is being performed, including the effective date of any changes thereof, in at least one conspicuous place for the information of the employees working on the project. The information so posted shall include a breakdown of contributions for health and welfare benefits, vacation benefits, pension benefits and any other economic benefit required to be paid. See Exhibit A: Federal Requirements for more details. See Exhibit G for Prevailing Wage Rates.

18. BONDING REQUIREMENTS/PERMITTING

Each bid must be accompanied by Bid Security made payable to the District in an amount of five percent (5%) of Bidder’s maximum Bid Price and in the form of cash, a certified or cashier’s check, or a Bid Bond, issued by a surety. The Bid Security shall be sealed in a separate envelope containing the Bid.

In addition, a performance bond from a licensed bonding agent in the State of Connecticut shall be required for the Contract amount (100%) for the faithful performance of the work. A payment bond equal to forty percent (40%) of the Contract amount is also required from a licensed bonding agent in the State of Connecticut.

The Contractor is responsible for obtaining all permits for the project, including but not limited permits for demolition, and street opening.

19. SINGLE BIDDER/SOLE SOURCE PROCUREMENT

In the event that a single bid is received, the District will conduct a price and/or cost analysis and review and audit all business records and related documents of the Bidder and any affiliated or parent company to determine the fairness and reasonableness of the bid. A price analysis is the process of examining the bid and evaluating a prospective price without evaluating separate cost elements. It should be recognized that a price analysis through comparison to other similar procurements must be based on an established or competitive price of the elements used in the comparisons. The comparison must be made to a purchase of similar quantity and involving similar specifications. Where a difference exists, a detailed analysis must be made of this difference and costs attached thereto.

Where it is impossible to obtain a valid price analysis, it may be necessary for the District to conduct a cost analysis of the bid price. The price and/or cost analysis shall be made by competent and experienced auditors or price analysis; an engineer’s estimate or comparison of the prices is insufficient.

The Federal Transit Administration (FTA) may be asked to lend support in obtaining the services of the Defense Contract Audit Agency, if necessary. The District will submit to FTA all data and analysis of determination prior to award of a sole source contract.

20. WITHDRAWAL OF BIDS

Bids may be withdrawn only by written request. For bids already submitted, written request to withdraw must be delivered to the District prior to bid opening. All bids opened will be considered to be valid offers and may not be withdrawn for a period of one hundred eighty (180) business days following the opening of the bids, unless the bidder is given written notice that its bid is not responsive to the specifications of this IFB.

21. SUBCONTRACTING

If subcontractors are necessary to complete any functions of this requirement, the Proposer must list the names and business locations of any proposed subcontractors, using the Subcontractor Form. The District reserves the right to review and approve any subcontractors proposed by the Respondent. Any approval of the subcontractor shall not be construed as making the District party of such contract, giving the subcontractor privities of contract with the District, or subjecting the District to liability of any kind to any subcontractor.

22. CONTRACTING

The District reserves the right to require the successful candidate to execute a contract in a format supplied by the District. The terms and conditions of the contract to be signed upon the award of the IFB will supersede any inconsistent provisions of the IFB documents.

The award of any contract is subject to the following conditions and contingencies:

1. The approval of such governmental agencies as may be required by law.
2. The appropriation of adequate funds by the proper agencies.
3. Compliance with all applicable laws, regulations, ordinances and codes of the United States and, the state of Connecticut.
4. The selected Proposer must be current in all tax or any other monetary obligation owed to the State of Connecticut.
5. The selected Candidate must have a current EEO certification on file with the State.

Contract Documents

The Contract Documents consist of the AIA Contract, this Invitation for Bids (IFB) and its reference documents, drawings, any Addenda issued, the Contractor's response to the IFB, the Federal Requirements (Exhibit A), the State of CT Requirements (Exhibit B), other documents listed in the Contract, and Modifications issued after execution of the Contract. A Modification is (1) a written amendment to the Contract signed by the parties, (2) a Change Order, (3) a Construction Change Directive or (4) a written order for a Minor change in the Work issued by the Design Professional on behalf of the District.

23. RETAINAGE

When progress payments are being made for items being built, the District will withhold 5% of the total project cost, or as otherwise specified in the contract for this project.

24. ASSIGNMENT

The contractor shall not assign, transfer, convey or otherwise dispose of the agreement or his/her or its interest in the same, or any part thereof, without prior written approval of the District.

25. REQUIRED CERTIFICATIONS

The required certifications must be submitted with the bid form for the proposal to be considered responsive to the bid specifications. All certification forms are contained in Exhibits D, E and F. Those bids which do not contain the required standard certifications, complete and signed as appropriate, will be determined ineligible.

26. INSURANCE REQUIREMENTS

Contractor shall obtain and maintain throughout the term of this Contract (or such longer period as may be specified below, if any) the following insurance:

A. Commercial General Liability

The Contractor shall carry Commercial General Liability Insurance, including a broad form comprehensive general liability endorsement and coverage against claims for personal injury, bodily injury, death or property damage, to be on the so-called "occurrence" form with a combined limit of not less than Two Million Dollars ($2,000,000) in the aggregate and One Million Dollars ($1,000,000) per occurrence, and to cover at least the following hazards: (1) premises and operations; (2) products and completed operations on an "if any" basis; (3) independent contractors; (4) blanket contractual liability for all insured contracts; and (5) contractual liability covering the indemnities in this Contract.

B. Workers' Compensation Insurance

With respect to all services the Contractor performs and all those performed for the Contractor by its subcontractors, the Contractor and its subcontractor(s) shall carry Workers' Compensation Insurance and, as applicable, insurance required in accordance with the U.S. Longshore and Harbor Workers' Compensation Act, in accordance with the requirements of the laws of the State of Connecticut, and of the laws of the United States, respectively.

C. Business Automobile Insurance

Business Automobile Liability Insurance, to cover the use of all owned, hired, and non-owned vehicles, providing for the following minimum liability limits: One Million Dollars ($1,000,000) for all damages arising out of bodily injuries to or death of all persons in any one accident or occurrence, and for all damages arising out of injury to or destruction of property in any one accident or occurrence. In cases where the insurance policy shows an aggregate limit as part of the automobile liability coverage, the aggregate limit must be at least Two Million Dollars ($2,000,000).

D. Professional Liability Insurance

If the Contractor or any of its subcontractors are providing design, architectural or engineering services with respect to this Contract, the Contractor and such subcontractors shall carry Professional Liability Insurance Policy in an annual aggregate amount not less than Two Million Dollars ($2,000,000), which coverage shall be maintained in force for a period of not less than three (3) years after the completion of the work under this Contract.

E. Contractors Pollution Liability Insurance

If the Work involves the transport, dissemination, use, or release of pollutants, the Contractor shall procure Pollution Liability insurance, with policy limits of not less than one million dollars ($1,000,000) per claim and two million dollars ($2,000,000) in the aggregate.

F. Certificate of Insurance

All insurance provided for above shall be obtained under valid and enforceable policies, and issued by financially sound and responsible insurance companies authorized to do business in the State of Connecticut and having a general policy rating of A- or better and a financial class of VIII or better, each as determined by AM Best Company, Inc. Prior to commencing any work under this Contract and at least ten (10) days prior to the expiration dates of any insurance required hereunder, Contractor shall deliver to the District certificates of insurance evidencing such coverage and any renewal or successor policies. If the Contractor engages any subcontractor to perform any of its obligations under this Contract, the Contractor shall also deliver to the District certificates of insurance from such subcontractor evidencing such coverage and any renewal or successor policies. All policies of insurance required hereunder shall name the District (and such other persons or entities designated by the District) as an additional insured (except the workers’ compensation and Professional Liability insurance). For the Workers' Compensation Insurance and, as applicable, U.S. Longshore and Harbor Workers' Compensation Act coverage, the policy number(s) and term of the policy (ies) shall be indicated on the certificate. With the exception of Professional Liability Insurance, each insurance policy shall state that the insurance company agrees to investigate and defend the insured against all claims for damages, even if groundless.

All insurance policies provided for above shall contain clauses or endorsements to the effect that: (i) no act or negligence of the Contractor, or anyone acting for the Contractor, or failure to comply with the provisions of any policy, which might otherwise result in a forfeiture of the insurance or any part thereof, shall in any way affect the validity or enforceability of the insurance insofar as the District is concerned; (ii) no such policies shall be canceled without at least thirty (30) days' notice to the District (10 days for non-payment of premium); (iii) shall contain a waiver of subrogation in favor of the District, and (iv) shall provide that such coverage is primary and non-contributory.

Such insurance shall protect the District against all claims, liabilities, suits, actions, damages, or costs resulting from or arising out of the ownership, lease, operation, maintenance, repairs, or use in any way of any project equipment for the purposes of the program covered by this Contract and for any other purpose. No project equipment shall be delivered to the Contractor, or operated by the Contractor until the Contractor has delivered the certificate(s) of insurance required hereunder. Prior to the annual renewal of a motor vehicle registration, the Contractor shall submit to the District a certificate of insurance for the project equipment. This Section shall not prevent the District from contracting for such required insurance coverage at any time, and in such event the Contractor shall pay the District for all costs of such insurance.

Indemnification

To the fullest extent permitted by law, the Contractor shall indemnify, defend and hold harmless the District and its officers, directors, employees and agents (collectively "Indemnified Parties") from and against all claims, damages, demands, losses, expenses, fines, penalties, causes of action, suits or other liabilities (including all costs of reasonable attorneys' fees) arising out of, related to, in connection with or resulting from, or alleged to arise out of or arise from the negligent acts or omissions, breach or failure to perform under the Contract or the violation of any applicable law or regulation, by Contractor, Contractor's subcontractors or anyone directly or indirectly employed by Contractor or by Contractor's subcontractors or anyone for whose acts any of them may be responsible or liable and whether such claim, damage, demand, loss, expense, fine, penalty, cause of action, suit or other liability is attributable to bodily injury, personal injury, sickness, disease or death, or to injury to or destruction of tangible property, including the loss of use resulting therefrom. This indemnity shall be effective regardless of whether or not such claim, damage, loss or expense is caused in part by any of the Indemnified Parties (but the indemnity shall not cover liability to the extent resulting from gross negligence or willful misconduct of the Indemnified Parties). Such indemnity obligation shall not be in derogation or limitation of any other obligation or liability of the Contractor or the rights of the District contained in this Contract or otherwise. This indemnification shall not be limited in any way by any limitation on the amount or type of damages, compensation or benefits payable by or for the Contractor under any workers' compensation acts, disability benefit acts or other employee benefits acts and includes any loss or injury suffered by an employee of Contractor. This indemnification shall survive the completion of the Work or the termination of the Contract.

To the extent the foregoing Indemnity applies to any violation of federal, state or local laws, ordinances or regulations, Contractor shall do and perform all work necessary to correct such violation.

27. NOTICE OF AWARD

The selected proposer will be provided with a written Notice of Award which shall be contingent upon the submission by the respondent of all documents required including, but not limited to, proper insurance certificates, performance and payment bonds, verification of DBE percentage contribution to the work and execution of contract within 10 days of the notice of award.

28. ATTACHED EXHIBITS

The following attachments are included in this package:

EXHIBIT A

- Federally Required Contract Clauses

EXHIBIT B

- State of Connecticut Grant Requirements

EXHIBIT C

- Procurement Procedures and Appeals Process

EXHIBIT D

- Bid Proposal Form

EXHIBIT E

- Required Certifications
    - Affidavit
    - Certificate of Eligibility
    - Certificate of Non-Collusion.
    - Certificate of Restrictions on Lobbying
    - Contractor's Statement on Sub-Contractors
    - Eligible Contractor's Certificate
    - Certificate for Disadvantaged Business Enterprise
    - DBE Good Faith Efforts Documentation Form
    - DBE Letter of Intent
    - Buy America Certification
    - Approved Equal Form
    - Statement of Bidder's Qualifications

EXHIBIT F

- State of Connecticut Required Certifications
    - Requirements of the State of Connecticut
    - Small/Minority Business Enterprise (SBE/MBE) Certification
    - SBE Letter of Intent
    - OPM Forms

EXHIBIT G

- Connecticut Department of Labor Prevailing Wage Bid Package

EXHIBIT H

- Technical Specifications and Special Provisions

EXHIBIT A
FEDERALLY REQUIRED CONTRACT CLAUSES

FEDERALLY REQUIRED CONTRACT CLAUSES

Access to Records and Reports –

a. Record Retention. The Contractor will retain, and will require its subcontractors of all tiers to retain, complete and readily accessible records related in whole or in part to the contract, including, but not limited to, data, documents, reports, statistics, leases, subcontracts, arrangements, other third-party Contracts of any type, and supporting materials related to those records.
b. Retention Period. The Contractor agrees to comply with the record retention requirements in accordance with 2 C.F.R. § 200.334. The Contractor shall maintain all books, records, accounts and reports required under this Contract for a period of at not less than three (3) years after the date of termination or expiration of this Contract, except in the event of litigation or settlement of claims arising from the performance of this Contract, in which case records shall be maintained until the disposition of all such litigation, appeals, claims or exceptions related thereto.
c. Access to Records. The Contractor agrees to provide sufficient access to FTA and its contractors to inspect and audit records and information related to performance of this contract in accordance with 2 CFR § 200.337.
d. Access to the Sites of Performance. The Contractor agrees to permit FTA and its contractors access to the sites of performance under this contract in accordance with 2 CFR § 200.337.

Americans with Disabilities Act (ADA) –

The contractor agrees to comply with all applicable requirements of section 504 of the Rehabilitation Act of 1973, as amended, 29 U.S.C. § 794, which prohibits discrimination on the basis of handicaps, with the Americans with Disabilities Act of 1990 (ADA), as amended, 42 U.S.C. §§ 12101 et seq., which requires that accessible facilities and services be made available to persons with disabilities, including any subsequent amendments to that Act, and with the Architectural Barriers act of 1968, as amended, 42 U.S.C. §§ 4151 et seq., which requires that buildings and public accommodations be accessible to persons with disabilities, including any subsequent amendments to that Act. In addition, the contractor agrees to comply with any and all applicable requirements issued by the FTA, DOT, DOJ, U.S. GSA, U.S. EEOC, U.S. FCC, any subsequent amendments thereto and any other nondiscrimination statute(s) that may apply to the Project.

Bond Requirements –

For construction or facility improvement contracts or subcontracts exceeding the Simplified Acquisition Threshold, the Federal awarding agency or pass-through entity may accept the bonding policy and requirements of the non-Federal entity provided that the Federal awarding agency or pass-through entity has made a determination that the Federal interest is adequately protected. If such a determination has not been made, the minimum requirements must be as follows:

(a) A bid guarantee from each bidder equivalent to five percent of the bid price. The “bid guarantee” must consist of a firm commitment such as a bid bond, certified check, or other negotiable instrument accompanying a bid as assurance that the bidder will, upon acceptance of the bid, execute such contractual documents as may be required within the time specified.

(b) A performance bond on the part of the contractor for 100 percent of the contract price. A “performance bond” is one executed in connection with a contract to secure fulfillment of all the contractor's requirements under such contract.

(c) A payment bond on the part of the contractor for 100 percent of the contract price. A “payment bond” is one executed in connection with a contract to assure payment as required by law of all persons supplying labor and material in the execution of the work provided for in the contract.

It is also understood and agreed that if the bidder should withdraw any part or all of their bid within [90] days after the bid opening without the written consent of the Agency, or refuse or be unable to enter into this Contract as provided above, or refuse or be unable to furnish adequate and acceptable Performance and Payment Bonds, or refuse or be unable to furnish adequate and acceptable insurance, as provided above, it shall forfeit its bid guaranty to the extent Agency’s damages occasioned by such withdrawal, or refusal, or inability to enter into a Contract, or provide adequate security thereof.

It is further understood and agreed that to the extent the defaulting bidder's bid guaranty shall prove inadequate to fully recompense Agency for the damages occasioned by default, then the bidder agrees to indemnify Agency and pay over to Agency the difference between the bid guarantee and Agency’s total damages so as to make Agency whole.

The bidder understands that any material alteration of any of the above or any of the material contained herein, other than that requested will render the bid unresponsive.

Performance Guarantee. A Performance Guarantee in the amount of 100% of the Contract value is required by the Agency to ensure faithful performance of the Contract. Either a Performance Bond or an Irrevocable Stand-By Letter of Credit shall be provided by the Contractor and shall remain in full force for the term of the Contract. The successful Bidder shall certify that it will provide the requisite Performance Guarantee to the Agency within ten (10) business days from Contract execution. The Agency requires all Performance Bonds to be provided by a fully qualified surety company acceptable to the Agency and listed as a company currently authorized under 31 C.F.R. part 22 as possessing a Certificate of Authority as described hereunder. Agency may require additional performance bond protection when the contract price is increased. The increase in protection shall generally equal 100 percent of the increase in contract price. The Agency may secure additional protection by directing the Contractor to increase the amount of the existing bond or to obtain an additional bond.

If the Bidder chooses to provide a Letter of Credit as its Performance Guarantee, the Bidder shall furnish with its bid, certification that an Irrevocable Stand-By Letter of Credit will be furnished should the Bidder become the successful Contractor. The Bidder shall also provide a statement from the banking institution certifying that an Irrevocable Stand-By Letter of Credit for the action will be provided if the Contract is awarded to the Bidder. The Irrevocable Stand-By Letter of Credit will only be accepted by the Agency if:

1. A bank in good standing issues it. The Agency will not accept a Letter of Credit from an entity other than a bank.
2. It is in writing and signed by the issuing bank.
3. It conspicuously states that it is an irrevocable, non-transferable, “standby” Letter of Credit.
4. The Agency is identified as the Beneficiary.
5. It is in an amount equal to 100% of the Contract value. This amount must be in U.S. dollars.
6. The effective date of the Letter of Credit is the same as the effective date of the Contract.
7. The expiration date of the Letter of Credit coincides with the term of the contract.
8. It indicates that it is being issued in order to support the obligation of the Contractor to perform under the Contract. It must specifically reference the Contract between the Agency and the Contractor the work stipulated herein.

The issuing bank’s obligation to pay will arise upon the presentation of the original Letter of Credit and a certificate and draft to the issuing bank’s representative at a location and time to be determined by the parties. This documentation will indicate that the Contractor is in default under the Contract.

Payment Bonds. A Labor and Materials Payment Bond equal to the full value of the contract must be furnished by the contractor to Agency as security for payment by the Contractor and subcontractors for labor, materials, and rental of equipment. The bond may be issued by a fully qualified surety company acceptable to (Agency) and listed as a company currently authorized under 31 C.F.R. part 223 as possessing a Certificate of Authority as described thereunder.

Buy America –
The contractor agrees to comply with 49 U.S.C. 5323(j) and 49 C.F.R. part 661 and 2 CFR § 200.322 Domestic preferences for procurements, which provide that Federal funds may not be obligated unless all steel, iron, and manufactured products used in FTA funded projects are produced in the United States, unless a waiver has been granted by FTA or the product is subject to a general waiver. General waivers are listed in 49 C.F.R. § 661.7.

Construction materials used in the Project are subject to the domestic preference requirement of the Build America, Buy America Act, Pub. L. 117-58, div. G, tit. IX, §§ 70911 – 70927 (2021), as implemented by the U.S. Office of Management and Budget, the U.S. Department of Transportation, and FTA. The Recipient acknowledges that this agreement is neither a waiver of § 70914(a) nor a finding under § 70914(b).

Separate requirements for rolling stock are set out at 49 U.S.C. 5323(j)(2)(C), 49 U.S.C. § 5323(u) and 49 C.F.R. § 661.11. Domestic preferences for procurements.

The bidder or offeror must submit to the Agency the appropriate Buy America certification. Bids or offers that are not accompanied by a completed Buy America certification will be rejected as nonresponsive. For more information, please see the FTA’s Buy America webpage at: https://www.transit.dot.gov/buyamerica.

<u>Cargo Preference Requirements</u> –

The contractor agrees:
a. to use privately owned United States-Flag commercial vessels to ship at least 50 percent of the gross tonnage (computed separately for dry bulk carriers, dry cargo liners, and tankers) involved, whenever shipping any equipment, material, or commodities pursuant to the underlying contract to the extent such vessels are available at fair and reasonable rates for United States-Flag commercial vessels;

b. to furnish within 20 working days following the date of loading for shipments originating within the United States or within 30 working days following the date of loading for shipments originating outside the United States, a legible copy of a rated, "on-board" commercial ocean bill-of-lading in English for each shipment of cargo described in the preceding paragraph to the Division of National Cargo, Office of Market Development, Maritime Administration, Washington, DC 20590 and to the FTA Recipient (through the contractor in the case of a subcontractor's bill-of-lading.); and

c. to include these requirements in all subcontracts issued pursuant to this contract when the subcontract may involve the transport of equipment, material, or commodities by ocean vessel.

<u>Civil Rights Laws and Regulations</u> –

The following Federal Civil Rights laws and regulations apply to all contracts.

1 **Federal Equal Employment Opportunity (EEO) Requirements**. These include, but are not limited to:
a) Nondiscrimination in Federal Public Transportation Programs. 49 U.S.C. § 5332, covering projects, programs, and activities financed under 49 U.S.C. Chapter 53, prohibits discrimination on the basis of race, color, religion, national origin, sex (including sexual orientation and gender identity), disability, or age, and prohibits discrimination in employment or business opportunity.

b) Prohibition against Employment Discrimination. Title VII of the Civil Rights Act of 1964, as amended, 42 U.S.C. § 2000e, and Executive Order No. 11246, "Equal Employment Opportunity," September 24, 1965, as amended, prohibit discrimination in employment on the basis of race, color, religion, sex, or national origin.

2 **Nondiscrimination on the Basis of Sex.** Title IX of the Education Amendments of 1972, as amended, 20 U.S.C. § 1681 et seq. and implementing Federal regulations, "Nondiscrimination on the Basis of Sex in Education Programs or Activities Receiving Federal Financial Assistance," 49 C.F.R. part 25 prohibit discrimination on the basis of sex.

3 **Nondiscrimination on the Basis of Age**. The "Age Discrimination Act of 1975," as amended, 42 U.S.C. § 6101 et seq., and Department of Health and Human Services implementing regulations, "Nondiscrimination on the Basis of Age in Programs or Activities Receiving Federal Financial Assistance," 45 C.F.R. part 90, prohibit discrimination by participants in federally assisted programs against individuals on the basis of age. The Age Discrimination in Employment Act (ADEA), 29 U.S.C. § 621 et

seq., and Equal Employment Opportunity Commission (EEOC) implementing regulations, “Age Discrimination in Employment Act,” 29 C.F.R. part 1625, also prohibit employment discrimination against individuals age 40 and over on the basis of age.

4 **Federal Protections for Individuals with Disabilities**. The Americans with Disabilities Act of 1990, as amended (ADA), 42 U.S.C. § 12101 et seq., prohibits discrimination against qualified individuals with disabilities in programs, activities, and services, and imposes specific requirements on public and private entities. Third party contractors must comply with their responsibilities under Titles I, II, III, IV, and V of the ADA in employment, public services, public accommodations, telecommunications, and other provisions, many of which are subject to regulations issued by other Federal agencies.

Civil Rights and Equal Opportunity

The Agency is an Equal Opportunity Employer. As such, the Agency agrees to comply with all applicable Federal civil rights laws and implementing regulations. Apart from inconsistent requirements imposed by Federal laws or regulations, the Agency agrees to comply with the requirements of 49 U.S.C. § 5323(h) (3) by not using any Federal assistance awarded by FTA to support procurements using exclusionary or discriminatory specifications.

Under this Contract, the Contractor shall at all times comply with the following requirements and shall include these requirements in each subcontract entered into as part thereof.

1. **Nondiscrimination**. In accordance with Federal transit law at 49 U.S.C. § 5332, the Contractor agrees that it will not discriminate against any employee or applicant for employment because of race, color, religion, national origin, sex, disability, or age. In addition, the Contractor agrees to comply with applicable Federal implementing regulations and other implementing requirements FTA may issue.

2. **Race, Color, Religion, National Origin, Sex**. In accordance with Title VII of the Civil Rights Act, as amended, 42 U.S.C. § 2000e et seq., and Federal transit laws at 49 U.S.C. § 5332, the Contractor agrees to comply with all applicable equal employment opportunity requirements of U.S. Department of Labor (U.S. DOL) regulations, "Office of Federal Contract Compliance Programs, Equal Employment Opportunity, Department of Labor," 41 C.F.R. chapter 60, and Executive Order No. 11246, "Equal Employment Opportunity in Federal Employment," September 24, 1965, 42 U.S.C. § 2000e note, as amended by any later Executive Order that amends or supersedes it, referenced in 42 U.S.C. § 2000e note. The Contractor agrees to take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, color, religion, national origin, or sex (including sexual orientation and gender identity). Such action shall include, but not be limited to, the following: employment, promotion, demotion or transfer, recruitment or recruitment advertising, layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. In addition, the Contractor agrees to comply with any implementing requirements FTA may issue.

3. **Age**. In accordance with the Age Discrimination in Employment Act, 29 U.S.C. §§ 621-634, U.S. Equal Employment Opportunity Commission (U.S. EEOC) regulations, “Age Discrimination in Employment Act,” 29 C.F.R. part 1625, the Age Discrimination Act of 1975, as amended, 42 U.S.C. § 6101 et seq., U.S. Health and Human Services regulations, “Nondiscrimination on the Basis of Age in Programs or Activities Receiving Federal Financial Assistance,” 45 C.F.R. part 90, and Federal transit law at 49 U.S.C. § 5332, the Contractor agrees to refrain from discrimination against present and prospective employees for reason of age. In addition, the Contractor agrees to comply with any Implementing requirements FTA may issue.

4. **Disabilities**. In accordance with section 504 of the Rehabilitation Act of 1973, as amended, 29 U.S.C. § 794, the Americans with Disabilities Act of 1990, as amended, 42 U.S.C. § 12101 et seq., the Architectural Barriers Act of 1968, as amended, 42 U.S.C. § 4151 et seq., and Federal transit law at 49 U.S.C. § 5332, the Contractor agrees that it will not discriminate against individuals on the basis of disability. In addition, the Contractor agrees to comply with any implementing requirements FTA may issue.

5. **Promoting Free Speech and Religious Liberty**. The Contractor shall ensure that Federal funding is expended in full accordance with the U.S. Constitution, Federal Law, and statutory and public policy requirements: including, but not limited to, those protecting free speech, religious liberty, public welfare, the environment, and prohibiting discrimination.

<u>Clean Air Act and Federal Water Pollution Control Act</u> –

The Contractor agrees to comply with all applicable standards, orders, or regulations issued pursuant to the Clean Air Act (42 U.S.C. § 7401-7671q) and the Federal Water Pollution Control Act as amended (33 U.S.C. § 1251-1387). Violations must be reported to FTA and the Regional Office of the Environmental Protection Agency. The following applies for contracts of amounts in excess of $150,000:

<u>Clean Air Act</u>

> (1) The contractor agrees to comply with all applicable standards, orders or regulations issued pursuant to the Clean Air Act, as amended, 42 U.S.C. § 7401 et seq.
>
> (2) The contractor agrees to report each violation to the Agency and understands and agrees that the Agency will, in turn, report each violation as required to assure notification to the Agency, Federal Emergency Management Agency, and the appropriate Environmental Protection Agency Regional Office.
>
> (3) The contractor agrees to include these requirements in each subcontract exceeding $150,000 financed in whole or in part with Federal assistance provided by FTA.

<u>Federal Water Pollution Control Act</u>

(1) The contractor agrees to comply with all applicable standards, orders or regulations issued pursuant to the Federal Water Pollution Control Act, as amended, 33 U.S.C. 1251 et seq.

(2) The contractor agrees to report each violation to the Agency and understands and agrees that the Agency will, in turn, report each violation as required to assure notification to the Agency, Federal Emergency Management Agency, and the appropriate Environmental Protection Agency Regional Office.

(3) The contractor agrees to include these requirements in each subcontract exceeding $150,000 financed in whole or in part with Federal assistance provided by FTA."

Contract Work Hours and Safety Standards Act –

a. Applicability: This requirement applies to all FTA grant and cooperative agreement programs.
b. Where applicable (see 40 U.S.C. § 3701), all contracts awarded by the non-Federal entity in excess of $100,000 that involve the employment of mechanics or laborers must include a provision for compliance with 40 U.S.C. §§ 3702 and 3704, as supplemented by Department of Labor regulations at 29 C.F.R. Part 5. See 2 C.F.R. Part 200, Appendix II.
c. Under 40 U.S.C. § 3702, each contractor must be required to compute the wages of every mechanic and laborer on the basis of a standard work week of 40 hours. Work in excess of the standard work week is permissible provided that the worker is compensated at a rate of not less than one and a half times the basic rate of pay for all hours worked in excess of 40 hours in the work week.
d. The requirements of 40 U.S.C. § 3704 are applicable to construction work and provide that no laborer or mechanic must be required to work in surroundings or under working conditions which are unsanitary, hazardous or dangerous. These requirements do not apply to the purchases of supplies or materials or articles ordinarily available on the open market, or contracts for transportation or transmission of intelligence.
e. The regulation at 29 C.F.R. § 5.5(b) provides the required contract clause concerning compliance with the Contract Work Hours and Safety Standards Act:

Compliance with the Contract Work Hours and Safety Standards Act.

(1) Overtime requirements. No contractor or subcontractor contracting for any part of the contract work which may require or involve the employment of laborers or mechanics shall require or permit any such laborer or mechanic in any workweek in which he or she is employed on such work to work in excess of forty hours in such workweek unless such laborer or mechanic receives compensation at a rate not less than one and one-half times the basic rate of pay for all hours worked in excess of forty hours in such workweek.
(2) Violation; liability for unpaid wages; liquidated damages. In the event of any violation of the clause set forth in paragraph (1) of this section the contractor and any subcontractor responsible therefor shall be liable for the unpaid wages. In

addition, such contractor and subcontractor shall be liable to the United States (in the case of work done under contract for the District of Columbia or a territory, to such District or to such territory), for liquidated damages. Such liquidated damages shall be computed with respect to each individual laborer or mechanic, including watchmen and guards, employed in violation of the clause set forth in paragraph (1) of this section, in the sum of $10 for each calendar day on which such individual was required or permitted to work in excess of the standard workweek of forty hours without payment of the overtime wages required by the clause set forth in paragraph (1) of this section.

(3) Withholding for unpaid wages and liquidated damages. The agency shall upon its own action or upon written request of an authorized representative of the Department of Labor withhold or cause to be withheld, from any moneys payable on account of work performed by the contractor or subcontractor under any such contract or any other Federal contract with the same prime contractor, or any other federally-assisted contract subject to the Contract Work Hours and Safety Standards Act, which is held by the same prime contractor, such sums as may be determined to be necessary to satisfy any liabilities of such contractor or subcontractor for unpaid wages and liquidated damages as provided in the clause set forth in paragraph (2) of this section.

(4) Subcontracts. The contractor or subcontractor shall insert in any subcontracts the clauses set forth in paragraph (1) through (4) of this section and also a clause requiring the subcontractors to include these clauses in any lower tier subcontracts. The prime contractor shall be responsible for compliance by any subcontractor or lower tier subcontractor with the clauses set forth in paragraphs (1) through (4) of this section."

Davis Bacon Act and Copeland Anti-Kickback Act –

For all prime construction, alteration or repair contracts in excess of $2,000 awarded by FTA, the Contractor shall comply with the Davis-Bacon Act and the Copeland "Anti-Kickback" Act. Under 49 U.S.C. § 5333(a), prevailing wage protections apply to laborers and mechanics employed on FTA assisted construction, alteration, or repair projects. The Contractor will comply with the Davis-Bacon Act, 40 U.S.C. §§ 3141-3144, and 3146-3148 as supplemented by DOL regulations at 29 C.F.R. part 5, "Labor Standards Provisions Applicable to Contracts Governing Federally Financed and Assisted Construction." In accordance with the statute, the Contractor shall pay wages to laborers and mechanics at a rate not less than the prevailing wages specified in a wage determination made by the Secretary of Labor. In addition, the Contractor agrees to pay wages not less than once a week. The Contractor shall also comply with the Copeland "Anti-Kickback" Act (40 U.S.C. § 3145), as supplemented by DOL regulations at 29 C.F.R. part 3, "Contractors and Subcontractors on Public Building or Public Work Financed in Whole or in part by Loans or Grants from the United States." The Contractor is prohibited from inducing, by any means, any person employed in the construction, completion, or repair of public work, to give up any part of the compensation to which he or she is otherwise entitled.

Debarment and Suspension–

The Contractor shall comply and facilitate compliance with U.S. DOT regulations, "Non-procurement Suspension and Debarment," 2 C.F.R. part 1200, which adopts and supplements the U.S. Office of Management and Budget (U.S. OMB) "Guidelines to Agencies on Governmentwide Debarment and Suspension (Non-procurement)," 2 C.F.R. part 180. These provisions apply to each contract at any tier of $25,000 or more, and to each contract at any tier for a federally required audit (irrespective of the contract amount), and to each contract at any tier that must be approved by an FTA official irrespective of the contract amount. As such, the Contractor shall verify that its principals, affiliates, and subcontractors are eligible to participate in this federally funded contract and are not presently declared by any Federal department or agency to be:

a) Debarred from participation in any federally assisted Award;
b) Suspended from participation in any federally assisted Award;
c) Proposed for debarment from participation in any federally assisted Award;
d) Declared ineligible to participate in any federally assisted Award;
e) Voluntarily excluded from participation in any federally assisted Award; or
f) Disqualified from participation in ay federally assisted Award.

By signing and submitting its bid or proposal, the bidder or proposer certifies as follows: The certification in this clause is a material representation of fact relied upon by the AGENCY. If it is later determined by the AGENCY that the bidder or proposer knowingly rendered an erroneous certification, in addition to remedies available to the AGENCY, the Federal Government may pursue available remedies, including but not limited to suspension and/or debarment. The bidder or proposer agrees to comply with the requirements of 2 C.F.R. part 180, subpart C, as supplemented by 2 C.F.R. part 1200, while this offer is valid and throughout the period of any contract that may arise from this offer. The bidder or proposer further agrees to include a provision requiring such compliance in its lower tier covered transactions.

Disadvantaged Business Enterprises -–

It is the policy of the Agency and the United States Department of Transportation ("DOT") that Disadvantaged Business Enterprises ("DBE's"), as defined herein and in the Federal regulations published at 49 C.F.R. part 26, shall have an equal opportunity to participate in DOT-assisted contracts.

The contractor or subcontractor shall not discriminate on the basis of race, color, national origin, or sex in the performance of this contract. The contractor shall carry out applicable requirements of 49 C.F.R. part 26 in the award and administration of DOT-assisted contracts. Failure by the contractor to carry out these requirements is a material breach of this contract, which may result in the termination of this contract or such other remedy as the Agency deems appropriate, which may include, but is not limited to:

(1) Withholding monthly progress payments;
(2) Assessing sanctions;
(3) Liquidated damages; and/or
(4) Disqualifying the contractor from future bidding as non-responsible. 49 C.F.R. § 26.13(b).

Prime contractors are required to pay subcontractors for satisfactory performance of their contracts no later than 30 days from receipt of each payment the Agency makes to the prime contractor. 49 C.F.R. § 26.29(a).

Finally, for contracts with defined DBE contract goals, each FTA Recipient must include in each prime contract a provision stating that the contractor shall utilize the specific DBEs listed unless the contractor obtains the Agency's written consent; and that, unless the Agency's consent is provided, the contractor shall not be entitled to any payment for work or material unless it is performed or supplied by the listed DBE. 49 C.F.R. § 26.53(f) (1).

Energy Conservation –

The contractor agrees to comply with mandatory standards and policies relating to energy efficiency, which are contained in the state energy conservation plan issued in compliance with the Energy Policy and Conservation Act (42 U.S.C.§ 6201).

Equal Employment Opportunity–

During the performance of this contract, the contractor agrees as follows:
(1) The contractor will not discriminate against any employee or applicant for employment because of race, color, religion, sex, sexual orientation, gender identity, or national origin. The contractor will take affirmative action to ensure that applicants are employed, and that employees are treated during employment, without regard to their race, color, religion, sex, sexual orientation, gender identity, or national origin. Such action shall include, but not be limited to the following: Employment, upgrading, demotion, or transfer, recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The contractor agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided by the contracting officer setting forth the provisions of this nondiscrimination clause.
(2) The contractor will, in all solicitations or advertisements for employees placed by or on behalf of the contractor, state that all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, or national origin.
(3) The contractor will not discharge or in any other manner discriminate against any employee or applicant for employment because such employee or applicant has inquired about, discussed, or disclosed the compensation of the employee or applicant or another employee or applicant. This provision shall not apply to instances in which an employee who has access to the compensation information of other employees or applicants as a part of such employee's essential job functions discloses the compensation of such other employees or applicants to individuals who do not otherwise have access to such information, unless such disclosure is in response to a formal complaint or charge, in furtherance of an investigation, proceeding, hearing, or action, including an investigation conducted by the employer, or is consistent with the contractor's legal duty to furnish information.
(4) The contractor will send to each labor union or representative of workers with which it has a collective bargaining agreement or other contract or understanding, a notice to be provided by the agency contracting officer, advising the labor union or workers' representative of the contractor's commitments under section 202 of Executive Order

11246 of September 24, 1965, and shall post copies of the notice in conspicuous places available to employees and applicants for employment.
(5) The contractor will comply with all provisions of Executive Order 11246 of September 24, 1965, and of the rules, regulations, and relevant orders of the Secretary of Labor.
(6) The contractor will furnish all information and reports required by Executive Order 11246 of September 24, 1965, and by the rules, regulations, and orders of the Secretary of Labor, or pursuant thereto, and will permit access to his books, records, and accounts by the contracting agency and the Secretary of Labor for purposes of investigation to ascertain compliance with such rules, regulations, and orders.
(7) In the event of the contractor's non-compliance with the nondiscrimination clauses of this contract or with any of such rules, regulations, or orders, this contract may be canceled, terminated or suspended in whole or in part and the contractor may be declared ineligible for further Government contracts in accordance with procedures authorized in Executive Order 11246 of September 24, 1965, and such other sanctions may be imposed and remedies invoked as provided in Executive Order 11246 of September 24, 1965, or by rule, regulation, or order of the Secretary of Labor, or as otherwise provided by law.
(8) The contractor will include the provisions of paragraphs (1) through (8) in every subcontract or purchase order unless exempted by rules, regulations, or orders of the Secretary of Labor issued pursuant to section 204 of Executive Order 11246 of September 24, 1965, so that such provisions will be binding upon each subcontractor or vendor. The contractor will take such action with respect to any subcontract or purchase order as may be directed by the Secretary of Labor as a means of enforcing such provisions including sanctions for noncompliance: Provided, however, that in the event the contractor becomes involved in, or is threatened with, litigation with a subcontractor or vendor as a result of such direction, the contractor may request the United States to enter into such litigation to protect the interests of the United States.

Notice to Third Party Participants –

Federal requirements that apply to the Recipient or the Award, the accompanying Underlying Agreement, and any Amendments thereto may change due to changes in federal law, regulation, other requirements, or guidance, or changes in the Recipient's Underlying Agreement including any information incorporated by reference and made part of that Underlying Agreement; and
Applicable changes to those federal requirements will apply to each Third-Party Agreement and parties thereto at any tier.

Federal Tax Liability and Recent Felony Convictions –

(1) The contractor certifies that it:

> (a) Does not have any unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or have lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability; and
>
> (b) Was not convicted of the felony criminal violation under any Federal law within the preceding 24 months.

If the contractor cannot so certify, the Recipient will refer the matter to FTA and not enter into any Third-Party Agreement with the Third-Party Participant without FTA's written approval.

(2) Flow-Down. The Recipient agrees to require the contractor to flow this requirement down to participants at all lower tiers, without regard to the value of any sub-agreement.

Fly America Requirements –
a) Definitions. As used in this clause—

1) "International air transportation" means transportation by air between a place in the United States and a place outside the United States or between two places both of which are outside the United States.
2) "United States" means the 50 States, the District of Columbia, and outlying areas.
3) "U.S.-flag air carrier" means an air carrier holding a certificate under 49 U.S.C. Chapter 411.

b) When Federal funds are used to fund travel, Section 5 of the International Air Transportation Fair Competitive Practices Act of 1974 (49 U.S.C. 40118) (Fly America Act) requires contractors, Agencies, and others use U.S.-flag air carriers for U.S. Government-financed international air transportation of personnel (and their personal effects) or property, to the extent that service by those carriers is available. It requires the Comptroller General of the United States, in the absence of satisfactory proof of the necessity for foreign-flag air transportation, to disallow expenditures from funds, appropriated or otherwise established for the account of the United States, for international air transportation secured aboard a foreign-flag air carrier if a U.S.-flag air carrier is available to provide such services.

c) If available, the Contractor, in performing work under this contract, shall use U.S.-flag carriers for international air transportation of personnel (and their personal effects) or property.

d) In the event that the Contractor selects a carrier other than a U.S.-flag air carrier for international air transportation, the Contractor shall include a statement on vouchers involving such transportation essentially as follows:

Statement of Unavailability of U.S.-Flag Air Carriers
International air transportation of persons (and their personal effects) or property by U.S.-flag air carrier was not available or it was necessary to use foreign-flag air carrier service for the following reasons. See FAR § 47.403. [State reasons]:

e) Contractor shall include the substance of this clause, including this paragraph (e), in each subcontract or purchase under this contract that may involve international air transportation.

Incorporation of Federal Transit Administration (FTA) Terms –

The provisions within include, in part, certain Standard Terms and Conditions required under the Uniform Administrative Requirements, Cost Principles, and Audit

Requirements for Federal Awards (2 CFR § 200), whether or not expressly set forth in the preceding contract provisions. All contractual provisions required by DOT, detailed in 2 CFR § 200 or as amended by 2 CFR § 1201, or the most recent version of FTA Circular 4220.1 are hereby incorporated by reference. Anything to the contrary herein notwithstanding, all mandated terms shall be deemed to control in the event of a conflict with other provisions contained in this Contract. The Contractor shall not perform any act, fail to perform any act, or refuse to comply with any request which would cause a violation of the FTA terms and conditions.

No Government Obligation to Third Parties –

The Recipient and Contractor acknowledge and agree that, notwithstanding any concurrence by the Federal Government in or approval of the solicitation or award of the underlying Contract, absent the express written consent by the Federal Government, the Federal Government is not a party to this Contract and shall not be subject to any obligations or liabilities to the Recipient, Contractor or any other party (whether or not a party to that contract) pertaining to any matter resulting from the underlying Contract. The Contractor agrees to include the above clause in each subcontract financed in whole or in part with Federal assistance provided by the FTA. It is further agreed that the clause shall not be modified, except to identify the subcontractor who will be subject to its provisions.

Notification to FTA –

If a current or prospective legal matter that may affect the Federal Government emerges, the Recipient must promptly notify the FTA Chief Counsel and FTA Regional Counsel for the Region in which the Recipient is located. The Recipient must include a similar notification requirement in its Third-Party Agreements and must require each Third-Party Participant to include an equivalent provision in its sub-agreements at every tier, for any agreement that is a “covered transaction” according to 2 C.F.R. §§ 180.220 and 1200.220.

(1) The types of legal matters that require notification include, but are not limited to, a major dispute, breach, default, litigation, or naming the Federal Government as a party to litigation or a legal disagreement in any forum for any reason.

(2) Matters that may affect the Federal Government include, but are not limited to, the Federal Government’s interests in the Award, the accompanying Underlying Agreement, and any Amendments thereto, or the Federal Government’s administration or enforcement of federal laws, regulations, and requirements.

(3) The Recipient must promptly notify the U.S. DOT Inspector General in addition to the FTA Chief Counsel or Regional Counsel for the Region in which the Recipient is located, if the Recipient has knowledge of potential fraud, waste, or abuse occurring on a Project receiving assistance from FTA. The notification provision applies if a person has or may have submitted a false claim under the False Claims Act, 31 U.S.C. § 3729 et seq., or has or may have committed a criminal or civil violation of law pertaining to such matters as fraud, conflict of interest, bribery, gratuity, or similar misconduct. This responsibility occurs whether the Project is subject to this Agreement or another agreement between the Recipient and FTA, or an agreement involving a principal, officer, employee, agent, or Third-Party Participant of the Recipient. It also applies to subcontractors at any tier.

Knowledge, as used in this paragraph, includes, but is not limited to, knowledge of a criminal or civil investigation by a Federal, state, or local law enforcement or other investigative agency, a criminal indictment or civil complaint, or probable cause that could support a criminal indictment, or any other credible information in the possession of the Recipient.

Program Fraud and False or Fraudulent Statements and Related Acts –

The Contractor acknowledges that the provisions of the Program Fraud Civil Remedies Act of 1986, as amended, 31 U.S.C. § 3801 et seq. and U.S. DOT regulations, "Program Fraud Civil Remedies," 49 C.F.R. part 31, apply to its actions pertaining to this Project. Upon execution of the underlying contract, the Contractor certifies or affirms the truthfulness and accuracy of any statement it has made, it makes, it may make, or causes to be made, pertaining to the underlying contract or the FTA assisted project for which this contract work is being performed. In addition to other penalties that may be applicable, the Contractor further acknowledges that if it makes, or causes to be made, a false, fictitious, or fraudulent claim, statement, submission, or certification, the Federal Government reserves the right to impose the penalties of the Program Fraud Civil Remedies Act of 1986 on the Contractor to the extent the Federal Government deems appropriate.
The Contractor also acknowledges that if it makes, or causes to be made, a false, fictitious, or fraudulent claim, statement, submission, or certification to the Federal Government under a contract connected with a project that is financed in whole or in part with Federal assistance originally awarded by FTA under the authority of 49 U.S.C. chapter 53, the Government reserves the right to impose the penalties of 18 U.S.C. § 1001 and 49 U.S.C. § 5323(l) on the Contractor, to the extent the Federal Government deems appropriate.
The Contractor agrees to include the above two clauses in each subcontract financed in whole or in part with Federal assistance provided by FTA. It is further agreed that the clauses shall not be modified, except to identify the subcontractor who will be subject to the provisions.

Prompt Payment –

The contractor is required to pay its subcontractors performing work related to this contract for satisfactory performance of that work no later than 30 days after the contractor’s receipt of payment for that work. In addition, the contractor is required to return any retainage payments to those subcontractors within 30 days after the subcontractor's work related to this contract is satisfactorily completed.

The contractor must promptly notify the Agency, whenever a DBE subcontractor performing work related to this contract is terminated or fails to complete its work and must make good faith efforts to engage another DBE subcontractor to perform at least the same amount of work. The contractor may not terminate any DBE subcontractor and perform that work through its own forces or those of an affiliate without prior written consent of the Agency.

Restrictions on Lobbying –

Conditions on use of funds.

(a) No appropriated funds may be expended by the recipient of a Federal contract, grant, loan, or cooperative agreement to pay any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with any of the following covered Federal actions: the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(b) Each person who requests or receives from an agency a Federal contract, grant, loan, or cooperative agreement shall file with that agency a certification, that the person has not made, and will not make, any payment prohibited by paragraph (a) of this section.

(c) Each person who requests or receives from an agency a Federal contract, grant, loan, or a cooperative agreement shall file with that agency a disclosure form if such person has made or has agreed to make any payment using non-appropriated funds (to include profits from any covered Federal action), which would be prohibited under paragraph (a) of this section if paid for with appropriated funds.

(d) Each person who requests or receives from an agency a commitment providing for the United States to insure or guarantee a loan shall file with that agency a statement, whether that person has made or has agreed to make any payment to influence or attempt to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with that loan insurance or guarantee.

(e) Each person who requests or receives from an agency a commitment providing for the United States to insure or guarantee a loan shall file with that agency a disclosure form if that person has made or has agreed to make any payment to influence or attempt to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with that loan insurance or guarantee.

Certification and disclosure.

(a) Each person shall file a certification, and a disclosure form, if required, with each submission that initiates agency consideration of such person for:

(1) Award of a Federal contract, grant, or cooperative agreement exceeding $100,000; or

(2) An award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

(b) Each person shall file a certification, and a disclosure form, if required, upon receipt by such person of:

(1) A Federal contract, grant, or cooperative agreement exceeding $100,000; or

(2) A Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000,

Unless such person previously filed a certification, and a disclosure form, if required, under paragraph (a) of this section.

(c) Each person shall file a disclosure form at the end of each calendar quarter in which there occurs any event that requires disclosure or that materially affects the accuracy of the information contained in any disclosure form previously filed by such person under paragraphs (a) or (b) of this section. An event that materially affects the accuracy of the information reported includes:

(1) A cumulative increase of $25,000 or more in the amount paid or expected to be paid for influencing or attempting to influence a covered Federal action; or
(2) A change in the person(s) or individual(s) influencing or attempting to influence a covered Federal action; or,
(3) A change in the officer(s), employee(s), or Member(s) contacted to influence or attempt to influence a covered Federal action.

(d) Any person who requests or receives from a person referred to in paragraphs (a) or (b) of this section:
(1) A subcontract exceeding $100,000 at any tier under a Federal contract;
(2) A subgrant, contract, or subcontract exceeding $100,000 at any tier under a Federal grant;
(3) A contract or subcontract exceeding $100,000 at any tier under a Federal loan exceeding $150,000; or,
(4) A contract or subcontract exceeding $100,000 at any tier under a Federal cooperative agreement,

Shall file a certification, and a disclosure form, if required, to the next tier above.

(e) All disclosure forms, but not certifications, shall be forwarded from tier to tier until received by the person referred to in paragraphs (a) or (b) of this section. That person shall forward all disclosure forms to the agency.

(f) Any certification or disclosure form filed under paragraph (e) of this section shall be treated as a material representation of fact upon which all receiving tiers shall rely. All liability arising from an erroneous representation shall be borne solely by the tier filing that representation and shall not be shared by any tier to which the erroneous representation is forwarded. Submitting an erroneous certification or disclosure constitutes a failure to file the required certification or disclosure, respectively. If a person fails to file a required certification or disclosure, the United States may pursue all available remedies, including those authorized by section 1352, title 31, U.S. Code.

(g) For awards and commitments in process prior to December 23, 1989, but not made before that date, certifications shall be required at award or commitment, covering activities occurring between December 23, 1989, and the date of award or commitment. However, for awards and commitments in process prior to the December 23, 1989 effective date of these provisions, but not made before December 23, 1989, disclosure forms shall not be required at time of award or commitment but shall be filed within 30 days.

(h) No reporting is required for an activity paid for with appropriated funds if that activity is allowable under either subpart B or C.

Seismic Safety–

The contractor agrees that any new building or addition to an existing building will be designed and constructed in accordance with the standards for Seismic Safety required in Department of Transportation (DOT) Seismic Safety Regulations 49 C.F.R. part 41 and will certify to compliance to the extent required by the regulation. The contractor also agrees to ensure that all work performed under this contract, including work performed by a subcontractor, is in compliance with the standards required by the Seismic Safety regulations and the certification of compliance issued on the project.

Severability –

The Contractor agrees that if any provision of this agreement or any amendment thereto is determined to be invalid, then the remaining provisions thereof that conform to federal laws, regulations, requirements, and guidance will continue in effect.

Simplified Acquisition Threshold –

Contracts for more than the simplified acquisition threshold, which is the inflation adjusted amount determined by the Civilian Agency Acquisition Council and the Defense Acquisition Regulations Council (Councils) as authorized by 41 U.S.C. § 1908, or otherwise set by law, must address administrative, contractual, or legal remedies in instances where contractors violate or breach contract terms, and provide for such sanctions and penalties as appropriate. (Note that the simplified acquisition threshold determines the procurement procedures that must be employed pursuant to 2 C.F.R. §§ 200.317–200.327. The simplified acquisition threshold does not exempt a procurement from other eligibility or processes requirements that may apply. For example, Buy America's eligibility and process requirements apply to any procurement in excess of $150,000. 49 U.S.C. § 5323(j)(13).)

Solid Wastes –

A Recipient that is a state agency or agency of a political subdivision of a state and its contractors must comply with section 6002 of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act. The requirements of Section 6002 include procuring only items designated in guidelines of the Environmental Protection Agency (EPA) at 40 CFR Part 247 that contain the highest percentage of recovered materials practicable, consistent with maintaining a satisfactory level of competition, where the purchase price of the item exceeds $10,000 or the value of the quantity acquired during the preceding fiscal year exceeded $10,000; procuring solid waste management services in a manner that maximizes energy and resource recovery; and establishing an affirmative procurement program for procurement of recovered materials identified in the EPA guidelines.

Special DOL EEO Clause –

During the performance of this contract, the contractor agrees as follows:

(1) The contractor will not discriminate against any employee or applicant for employment because of race, color, religion, sex, sexual orientation, gender identity, or national origin. The contractor will take affirmative action to ensure that applicants are employed, and that employees are treated during employment without regard to their race, color, religion, sex, sexual orientation, gender identity, or national origin. Such action shall include, but not be limited to the following:

Employment, upgrading, demotion, or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The contractor agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided setting forth the provisions of this nondiscrimination clause.

(2) The contractor will, in all solicitations or advertisements for employees placed by or on behalf of the contractor, state that all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, or national origin.

(3) The contractor will not discharge or in any other manner discriminate against any employee or applicant for employment because such employee or applicant has inquired about, discussed, or disclosed the compensation of the employee or applicant or another employee or applicant. This provision shall not apply to instances in which an employee who has access to the compensation information of other employees or applicants as a part of such employee's essential job functions discloses the compensation of such other employees or applicants to individuals who do not otherwise have access to such information, unless such disclosure is in response to a formal complaint or charge, in furtherance of an investigation, proceeding, hearing, or action, including an investigation conducted by the employer, or is consistent with the contractor's legal duty to furnish information.

(4) The contractor will send to each labor union or representative of workers with which he has a collective bargaining agreement or other contract or understanding, a notice to be provided advising the said labor union or workers' representatives of the contractor's commitments under this section, and shall post copies of the notice in conspicuous places available to employees and applicants for employment.

(5) The contractor will comply with all provisions of Executive Order 11246 of September 24, 1965, and of the rules, regulations, and relevant orders of the Secretary of Labor.

(6) The contractor will furnish all information and reports required by Executive Order 11246 of September 24, 1965, and by rules, regulations, and orders of the Secretary of Labor, or pursuant thereto, and will permit access to his books, records, and accounts by the administering agency and the Secretary of Labor for purposes of investigation to ascertain compliance with such rules, regulations, and orders.

(7) In the event of the contractor's noncompliance with the nondiscrimination clauses of this contract or with any of the said rules, regulations, or orders, this contract may be canceled, terminated, or suspended in whole or in part and the contractor may be declared ineligible for further Government contracts or federally assisted construction contracts in accordance with procedures authorized in Executive Order 11246 of September 24, 1965, and such other sanctions may be imposed and remedies invoked as provided in Executive Order 11246 of September 24, 1965, or by rule, regulation, or order of the Secretary of Labor, or as otherwise provided by law.

(8) The contractor will include the portion of the sentence immediately preceding paragraph (1) and the provisions of paragraphs (1) through (8) in every subcontract or purchase order unless exempted by rules, regulations, or orders of the Secretary of Labor issued pursuant to section 204 of Executive Order 11246 of September 24, 1965, so that such provisions will be binding upon each subcontractor or vendor. The contractor will take such action with respect to any subcontract or purchase order as the administering agency may direct as a means of enforcing such provisions, including sanctions for noncompliance:

Provided, however, that in the event a contractor becomes involved in, or is threatened with, litigation with a subcontractor or vendor as a result of such direction by the administering agency, the contractor may request the United States to enter into such litigation to protect the interests of the United States.

The applicant further agrees that it will be bound by the above equal opportunity clause with respect to its own employment practices when it participates in federally assisted construction work: Provided, that if the applicant so participating is a State or local government, the above equal opportunity clause is not applicable to any agency, instrumentality or subdivision of such government which does not participate in work on or under the contract.

Termination –

Termination for Convenience (General Provision)
The Agency may terminate this contract, in whole or in part, at any time by written notice to the Contractor when it is in the Agency's best interest. The Contractor shall be paid its costs, including contract close-out costs, and profit on work performed up to the time of termination.
The Contractor shall promptly submit its termination claim to Agency to be paid the Contractor. If the Contractor has any property in its possession belonging to Agency, the Contractor will account for the same, and dispose of it in the manner Agency directs.

Termination for Default [Breach or Cause] (General Provision)
If the Contractor does not deliver supplies in accordance with the contract delivery schedule, or if the contract is for services, the Contractor fails to perform in the manner called for in the contract, or if the Contractor fails to comply with any other provisions of the contract, the Agency may terminate this contract for default. Termination shall be affected by serving a Notice of Termination on the Contractor setting forth the manner in which the Contractor is in default. The Contractor will be paid only the contract price for supplies delivered and accepted, or services performed in accordance with the manner of performance set forth in the contract. If it is later determined by the Agency that the Contractor had an excusable reason for not performing, such as a strike, fire, or flood, events which are not the fault of or are beyond the control of the Contractor, the Agency, after setting up a new delivery of performance schedule, may allow the Contractor to continue work, or treat the termination as a Termination for Convenience.

Opportunity to Cure (General Provision)
The Agency, in its sole discretion may, in the case of a termination for breach or default, allow the Contractor [an appropriately short period of time] in which to cure the defect. In such case, the Notice of Termination will state the time period in which cure is permitted and other appropriate conditions

If Contractor fails to remedy to Agency's satisfaction the breach or default of any of the terms, covenants, or conditions of this Contract within [10 days] after receipt by Contractor of written notice from Agency setting forth the nature of said breach or default, Agency shall have the right to terminate the contract without any further obligation to Contractor. Any such termination for default shall not in any way operate to preclude Agency from also pursuing all available remedies against Contractor and its sureties for said breach or default.

Waiver of Remedies for any Breach
In the event that Agency elects to waive its remedies for any breach by Contractor of any covenant, term or condition of this contract, such waiver by Agency shall not limit Agency's remedies for any succeeding breach of that or of any other covenant, term, or condition of this contract.

Termination for Convenience (Professional or Transit Service Contracts)
The Agency, by written notice, may terminate this contract, in whole or in part, when it is in the Agency's interest. If this contract is terminated, the Agency shall be liable only for payment under the payment provisions of this contract for services rendered before the effective date of termination.

Termination for Default (Supplies and Service)

If the Contractor fails to deliver supplies or to perform the services within the time specified in this contract or any extension, or if the Contractor fails to comply with any other provisions of this contract, the Agency may terminate this contract for default. The Agency shall terminate by delivering to the Contractor a Notice of Termination specifying the nature of the default. The Contractor will only be paid the contract price for supplies delivered and accepted, or services performed in accordance with the manner or performance set forth in this contract.

If, after termination for failure to fulfill contract obligations, it is determined that the Contractor was not in default, the rights and obligations of the parties shall be the same as if the termination had been issued for the convenience of the Agency.

Termination for Default (Transportation Services)
If the Contractor fails to pick up the commodities or to perform the services, including delivery services, within the time specified in this contract or any extension, or if the Contractor fails to comply with any other provisions of this contract, the Agency may terminate this contract for default. The Agency shall terminate by delivering to the Contractor a Notice of Termination specifying the nature of default. The Contractor will only be paid the contract price for services performed in accordance with the manner of performance set forth in this contract.

If this contract is terminated while the Contractor has possession of Agency goods, the Contractor shall, upon direction of the Agency, protect and preserve the goods until surrendered to the Agency or its agent. The Contractor and Agency shall agree on payment for the preservation and protection of goods. Failure to agree on an amount will be resolved under the Dispute clause.

If, after termination for failure to fulfill contract obligations, it is determined that the Contractor was not in default, the rights and obligations of the parties shall be the same as if the termination had been issued for the convenience of the Agency.

<u>Tracking In Persons</u> –

The contractor agrees that it and its employees that participate in the Recipient's Award, may not:

(a) Engage in severe forms of trafficking in persons during the period of time that the Recipient's Award is in effect;

(b) Procure a commercial sex act during the period of time that the Recipient's Award is in effect; or

(c) Use forced labor in the performance of the Recipient's Award or sub-agreements thereunder.

<u>Veterans Hiring Preference</u> –

Veterans Employment - Recipients and subrecipients of Federal financial assistance shall ensure that contractors working on a capital project funded using such assistance give a hiring preference, to the extent practicable, to veterans (as defined in section 2108 of title 5) who have the requisite skills and abilities to perform the construction work required under the contract. This subsection shall not be understood, construed or enforced in any manner that would require an employer to give a preference to any veteran over any equally qualified applicant who is a member of any racial or ethnic minority, female, an individual with a disability, or a former employee.

<u>Violation and Breach of Contract</u> –

Disputes:
Disputes arising in the performance of this Contract that are not resolved by agreement of the parties shall be decided in writing by the authorized representative of the agency. This decision shall be final and conclusive unless within [10] days from the date of receipt of its copy, the Contractor mails or otherwise furnishes a written appeal to the agencies authorized representative. In connection with any such appeal, the Contractor shall be afforded an opportunity to be heard and to offer evidence in support of its position. The decision of the agencies authorized representative shall be binding upon the Contractor and the Contractor shall abide be the decision.

Performance During Dispute:
Unless otherwise directed by the agencies authorized representative, contractor shall continue performance under this contract while matters in dispute are being resolved.

Claims for Damages:
Should either party to the contract suffer injury or damage to person or property because of any act or omission of the party or of any of his employees, agents or others for whose acts he is legally liable, a claim for damages therefore shall be made in writing to such other party within a reasonable time after the first observance of such injury or damage.

Remedies:
Unless this contract provides otherwise, all claims, counterclaims, disputes and other matters in question between the agencies authorized representative and contractor arising out of or relating to this agreement or its breach will be decided by arbitration if the parties mutually agree, or in a court of competent jurisdiction within the State in which the Agency is located.

Rights and Remedies:
Duties and obligations imposed by the contract documents and the rights and remedies available thereunder shall be in addition to and not a limitation of any duties, obligations, rights and remedies otherwise imposed or available by law. No action or failure to act by the Agency or contractor shall constitute a waiver of any right or duty afforded any of them under the contract, nor shall any such action or failure to act constitute an approval of or acquiescence in any breach thereunder, except as may be specifically agreed in writing.

EXHIBIT B
STATE OF CONNECTICUT
GRANT REQUIREMENTS

STATE OF CONNECTICUT GRANT REQUIREMENTS

Small Business Enterprises. In connection with the performance of this Agreement, the Consultant shall cooperate with the District in meeting its commitments and goals with regard to the maximum utilization of small business enterprises ("SBEs"), as defined in Section 4a-60 of the Connecticut General Statutes, and will use its best efforts to insure that SBEs shall have the maximum practicable opportunity to compete for any sub-contract work under this Agreement.

The District has agreed with the Connecticut Department of Transportation to include in the Agreement the Special Provisions Requirements of Section 46a-68j-30(9) of the Contract Compliance Regulations.

The Contractor agrees to ensure that small business enterprises as defined in Section 4a-60 of the Connecticut General Statutes have the maximum opportunity to participate in the performance of contracts and subcontracts financed in whole or in part with State funds provided under this agreement. In this regard all recipients or contractors shall take necessary and reasonable steps in accordance with Section 4a-60 of the Connecticut General Statutes to ensure that small business enterprises have the maximum opportunity to compete and perform contracts. Recipients and their contractors shall not discriminate on the basis of race, creed, color, national origin, age or sex in the award of federal assisted contracts.

Failure by the contractor to carry out these requirements is a material breach of this contract, which may result in the termination of this contract or such other remedy as the recipient (the District) deems appropriate.

Non-Discrimination in Employment and Affirmative Action. In connection with the carrying out of the Project the Consultant shall not discriminate against any employee or applicant for employment because of race, color, religion, sex or national origin. The Consultant shall take affirmative action to ensure that applicants are employed, and that employees are treated during their pre-employment, without regard to their race, color, religion, sex or national origin. Such action shall include, but not be limited to the following: employment, upgrading, demotion, or transfer; recruitment or recruitment advertising; layoff, or termination; rates of pay, or other forms of compensation; and selection for training, including apprenticeship. The provisions of Executive Order No. 11246 of September 21, 1965, as amended, and all rules, regulations and orders of the Federal government issued pursuant thereto are incorporated herein by reference and made a part hereof. The Consultant agrees to comply with Title VI of the Civil Rights Act of 1964 (42 U.S.C. §2000d-4) and all requirements imposed by Title 49 C.F.R. part 21 and other pertinent directives of the federal government to the end that no person shall on the grounds of race, color, sex or national origin be excluded from participation in, or be denied the benefits of, or be otherwise subjected to discrimination under the Project.

The District has agreed with the Connecticut Department of Transportation ("CTDOT") to include in this Agreement the following Sections from the Agreement between the District and CTDOT:

Section 32 Civil Rights. (b)(1) The Second Party (the "District and its Operator") agrees and warrants that in the performance of the contract such Second Party will not discriminate or permit discrimination against any person or group of persons on the grounds of race, color, religious creed, age, marital status, national origin, ancestry, sex, mental retardation or physical disability, including, but not limited to, blindness, unless shown by such Second Party that such disability prevents performance of the work involved, in any manner prohibited by the laws of the United States or of the State of Connecticut. The Second Party further agrees to take affirmative action to insure that applicants with job related qualifications are employed and that employees are treated when employed without regard to their race, color, religious creed, age, marital status, national origin, ancestry, sex, mental retardation, or physical disability, including, but not limited to, blindness, unless shown by such Second Party that such disability prevents performance of the work involved; (2) the Second Party agrees, in all solicitations or advertisements for employees placed by or on behalf of the Second Party, to state that it is an "affirmative action-equal opportunity employer" in accordance with regulations adopted by the Commission (on Human Rights and Opportunities of the State of Connecticut); (3) the Second Party agrees to provide each labor union or representative of workers with which such Second Party has a collective bargaining agreement or other contract or understanding and each vendor with which such Second Party has a contract or understanding, a notice to be provided by the Commission advising the labor union or workers' representative of the Second Party's commitments under this section, and to post copies of the notice in conspicuous places available to employees and applicants for employment; (4) the Second Party agrees to comply with each provision of this section and Conn. Gen. Stat. §§ 46a-68e and 46a-68f and with each regulation or relevant order issued by said Commission pursuant to Conn. Gen. Stat. §§ 46a-56, 46a-68e, and 46a-68f; (5) the Second Party agrees to provide the Commission on Human Rights and Opportunities with such information requested by the Commission, and permit access to pertinent books, records and accounts, concerning the employment practices and procedures of the Second Party as they relate to the provisions of this section and § 46a-56.

Section 33. Nondiscrimination (Sexual Orientation). (a) Pursuant to § 4a.60 of the Connecticut General Statutes, (1) the Second Party agrees and warrants that in the performance of the contract such Second Party sill not discriminate or permit discrimination against any person or group of persons on the grounds of sexual orientation, in any manner prohibited by the laws of the United States or of the State of Connecticut, and that employees are treated when employed without regard to their sexual orientation; (2) the Second Party agrees to provide each labor union or representative of workers with which such Second Party has a collective bargaining agreement or other contract or understanding and each vendor with which such Second Party has a contract or understanding, a notice to be provided by the Commission advising the labor union or workers' representative of the Second Party's commitments under this section, and to post copies of the notice in conspicuous places available to employees and applicants for employment; (3) the Second Party agrees to comply with each provision of this section and with each regulation or relevant order issued by said Commission pursuant to § 46a-56 of the general statutes; (4) the Second Party agrees to provide the Commission on Human Rights and Opportunities with such information requested by the Commission, and permit access to pertinent books, records and accounts, concerning the employment practices and procedures of the Second Party as they relate to the provisions of this section and § 46a-56.

Non-Discrimination on the Basis of Disability. The Consultant shall insure that all fixed facility construction or alteration and all new equipment purchased to provide the Services comply with applicable regulations regarding Non-Discrimination on the Basis of Handicap in Programs and Activities Receiving or Benefitting from Federal Financial Assistance, set forth at Title 49, Code of Federal Regulations, Part 27, and any amendments thereto.

The Agreement shall be deemed to include the CONNECTICUT REQUIRED CONTRACT/AGREEMENT PROVISIONS including but not limited to Equal Employment Opportunity Responsibilities, Policy on SBEs, and Code of Ethics, incorporated herein by reference, and all requirements upon consultants and contractors of the "Second Party" (the "District") set forth in said PROVISIONS shall be deemed requirements upon the Consultant hereunder. In any event, the Consultant shall do nothing which would cause the District to be in violation of the requirements upon it, as the "Second Party" under said PROVISIONS.

EXECUTIVE ORDERS

This Agreement is subject to the provisions of Executive Order No 7C of Governor M. Jodi Rell, promulgated July 13, 2006, concerning contracting reforms, Executive Order No. Three of Governor Thomas J. Meskill, promulgated June 16, 1971, concerning labor employment practices, Executive Order No. Seventeen of Governor Thomas J. Meskill, promulgated February 15, 1973, concerning the listing of employment openings and Executive Order No. Sixteen of Governor John G Rowland promulgated August 4, 1999, concerning violence in the workplace, all of which are incorporated into and are made a part of this agreement as if they had been fully set forth in it. For complete text of said documents, please go to:
https://portal.ct.gov/Office-of-the-Governor/Governors-Actions/Executive-Orders

Environmental Law Compliance
The Proposer shall be responsible to comply with all federal and state environmental laws and regulations pertaining to the operation of transit motor buses and/or facilities managed by the Second Party, including but not limited to, pollutants emissions control, storage and/or disposal of waste, fluids, fuels, oil, and chemicals in general. The Second Party shall be responsible to comply with OSHA regulations. The Second Party will hold the State and CTTRANSIT harmless of any lawsuits and/or fines with respect to any environmental and/or OSHA regulations violations.

Publication of Reports
The ownership of all data and material collected under this Agreement shall be vested in the Proposer and the State. All reports shall be submitted to District for review prior to publication. The following statement should appear on the cover or title page of any published report prepared under the terms of this Agreement:

"Prepared in cooperation with the U.S. Department of Transportation (including its participating agencies), Connecticut Department of Transportation and the Greater Hartford Transit District. The opinions, findings and conclusions expressed in this publication are those of the Second Party and do not necessarily reflect the official views or policies of the District, Connecticut Department of Transportation and/or the U.S. Department of Transportation."

Jurisdiction and Forum Language
This Agreement shall be governed, interpreted and construed under and in accordance with the laws of the State of Connecticut, whether or not its conflict of laws principles would dictate otherwise. This Agreement shall be deemed to have been made in Hartford, Connecticut.

The Proposer irrevocably consents with respect to any claims or remedies at law or in equity, arising out of or in connection with this Agreement to the jurisdiction of the Connecticut Superior Court (except as otherwise required by law or that Agreement), and, with respect to any claim between the Parties, to venue in Judicial District of Hartford-New Britain at Hartford or the United States Federal Court, District of Connecticut, and irrevocably waives any objections that it may have to such jurisdiction on the grounds of lack of personal jurisdiction of such court or the laying of venue of such court or on the basis of forum non convenience or otherwise. Nothing herein shall be construed to waive any of the States or the District's immunities.

Litigation
The Proposer agrees that the sole and exclusive means for the presentation of any claim against the State arising from or in connection with this Agreement shall be in accordance with Chapter 53 of the Connecticut General Statutes (Claims against the State) and the Proposer further agrees not to initiate legal proceedings in any State or Federal Court in addition to, or in lieu of, said Chapter 53 proceedings.

FREEDOM OF INFORMATION ACT
The State is entitled to receive a copy of records and files related to the performance of the Proposer under this Agreement, and such records and files may be subject to the Freedom of Information Act and may be disclosed by the Sate pursuant to the Freedom of Information Act. No request to inspect or copy such records or files shall be valid unless the request is made to the State in accordance with the Freedom of Information Act. Any complaint by a person who is denied the right to inspect or copy such records or files shall be brought to the Freedom of Information Commission in accordance with the provisions of Sections 1-205 and 1-206 of the Connecticut General Statutes.

RIGHT TO INSPECT RECORDS
By way of its agreement with the Connecticut Department of Transportation, the District agrees to include in all its subcontracts a provision to the effect the subcontractor agrees that the State, the U.S. Department of Transportation and the Comptroller General of the United States or any of their duly authorized representatives, shall, until the expiration of three (3) years after the final payment under the subcontract, have access to and the right to examine any directly pertinent books, documents, papers, and records of such subcontractor, involving transactions related to the subcontractor. The term "subcontractor" as used in this clause excludes work not exceeding $25,000.00.

The period of access and examination described above, for records which relate to (1) appeals for disputes, (2) litigation of the settlement of claims arising out of the performance of this contract, or (3) costs and expenses in relation to the performance of this contract to which exception has been taken by the State, the Comptroller General or any of their duly authorized representatives, shall continue until such appeals, litigation, claims or exceptions have been disposed of.

PROVISIONS DATED MARCH 6, 1998
"SPECIFIC EQUAL EMPLOYMENT OPPORTUNITY RESPONSIBILITIES"

1. General

A. Equal employment Opportunity Requirements not to discriminate and to take affirmative action to assure equal employment opportunity as required by Executive Order 11246, Executive Order 11375, the Railroad Revitalization and Regulatory Reform Act of 1976 and other U.S. Department of Transportation nondiscrimination legislation are set forth in this Required Contract/Agreement Provision. The requirements set forth in these special provisions shall constitute the specific affirmative action requirements for project activities under this contract (or agreement) and supplement the equal employment opportunity requirements set forth in other related contract provisions.

B. "Company" refers to any entity doing business with the Connecticut Department of Transportation and includes but is not limited to the following:

Contractors	Vendors (where applicable)
Subcontractors	Suppliers of Materials (where applicable)
Consultants	Municipalities (where applicable)
Subconsultants	Utilities (where applicable)

C. The Company will work with the Connecticut Department of Transportation and the federal government in carrying out equal employment opportunity obligations and in their review of his/her activities under the contract or agreement.

E. The Company and all their subcontractors or subconsultants holding subcontracts or subagreements of $10,000 or more on federally assisted projects and $5,000 or more on state funded projects, will comply with the following minimum specific requirement activities of equal employment opportunity. The Company will physically include these requirements in every subcontract or subagreement meeting the monetary criteria above with such modification or language as is necessary to make them binding on the subcontractor or subconsultant.

F. These Required Contract Provisions apply to all state funded and/or federally assisted projects. activities and programs in all facets of the Connecticut Department of Transportation operations resulting in contracts or agreements.

2. Equal Employment Opportunity Policy

The Company will develop, accept and adopt as its operating policy and Affirmative Action Plan utilizing as a guide the Connecticut Department of Transportation Affirmative Action Plan Guideline.

3. Equal Employment Opportunity Officer

The Company will designate and make known to the State Department of Transportation contracting officers an equal employment opportunity officer (hereinafter referred to as the EEO Officer) who will have the responsibility for and must be capable of effectively administering and promoting an active program of equal employment opportunity and who must be assigned adequate authority and responsibility to do so.

4. Dissemination of Policy

A. All members of the Company's staff who are authorized to hire, supervise, promote, and discharge employees, or who recommend such action, or who are substantially involved in such action, will be made fully cognizant of, and will implement, the Company's equal employment opportunity policy and contractual responsibilities to provide equal employment opportunity in each grade and classification of employment. To ensure that the above agreement will be met, the following actions will be taken as a minimum:

(1) Periodic meetings of supervisory and personnel office employees will be conducted before the start of work and then not less than once every six (6) months thereafter, at which time the Company's equal employment opportunity policy and its implementation will be reviewed and explained. The meetings will be conducted by the EEO Officer or other knowledgeable Company Official.

(2) All new supervisory or personnel office employees will be given a thorough indoctrination by the EEO Officer or other knowledgeable Company official covering all major aspects of the Company's equal employment opportunity obligations within thirty (30) days following their reporting for duty with the Company.

(3) All personnel who are engaged in direct recruitment for the project will be instructed by the EEO Officer or appropriate Company official in the Company's procedures for locating and hiring protected class group employees.

B. In order to make the Company's equal employment opportunity policy known to all employees, prospective employees and potential sources of employees, i.e., schools, employment agencies, labor unions (where appropriate), college placement officers, etc., the Company will take the following actions:

(1) Notices and posters setting forth the Company's equal employment opportunity policy will be placed in areas readily accessible to employees, applicants for employment and potential employees.

(2) The Company's equal employment opportunity policy and the procedures to implement such policy will be brought to the attention of employees by means of meetings, employee handbooks, or other appropriate means.

5. Recruitment

   A. When advertising for employees, the Company will include in all advertisements for employees the notation: “An Equal Opportunity Employer”. All such advertisements will be published in newspapers or other publications having a large circulation among minority groups in the area from which the project work force would normally be derived.

   B. The Company will, unless precluded by a valid bargaining agreement, conduct systematic and direct recruitment through public and private employee referral sources likely to yield qualified minority group applicants, including, but not limited to, State employment agencies, schools, colleges and minority group organizations. To meet this requirement, the Company will, through its EEO Officer, identify sources of potential minority group employees, and establish with such identified sources procedures whereby minority group applicants may be referred to the Company for employment consideration.

In the event the Company has a valid bargaining agreement providing for exclusive hiring of all referrals, the Company is expected to observe the provisions of that agreement to the extent that the system permits the Company’s compliance with equal employment opportunity contract provisions. (The U.S. Department of Labor has held that where implementation of such agreements have the effect of discriminating against minorities or women, or obligates the Company to do the same, such implementation violates Executive Order 11246, as amended.)

   C. The Company will encourage its present employees to refer minority group applicants for employment by posting appropriate notices or bulletins in the areas accessible to all such employees. In addition, information and procedures with regard to referring minority group applicants will be discussed with employees.

6. Personnel Actions

   Wages, working conditions, and employee benefits shall be established and administered, and personnel actions of every type, including hiring, upgrading, promotion, transfer, demotion, layoffs, and termination, shall be taken without regard to race, color, religion, sex, or national origin, etc. The following procedures shall be followed:

   A. The Company will conduct periodic inspections of project sites to insure that working conditions and employee facilities do not indicate discriminatory treatment of project site personnel.

   B. The Company will periodically evaluate the spread of wages paid within each classification to determine any evidence of discriminatory wage practice.

   C. The Company will periodically review selected personnel actions in depth to determine whether there is evidence of discrimination. Where evidence is found, the Company will promptly take corrective action. If the review indicates that the discrimination may extend beyond the actions reviewed, such corrective actions shall include all affected persons.

D. The Company will promptly investigate all complaints of alleged discrimination made to the Company in connection with his obligations under this contract, will attempt to resolve such complaints, and will take appropriate corrective action within a reasonable time. If the investigation indicates that the discrimination may affect persons other than the complainant, such corrective action shall include such other persons. Upon completion of each investigation, the Company will inform every complainant of all of his avenues of appeal.

E. The general contact provision entitled A(76) Affirmative Action Requirements is made part of this document by reference. In conjunction with this contract provision, only the job categories will change in order to be comparable with the job categories utilized by the Company proposing to do business with the Connecticut Department of Transportation. The goals and timetables will remain the same throughout the contract provision.

7. <u>Training and Promotion</u>

A. The Company will assist in locating, qualifying, and increasing the skills of minority group and women employees, and applicants for employment.

B. Consistent with the Company's work force requirements and as permissible under Federal and State regulations, the Company shall make full use of training programs, i.e., apprenticeship, and on-the-job training programs for the geographical area of contact performance. Where feasible, 25 percent of apprentices of trainees in each occupation shall be in their first year of apprenticeship of training. In the event the Training Special Provision is provided under this contract, this subparagraph will be superseded.

C. The Company will advise employees and applicants for employment of available training programs and entrance requirements for each.

D. The Company will periodically review the training and promotion potential of minority group and women employees and will encourage eligible employees to apply for such training and promotion.

8. <u>Unions</u>

If the Company relies in whole or in part upon unions as a source of employees, it will use its best efforts to obtain the cooperation of such unions to increase opportunities for minority groups and women within the unions, and to effect referrals by such unions of minority and female employees. Actions by the Company either directly or through an association acting as agent will include the procedures set forth below:

A. The Company will use its best efforts to develop, in cooperation with the unions, joint training programs aimed toward qualifying more minority group members and women for membership in the unions and increasing the skills of minority group employees and women so that they may qualify for higher paying employment.

B. The Company will use its best efforts to incorporate an equal employment opportunity clause into each union agreement to the end that such union will be contractually bound to refer applicants without regard to their race, color, religion, sex, or national origin, etc.

C. The Company is to obtain information as to the referral practices and policies of the labor union except that to the extent such information is within the exclusive possession of the labor union and such labor union refuses to furnish such information to the Company, the Company shall so certify to the Connecticut Department of Transportation and shall set forth what efforts have been made to obtain such information.

D. In the event the union is unable to provide the Company with a reasonable flow of minority and women referrals within the time limit set forth in the collective bargaining agreement, the Company will, through independent recruitment efforts, fill the employment vacancies without regard to race, color, religion, sex or national origin, etc. making full efforts to obtain qualified and/or qualifiable minority group persons and women. (The U.S. Department of Labor has held that there shall be no excuse that the union with which the Company has a collective bargaining agreement providing for exclusive referral failed to refer minority employees). In the event the union referral practice prevents the Company from meeting the obligations pursuant to Executive Order 11246, as amended, and these provisions, such Company shall immediately notify the Connecticut Department of Transportation.

9. Subcontracting

A. The Company will use its best efforts to solicit Bids from and to utilize minority group subcontractors, or subcontractors with meaningful minority group and female representation among their employees. Companies shall obtain a list of applicable Disadvantaged Business Enterprise firms from the Division of Contract Compliance.

B. The Company will use its best efforts to ensure subcontractor compliance with their equal employment opportunity obligations.

C. The General Contract Provisions entitled "Minority Business Enterprises as Subcontractors" is made part of this document by reference and its requirements are applicable to all entities proposing to do business with the Connecticut Department of Transportation.

10. Records and Reports

For the duration of the project, the company will maintain records as are necessary to determine compliance with the Company's equal employment opportunity obligations and Affirmative Action requirements. Additionally, the company will submit all requested reports in the manner required by the contracting agency.

A. The number of minority and non-minority group members and women employed in each work classification on the project.

B. The progress and efforts being made in cooperation with unions to increase employment opportunities for minorities and women (applicable only to Companies which rely on whole or in part on unions as a source of their work force).

C. The progress and efforts being made in locating, hiring, training, qualifying, and upgrading minority and female employees, and

D. The progress and efforts being made in securing the services of minority and female owned businesses.

   (1) All such records must be retained for a period of three (3) years following completion of the contract work and shall be available at reasonable times and places for inspection by authorized representatives of the State Department of Transportation and the U.S. Department of Transportation including consultant firms.

   (2) If on-the-job training is being required by the "Training Special Provision", the Company will be required to furnish a Monthly Training Report and Supplement Report (1409) for each trainee.

11. Affirmative Action Plan

   A. Contractors, subcontractors, Vendors, suppliers, and all other Companies with contracts, agreements or purchase orders completely state funded will submit an Affirmative Action Plan if the contract value is $5,000 or over.

   B. Contractors, subcontractors, Vendors, suppliers, and all other Companies with federally assisted contracts, agreements, or purchase orders valued at $10,000 or more will submit an Affirmative Action Plan.

   C. Companies with contracts, agreements, or purchase orders with total dollar value under that which is stipulated in A and B above shall be exempt from the required submission of an Affirmative Action Plan unless otherwise directed by the Division of Contract Compliance.

EXHIBIT C
PROCUREMENT AND APPEALS PROCESS

GHTD Procedures and Appeals Process

It is the policy of the Greater Hartford Transit District that it is responsible for resolving all Pre-Bid, Pre-Award and Post-Award Procurement Protest disputes arising out of third party procurements using good administrative practices and sound business judgment. It is the District's intention that its procurement process provides for fair and open competition in compliance with federal and state laws and District Policies.

The District has established these pre-bid, pre-award, and post-award procurement protest policy and procedures so that all procurement protests/disputes are filed, processed and resolved in a manner consistent with the requirements of the Federal Transit Administration.

1. Pre-Bid

   A pre-bid or solicitation phase protest is received prior to the bid opening or proposal due date. Pre-bid protests are those based on the content of the initial notice and/or solicitation published by the District requesting bids or proposals from vendors or other interested parties.

2. Pre-award

   A pre-award protest is a protest against making an award and is received after receipt of proposals or bids, but before award of a contract.

3. Post-Award

   A post-award protest is a protest received after award of a contract. A post-award protest must be received within 5 business days of the notification of the award. A post-award protest generally alleges a violation of applicable federal or state law and/or District policy or procedures relative to the seeking, evaluating and/or awarding of the contract. Each Proposer will be notified by first class mail of the decision of the District as to the selection of firm under this procurement. Included in that notification will be a proposed effective date of engagement which will be no less than 15 days following the date of notification of award.

It is the policy of the District not to proceed with the award phase of any procurement if there is a pending protest.

All Protests must be filed in writing to:

> Vicki L. Shotland, Executive Director
> Greater Hartford Transit District
> One Union Place
> Hartford, CT 06103

A Protest must be in writing and set forth the specific grounds of the dispute and shall be fully supported with technical data, test results, or other pertinent information related to the subject being protested. The Protest shall include the name and contact information of the Protester, solicitation number or description, and what remedy the Protester is seeking. The Protester is responsible for adhering to this regulation

Greater Hartford Transit District, Vicki L. Shotland, Executive Director or designee shall make a determination on the Protest generally within ten (10) working days from receipt of the

Protest. The Decision of the Executive Director or Designee must be in writing and shall include a response to each substantive issue raised in the Protest. The Executive Director's decision shall constitute the District's final administrative determination.

If the District postpones the date of Bid submission because of a Protest or Appeal of the solicitation specifications, addenda, dates or any other issue relating to the procurement, the District will notify, via addendum, all parties who are on record as having obtained a copy of the solicitation documents that a Protest/Appeal has been filed and the due date for Bid submission shall be postponed until the District has issued its final decision.

The Protester may withdraw its Protest or Appeal at any time before a final decision is issued.

A Protester must exhaust all administrative remedies with the District before pursuing a protest with the Federal Transit Administration (FTA). Reviews of protests by the FTA will be limited to (1) failure to have or to follow the District's protest procedures or failure to review a complaint or Protest or (2) violations of Federal law or regulation.

A Protest Appeal to FTA must be received within five (5) working days of the date of the final decision by the Greater Hartford Transit District is rendered. The appeal must be in writing and must include the name and address of the protestor, cite the District as the grantee, the number of the solicitation, a statement of the grounds for protest and any supporing documentation, including a copy of the local Protest filed with the District and a copy of the District's decision, if any. Protest appeals should be filed with:

Federal Transit Administration Region 1 Office,
Kendall Square
Attention: Procurement Appeal
55 Broadway, Suite 920
Cambridge, MA 02142-1093

Upon receipt of a notice that an appeal has been submitted to FTA prior to the award of a contract, the District will immediately contact the appropriate FTA official to determine if the Response Date should be postponed. If the Response Date is postponed, the District will contact all Proposers or firms who have been furnished a copy of the RFP that an appeal has been filed and that the Response Date is postponed until FTA has issued its decision. Appropriate addenda will be issued rescheduling the Response Date.

Any appeal to FTA may be withdrawn at any time before FTA has issued its decision.

FTA's decision on any appeal will be final. No further appeals will be considered by FTA.

EXHIBIT D
BID PROPOSAL FORM AND EQUIPMENT LISTS

BID PROPOSAL FORM

1.1 BID INFORMATION

A. Bidder: ____.

B. Project Name: GREATER HARTFORD TRANSIT DISTRICT
HVAC EQUIPMENT REPLACEMENT (UNION STATION)
ONE UNION PLACE
HARTFORD, CT 06103

C. Project Location: One Union Place, Hartford, CT 06103.

D. Owner: Greater Hartford Transit District.

E. Owner Project Number: IFB #02-024 HVAC Equipment Replacement (Union Station)

F. Architect/Engineers: AI Engineers, Inc.

1.2 CERTIFICATIONS AND BASE BID

Base Bid, Single-Prime (All Trades) Contract:

MECHANICAL

A. Base bid shall include replacement of the following equipment and controls:

1. (4) air handler units: AHU-9L, AHU-9R, AHU-11L, AHU-11R.
2. (3) package units: PK1, PK2 and PK3.
3. (4) air handler units AHU-14L-1, AHU-14L-2, AHU-14L-3, AHU-14L-5, serving Propark (South wing).
4. (1) make up air unit MAU-1 in Transportation Center.

ELECTRICAL

B. Base bid shall include:

1. New overcurrent protective device (in existing source panel or switchboard), feeder, conduit, local fused disconnect switch for:
   a. (4) air handler units: AHU-9L, AHU-9R, AHU-11L, AHU-11R.
   b. (3) package units: PK1, PK2 and PK3.
   c. (4) air handler units AHU-14L-1, AHU-14L-2, AHU-14L-3, AHU-14L-5, serving Propark (South wing).
   d. (1) make up air unit MAU-1 in Transportation Center.
2. New duct smoke detectors (with remote test switches) for local fan shutdown, wired to existing fire alarm control panel.

The undersigned Bidder, having carefully examined the Procurement and Contracting Requirements, Conditions of the Contract, Drawings, Specifications, and all subsequent Addenda, as prepared by AI Engineers, Inc., having visited the site, and being familiar with all conditions and requirements of the Work, hereby agrees to furnish all material, labor, equipment and services, including all scheduled allowances, necessary to complete the construction of the above-named project, according to the requirements of the Procurement and Contracting Documents, for the stipulated sum of:

1. ____ Dollars ($_____________).

1.3 BID GUARANTEE

A. The undersigned Bidder agrees to execute a contract for this Work in the above amount and to furnish a Bid Security made payable to the Greater Hartford Transit District as specified in the Invitation to Bid. If Bidder fails to execute a contract for this Work 10 days after receiving a written Notice of Award, he will forfeit to Owner the enclosed cash, certified check, cashier's check, or Bid Bond issued by a surety, as liquidated damages for such failure, in the following amount constituting five percent (5%) of the Base Bid Amount above:

1. ____ Dollars ($_____________).

B. In the event Owner does not offer Notice of Award within 120 days after receipt of Bid, Owner will return to the undersigned the cash, cashier's check, certified check, U.S. money order, or bid bond.

1.4 ADD ALTERNATES: Hartford's Union Station is a 24 hour/7 days a week operational facility. In order to continue its operation proposed are Add Alternates.
The add alternates for project:

Greater Hartford Transit District
HVAC Equipment Replacement
One Union Place
Hartford, CT 06103

are limited to:

ADD Alternate #1

Mechanical Scope of Work shall include replacement of the following equipment and controls:

1. (7) air handler units AHU-2, AHU-3, AHU-4, AHU-5, AHU-6, AHU-7 and AHU-8, located in the attic.
2. (7) air exhaust fans EX-2, EX-3, EX-4, EX-5, EX-6, EX-7, EX-8, located in the attic.
3. Building Management System (BMS). The BMS shall be provided as detailed in specification 230923. The equipment to be integrated into the BMS shall include at minimum:

   a. All HVAC equipment (including existing air handling equipment and fans not part of project)
   b. All air cooled chillers (including existing air cooled chillers not part of project)
   c. All pumps
   d. All boilers

The BMS shall have in addition to the status of equipment a minimum of 20 additional points to be defined by the owner at no cost. The BMS shall be expandable to allow for future expansion.
The price shall include cost for all equipment, programming, wiring, design, installation, functional test, and commissioning.

Electrical Scope of Work shall include:

1. New overcurrent protective device (in existing source panel or switchboard), feeder, conduit, local fused disconnect switch for:

a. (7) air handler units AHU-2, AHU-3, AHU-4, AHU-5, AHU-6, AHU-7 and AHU-8, located in the attic.
b. (7) air exhaust fans EX-2, EX-3, EX-4, EX-5, EX-6, EX-7, EX-8, located in the attic.

2. 120V circuit for new BMS panel in attic. 120V circuit to new BMS sub-panels.
3. New duct smoke detectors (with remote test switches) for local fan shutdown, wired to existing fire alarm control panel.

ADD Alternate #2

Mechanical Scope of Work shall include replacement of the following equipment and controls:

1. (3) air cooled chillers CH-4, CH-5, CH-6, located on grade.

Electrical Scope of Work shall include new overcurrent protective device (in existing source panel or switchboard), feeder, conduit, local fused disconnect switch for:

1. (3) air cooled chillers CH-4, CH-5, CH-6, located on grade.

Add Alt. 1 ____ Dollars ($_______________).

Add Alt. 2____ Dollars ($_______________).

Add Alt. 3____ Dollars ($_______________).

Add Alt. 4____ Dollars ($_______________).

1.5 SUBCONTRACTORS AND SUPPLIERS

The following companies shall execute subcontracts for the portions of the Work indicated:

1. HVAC ductwork and equipment installation. ____
2. HVAC piping and valves installation. ____
3. Air Temperature Controls and BMS installation. ____

1.6 TIME OF COMPLETION

A. The undersigned Bidder proposes and agrees hereby to commence the Work promptly, and shall fully complete the Work of all phases within **12** months after execution of the Contract.

1.7 ACKNOWLEDGMENT OF ADDENDA

A. The undersigned Bidder acknowledges receipt of and use of the following Addenda in the preparation of this Bid:

1. Addendum No. 1, dated ______________________.

2. Addendum No. 2, dated ______________________.

3. Addendum No. 3, dated ______________________.

4. Addendum No. 4, dated ____________________.

1.9 CONTRACTOR'S LICENSE

A. The undersigned further states that it is a duly licensed contractor, for the type of work proposed, in the State of Connecticut, and that all fees, permits, etc., pursuant to submitting this proposal have been paid in full.

1.10 FEDERALLY REQUIRED CONTRACT CLAUSES (Exhibit A)

A. The undersigned acknowledges receipt of the Federally Required Contract Clauses contained in “Exhibit A” and agrees to comply with them.

1.11 STATE OF CONNECTICUT CONTRACT CLAUSES (Exhibit B)

A. The undersigned acknowledges receipt of the State of Connecticut Contract Clauses contained in “Exhibit B” and agrees to comply with them.

1.12 REQUIRED CERTIFICATIONS (Exhibits E & F)

A. The undersigned acknowledges receipt of the Required Certificates contained in “Exhibits E & F” and agrees to comply with their requirements. Signed copies of the Required Certificates are included as part of this Bid.

1.13 SUBMISSION OF BID

A. Respectfully submitted this ______ day of ______________________________, 2024.

B. Submitted By: _________________________________ (Name of bidding firm or corporation).

C. Authorized Signature: _______________________________________ (Handwritten signature).

D. Signed By: ____ (Type or print name).

E. Title: ______________________________________ (Owner/Partner/President/Vice President).

F. Witnessed By: ____ (Handwritten signature).

G. Attest: ____ (Handwritten signature).

H. By: ____ (Type or print name).

I. Title: ____________________________________ (Corporate Secretary or Assistant Secretary).

J. Street Address: ____.

K. City, State, Zip: ____.

L. Phone: ____.

M. License No.: ____.

N. Federal ID No.: _______________________________________ (Affix Corporate Seal Here).

END OF BID PROPOSAL FORM
GREATER HARTFORD TRANSIT DISTRICT
HVAC EQUIPMENT REPLACEMENT (UNION STATION)
ONE UNION PLACE
HARTFORD, CT 06103

EXISTING EQUIPMENT LIST

Equipment Tag	Equipment Type	Manufacturer	Model Number	Serial Number
AHU-4	Air handler	Trane	CCDB17AUEEH3AIL0ILLAKI00D2B2B100KBB4E110000F000000000000000	K86C97539
AHU-3	Air handler	Trane	CCDB17AUEEH3A1L01RRAK100D2B2BI00KBBAE110000F000000000000000	K86C97524
AHU-5	Air handler	Trane	CCDB12AUEEH3AILO1RRAJ100D3B2B100J9A4E110000F000000000000000	K86C97525
AHU-9R	Air handler	Trane	CCDB0BANEEV3ABR0IRRAH300L4828300M084E110000F000000000000000	K86C97526
AHU-10R	Air handler	Trane	CCDB06ANEEH3A1RO1RRAG100N7828100J0A4E110000F000000000000000	K86C97527
AHU-11	Air handler	Trane	CCDB06ANEEH3A1R01RRAF100L3B2B100E6A2E110000F000000000000000	K86C97528
AHU-11R	Air handler	Trane	CCDB06ANEEV3ABR01RRAF100L3B2B100E6A2E110000F000000000000000	K86CP7529
AHU-13R	Air handler	Trane	CCDB03ANEEH3A1RD1RRAE300L1B2B300E6A2E110000F000000000000000	K86C97530-81
AHU-13	Air handler	Trane	CCDB03ANDEN3A1R01R0AE100E582C00000000110000F000000000000000	K86C97532
AHU-14R	Air handler	Trane	CCDB03ANEEH3A1R01RRAD100L5B2B100G5A4E110000F000000000000000	K86C97533-35
AHU-1	Air handler	Trane	CCDB25AUEEH3AIL01RRAK100D2B2B100J8BE110000F000000000000000	K86C97536
AHU-2	Air handler	Trane	CCDB25AUEEH3A1R01LLAL100D2B2B100JAB4E110000F000000000000000	K86C97537
AHU-7,AHU-8	Air handler	Trane	CCDR17AUEEH3A1R01LLAK10D2B2B100KBB4E110000F000000000000000	K86C97539-40
AHU-6	Air handler	Trane	CCDB12AUEEH3A1R01LLAJ100D3B2B100J7A4E110000F000000000000000	K86C97541
AHU-9L	Air handler	Trane	CCDE09AVEEV3A8L01LLAH300L4B2B300M0B4E110000F000000000000000	K86C97542
AHU-10L	Air handler	Trane	CCDPD5ANEEH3A1LD1LLAG100N7B2B1DDJ0A4E110000F000000000000000	K86C97543
AHU-11L	Air handler	Trane	CCDB06ANEEV3ABL01LLAF100L3B2B100E6A2E110000F000000000000000	K86C97544
AHU-13L	Air handler	Trane	CCDB03ANEEM3A1LD1LLAE300L1B2B300E6A2E110000F000000000000000	K86C97545
AHU-13 MUL	Air handler	Trane	CCD8D3AW0EM3A1L01L0AE100ESB2C00000000110000F000000000000000	K86C97546
AHU-14L	Air handler	Trane	CCDB03ANEEH3A1L01LLAD10015B2B100G5A4E110000F000000000000000	K86C97547-49
PK-1	Packaged AC Unit	Trane	TCH036A100AB	D32160593
PK-2	Packaged AC Unit	Trane	BTC024C100BA	B27168060
PK-3	Packaged AC Unit	Trane	BTC024C100BA	B27168061
CH-4	Chiller	Trane	CGAM 052F 2E02 AXD2 A1A1 A1AX XA1D 1A2X XXXX XBXA 3A1D XXXC XX	U11K25628
CH-5	Chiller	Trane	CGAM 052F 2E02 AXD2 A1A1 A1AX XA1D 1A2X XXXX XBXA 3A1D XXXC XX	U11K25629
CH-6	Chiller	Trane	CGAM 040F 2E02 AXD2 A1A1 A1AX XA1D 1A2X XXXX XBXA 3A1D XXXC XX	U11K25630
EX-1	Return/Exhaust Fan	Trane	33B-9-1HC	L86B36171
EX-2	Return/Exhaust Fan	Trane	33B-9-1HC	L86B36172
EX-3	Return/Exhaust Fan	Trane	30B-9-1HC	L86B36173
EX-4	Return/Exhaust Fan	Trane	30B-9-1HC	L86B36174
EX-5	Return/Exhaust Fan	Trane	27B-9-1H	L86B36177
EX-6	Return/Exhaust Fan	Trane	27B-9-1H	L86B36178
EX-7	Return/Exhaust Fan	Trane	30B-9-1HC	L86B36175
EX-8	Return/Exhaust Fan	Trane	30B-9-1HC	L86B36176

FIRST FLOOR LEVEL AIR HANDLING UNIT SCHEDULE - BASE BID

TAG	MANUFACTURER	MODEL	SUPPLY FAN		HEATING COIL							COOLING COIL							ELECTRICAL				REMARKS
			AIRFLOW	TOTAL SP	FLUID TYPE	ROWS	MBH	ENTERING FLUID TEMP	LEAVING FLUID TEMP	FLOW RATE	AIR PRESSURE...	FLUID TYPE	ROWS	TOTAL MBH	GPM	SENSIBLE MBH	AIR PRESSURE DROP	FLUID PRESSURE DROP	UNIT VOLTAGE/HZ/PHASE	FLA	MCA	MOP	
			CFM	IN. H20				F	F	GPM	IN. H20						IN. H2O	FT. H20		AMPS	AMPS	AMPS	
AHU-9L	TRANE	UCCAD08A0F0RBL52000000EDV00BA0000000B0B0	4000	2.543	HYDRONIC	1	195	180	163	23.58	0.152	30% PROPYLENE GYCOL CHILLED WATER	6	154	33.66	110	0.768	5.44	208/60/3	22.5	28	50	1,2,3,4,5,6,11
AHU-9R	TRANE	UCCAD08A0F0RBL52000000EDV00BA0000000B0B0	4000	2.543	HYDRONIC	1	195	180	163	23.58	0.152	30% PROPYLENE GYCOL CHILLED WATER	6	154	33.66	110	0.768	5.44	208/60/3	22.5	28	50	1,2,3,4,5,6,11
AHU-11L	TRANE	BCVE090	2000	1.438	HYDRONIC	1	109	180	160	10.9	0.059	30% PROPYLENE GYCOL CHILLED WATER	4	77	16.25	55.12	0.281	6.8	208/60/3	4.6	5.75	15	2,3,5,7,8,9,11
AHU-11R	TRANE	BCVE090	2000	1.438	HYDRONIC	1	109	180	160	10.9	0.059	30% PROPYLENE GYCOL CHILLED WATER	4	77	16.25	55.12	0.281	6.8	208/60/3	4.6	5.75	15	2,3,5,7,8,9,11
MAU-1	TRANE	UCCAA03A0F0RBM72000000CD600AA00000000000	1650	3.032	HYDRONIC	1	106.92	180	180	21.4	.2	30% PROPYLENE GYCOL CHILLED WATER	6	62.38	13.5	45.47	1.071	9.17	208/60/3	7.3	9	15	1,2,3,4,5,6,11
AHU-14L-1	TRANE	BCHE036	800	1.395	HYDRONIC	1	47.02	180	160	4.7	0.051	30% PROPYLENE GYCOL CHILLED WATER	4	22.5	6	18.84	0.217	7.13	208/60/3	2.4	3	15	2,3,5,7,8,9,10,11
AHU-14L-2	TRANE	BCHE036	800	1.395	HYDRONIC	1	47.02	180	160	4.7	0.051	30% PROPYLENE GYCOL CHILLED WATER	4	22.5	6	18.84	0.217	7.13	208/60/3	2.4	3	15	2,3,5,7,8,9,10,11
AHU-14L-3	TRANE	BCHE036	800	1.395	HYDRONIC	1	47.02	180	160	4.7	0.051	30% PROPYLENE GYCOL CHILLED WATER	4	22.5	6	18.84	0.217	7.13	208/60/3	2.4	3	15	2,3,5,7,8,9,10,11
AHU-14L-5	TRANE	BCHE036	800	1.395	HYDRONIC	1	47.02	180	160	4.7	0.051	30% PROPYLENE GYCOL CHILLED WATER	4	22.5	6	18.84	0.217	7.13	208/60/3	2.4	3	15	2,3,5,7,8,9,10,11

NOTES:

1. PROVIDE REMOTE MOUNTED VARIABLE FREQUENCY DRIVE WITH MANUAL BYPASS (BY ABB, ALLEN BRADLEY OR SCHNEIDER) ON THE SUPPLY FAN.
2. PRE-FILTER SECTION SHALL CONTAIN MERV-8 FILTERS.
3. PROVIDE SINGLE POINT POWER CONNECTION.
4. STAINLESS STEEL DRAIN PAN WITH CONDENSATE OVERFLOW SWITCH.
5. BACnet CONTROLLER. CONTROLS TRANSFORMER.
6. R/A OPENING WITH LOW AIR LEAK MOTORIZED DAMPER SECTION ON TOP, NO O/A DAMPER OPENING ON UNIT.
7. INSULATED ACCESS DOORS.
8. INSULATED ACCESS DOOR FOR FILTER SECTION. POLYMER DRAIN PAN WITH CONDENSATE OVERFLOW SWITCH.
9. ELECTRONICALLY COMMUTATED MOTOR (ECM).
10. PROVIDE SPRING ISOLATOR WITH 1" STATIC DEFLECTION.
11. APPROVED EQUAL MANUFACTURERS: CARRIER AND YORK. APPROVED EQUAL MANUFACTURER SHALL PROVIDE ALL SPECIFIED ITEMS.

ATTIC AIR HANDLING UNIT SCHEDULE - ADD ALTERNATE #1																								
TAG	MANUFACTURER	MODEL	OA FLOW		SUPPLY FAN		HEATING COIL					COOLING COIL							ELECTRICAL				REMARKS
			MIN. (CFM)	MAX. (CFM)	AIRFLOW	TOTAL SP	FLUID TYPE	ROWS	MBH	STEAM PRESSURE	AIR PRESSURE DROP	FLUID TYPE	ROWS	TOTAL MBH	GPM	SENSIBLE MBH	AIR PRESSURE DROP	FLUID PRESSURE DROP	UNIT VOLTAGE/HZ/ PHASE	FLA	MCA	MOP	
AHU-2	TRANE	PSCA-28	1200	2400	12000	2.69	STEAM	1	520.56	15	0.099	30% PROPYLENE GYCOL CHILLED WATER	6	450	97.32	330	0.788	12.59	208/60/3	42	52.5	90	ALL
AHU-3	TRANE	UCCAG17A0F0EGM5200000 0GD881AA0000000001	1000	2000	8500	3.101	STEAM	1	526.5	15	0.181	30% PROPYLENE GYCOL CHILLED WATER	6	321	79.72	235	0.894	18.73	208/60/3	42.5	53	90	ALL
AHU-4	TRANE	UCCAG17A0F0EGM5200000 0GD881AA0000000001	1000	2000	8500	3.101	STEAM	1	526.5	15	0.181	30% PROPYLENE GYCOL CHILLED WATER	6	321	79.72	235	0.894	18.73	208/60/3	42.5	53	90	ALL
AHU-5	TRANE	UCCAG12A0EGM52000000F D882AA0000000001	800	1600	6000	2.971	STEAM	1	353.01	15	0.215	30% PROPYLENE GYCOL CHILLED WATER	6	225	61.49	165	0.806	13.95	208/60/3	28.5	35.5	60	ALL
AHU-6	TRANE	UCCAG12A0EGM52000000F D882AA0000000001	800	1600	6000	2.971	STEAM	1	353.01	15	0.215	30% PROPYLENE GYCOL CHILLED WATER	6	225	61.49	165	0.806	13.95	208/60/3	28.5	35.5	60	ALL
AHU-7	TRANE	UCCAG17A0F0EGM5200000 0GD881AA0000000001	1000	2000	8500	3.101	STEAM	1	526.5	15	0.181	30% PROPYLENE GYCOL CHILLED WATER	6	321	79.72	235	0.894	18.73	208/60/3	42.5	53	90	ALL
AHU-8	TRANE	UCCAG17A0F0EGM5200000 0GD881AA0000000001	1000	2000	8500	3.101	STEAM	1	526.5	15	0.181	30% PROPYLENE GYCOL CHILLED WATER	6	321	79.72	235	0.894	18.73	208/60/3	42.5	53	90	ALL

NOTES:
1. PROVIDE REMOTE MOUNTED VARIABLE FREQUENCY DRIVE WITH MANUAL BYPASS (BY ABB, ALLEN BRADLEY OR SCHNEIDER) ON THE SUPPLY FAN.
2. PRE-FILTER SECTION SHALL CONTAIN MERV-8 FILTERS.
3. PROVIDE SINGLE POINT POWER CONNECTION.
4. STAINLESS STEEL DRAIN PAN WITH CONDENSATE OVERFLOW SWITCH.
5. BACnet CONTROLLER. CONTROLS TRANSFORMER.
6. APPROVED EQUAL MANUFACTURERS: CARRIER AND YORK. APPROVED EQUAL MANUFACTURER SHALL PROVIDE ALL SPECIFIED ITEMS.

MEZZANINE AIR CONDITIONING UNIT SCHEDULE - BASE BID

TAG	MANUFACTURER	MODEL	SUPPLY FAN			HEATING COIL		COOLING COIL		ELECTRICAL			EER	WEIGHT (LBS)	REMARKS
			AIRFLOW	ESP	EER	HEATING TYPE	MAXIMUM BTUH	COOLING TYPE	MAXIMUM BTUH	UNIT VOLTAGE/HZ/PHASE	MCA	MOP			
			CFM	IN. H20							AMPS	AMPS			
PK-1	TRANE	4WCC4036A1000A	1200	0.5	11	HEAT PUMP	34400	DX HEAT PUMP	35200	208/60/1	24.4	40	11	364	ALL
PK-2	TRANE	4WCC4024A1000A	800	0.5	11	HEAT PUMP	23200	DX HEAT PUMP	23800	208/60/1	20.6	30	11	328	ALL
PK-3	TRANE	4WCC4024A1000A	800	0.5	11	HEAT PUMP	23200	DX HEAT PUMP	23800	208/60/1	20.6	30	11	328	ALL

NOTES:
1. PROVIE SINGLE POINT POWER CONNECTION.
2. PROVIDE MANUFACTURER'S 18" HIGH EQUIPMENT ISOLATION BASE WITH SPRING ISOLATORS WITH 1" STATIC DEFLECTION. POLYMER DRAIN PAN WITH CONDENSATE OVERFLOW SWITCH.
3. APPROVED EQUAL MANUFACTURER: CARRIER AND YORK. APPROVED EQUAL MANUFACTURER SHALL PROVIDE ALL SPECIFIED ITEMS.

AIR COOLED CHILLER SCHEDULE - ADD ALTERNATE #2

TAG	MANUFACTURER	MODEL	NOMINAL TONS	COOLING EFFICIENCY		FLUID TYPE	ENTERING WATER TEMP	LEAVING WATER TEMP	DESIGN FLOW RATE	COMPRESSOR DATA			ELECTRICAL			REMARKS
				IPLV	EER		F	F	GPM	QTY	TYPE	REFRIGERANT	UNIT VOLTAGE/HZ /PHASE	MCA AMPS	MOP AMPS	
CH-4	TRANE	CGAM052F2	52	16.41	10.99	30% PG	54	44	124.2	4	SCROLL	R-458-B	460/60/3	107	150	ALL
CH-5	TRANE	CGAM052F2	52	16.41	10.99	30% PG	54	44	124.2	4	SCROLL	R-458-B	460/60/3	107	150	ALL
CH-6	TRANE	CGAM040F2	40	16.50	11.29	30% PG	54	44	95.1	4	SCROLL	R-458-B	460/60/3	95	125	ALL

NOTES:

1. EQUIPMENT SPECIFIED TO REPLACE EXISTING CHILLERS.
2. PROVIDE FREEZE PROTECTION.
3. PROVIDE SINGLE POINT POWER CONNECTION.
4. SOUND POWER: 89 dBA.
5. BACnet CONTROLLER. CONTROLS TRANSFORMER.
6. UNIT MOUNTED STARTER.
7. FACTORY INSULATED EVAPORATOR AND REFRIGERATION SYSTEM.
8. APPROVED EQUAL MANUFACTURERS: CARRIER AND YORK. APPROVED EQUAL MANUFACTURER SHALL PROVIDE ALL SPECIFIED ITEMS.

INLINE EXHAUST FANS - ADD ALTERNATE #1

TAG	MANUFACTURER	MODEL	LOCATION	FAN				MOTOR		ELECTRICAL		REMARKS
				CFM	STATIC PRESSURE (IN. H20)	DRIVE	RPM	HP	RPM	VOLTS	PHASE	
EX-2	GREENHECK	TDI-3-36-3...	ATTIC	12000	0.5	DIRECT	1725	3	1725	208	3	ALL
EX-3	GREENHECK	TDI-3-30-4...	ATTIC	8500	0.5	DIRECT	1725	2	1725	208	3	ALL
EX-4	GREENHECK	TDI-3-30-4...	ATTIC	8500	0.5	DIRECT	1725	2	1725	208	3	ALL
EX-5	GREENHECK	TDI-3-24-3...	ATTIC	6000	0.5	DIRECT	1725	1-1/2	1725	208	3	ALL
EX-6	GREENHECK	TDI-3-24-3...	ATTIC	6000	0.5	DIRECT	1725	1-1/2	1725	208	3	ALL
EX-7	GREENHECK	TDI-3-30-4...	ATTIC	8500	0.5	DIRECT	1725	2	1725	208	3	ALL
EX-8	GREENHECK	TDI-3-30-40 9	ATTIC	8500	0.5	DIRECT	1725	2	1725	208	3	ALL

NOTES:
1. FAN CONTROL BASED UPON DESIGNATED AHU OPERATIONS, PROVIDE FAN WITH REMOTE-MOUNTED VFD CONTROLLER WITH MANUAL BYPASS (BY ABB, ALLEN BRADLEY, OR SCHNEDER).
2. PROVIDE SPRING ISOLATORS WITH 2" STATIC DEFLECTION.
3. APPROVED EQUAL MANUFACTURER: LOREN COOK. APPROVED EQUAL MANUFACTURER SHALL PROVIDE ALL SPECIFIED ITEMS.

EXHIBIT E
REQUIRED FORMS AND CERTIFICATES

AFFIDAVIT

STATE OF CONNECTICUT)
) ss.____________________, 20___
COUNTY OF ____________________)

I,________________________________, being duly sworn, depose and say:
(insert name of authorized agent)

1. I am the ______________________ of __________________________ (the
(insert title) (insert name of company)
"Respondent") and am authorized on behalf of the Proposer to make this Affidavit.

2. I am over 18 years of age and understand the obligations of an oath.

3. There are no delinquent real and personal property taxes due the State of Connecticut from the Respondent.

4. The Respondent is current on all monetary obligations due the State of Connecticut.

5. The Respondent is currently in compliance with all applicable laws, regulations and ordinances of the United States and, State of Connecticut.

____
(Insert name of company)

By:
____

Name: Title:

Subscribed and sworn to before me,_________________________, the undersigned officer this

_______________day of________________, 20___.

____
Notary Public

My Commission Expires:

CERTIFICATION OF ELIGIBILITY

____ hereby certifies that neither
(Name of Proposer)
it nor its "principals" is included on the U.S. Comptroller General's Debarred Bidders List.

Signature: ____

Firm: ____

The Proposer certifies to the best of its knowledge and belief that it and its principals

A. Are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from participating in this transaction by any Federal department or agency.

B. Have not, within a three-year period preceding the date of this Proposal, been convicted of or had a civil judgment rendered against it for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State or local) transaction or contract under a public transaction, violation of Federal or State anti-trust statues or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statement, or receiving stolen property.

C. Are not presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State or local) with commission of any of the offenses enumerated in Paragraph B of this Certification.

D. Have not, within a three-year period preceding the date of this Proposal, had one or more public transactions (Federal, State or local) terminated for cause or default.

Where the Proposer is unable to certify to any of the statements in this certification, such Proposer shall include an explanation in such regard with its Proposal.

THE UNDERSIGNED CERTIFIES OR AFFIRMS THE TRUTHFULNESS AND ACCURACY OF THE CONTENTS OF THE STATEMENTS SUBMITTED ON OR WITH THIS CERTIFICATION AND UNDERSTANDS THAT THE PROVISIONS OF 31 U.S.C. SECTIONS 3801 ET SEQ. ARE APPLICABLE THERETO.

(Check One)

___________ I DO CERTIFY ___________ I DO NOT CERTIFY

DATE: ____

SIGNATURE: ____

TITLE: ____

CERTIFICATION OF NON-COLLUSION

The Undersigned certifies, under penalties of perjury:

That this Proposal has been made by the Proposer independently, and has been submitted without collusion, and without any agreement, understanding, or planned common course of action with any other vendor of materials, supplies, equipment, or services described in this procurement document, designed to limit independent bidding or competition;

That the contents of the proposal have not been communicated by the Proposer or its employees or agents to any person not an employee or agent of the Proposer or it's surety or any bond furnished with the proposal, and will not be communicated to any such person prior to the official awarding of this procurement.

That I have fully informed myself regarding the accuracy of the statement made in the certificate.

SIGNATURE: ______________________________

NAME: ______________________________

FIRM: ______________________________

TITLE: ______________________________

DATE: ______________________________

CERTIFICATION OF RESTRICTIONS ON LOBBYING

I, _______________________________, of _______________________________,
Name & Title Name of Firm

hereby certify that:

1. No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of an agency, a member of Congress, an officer or employee of Congress, or an employee of a member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan or cooperative agreement.

2. If any funds other than Federal appropriated funds have been paid or will be paid to any person for making lobbying contacts to an officer or employee of any agency, a member of Congress, an officer or employee of Congress, or an employee of a member of Congress in connection with this federal contract, grant, loan or cooperative agreement, the undersigned shall complete and submit Standard Form, "Disclosure Form to Report Lobbying," in accordance with its instruction as amended.

3. The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements), and that all subrecipients shall certify and disclose accordingly.

4. The undersigned acknowledges that this certification is a material representation of fact, upon which reliance is placed at the time that the transaction concerned herewith was made or entered into, and that submission of this certification is a prerequisite for making or entering into such transaction imposed by Section 1352, Title 31, U.S. Code as amended. Any person who fails to file the required certification shall be subject to civil penalty of not less than $10,000, and not more than $100,000 for each such failure.

5. The undersigned certifies or affirms the truthfulness and accuracy of each statement of its certification and disclosure, if any. In addition, the undersigned understands and agrees that the provisions of 31 US Code A3801, et seq., apply to this certification and disclosure, if any.

Executed this _______ day of _______________, 20_______.

By: ____
Signature & Title of Authorized Official

CONTRACTOR'S STATEMENT ON SUB-CONTRACTORS

1. There are NO sub-Contractors associated with this proposal.

Authorized Signee:____

Printed Name: ____

Title: Date: ____

For (Company): ____

OR

2. Listed below are sub-Contractors associated with this proposal. Additional sheets are attached as required. I ________________________________have also attached appropriate Disadvantage Business Certifications.

Name of Company: ____

Address:____

Contact Person: ____

Telephone #: ____

E-mail: ____

Name of Company: ____

Address:____

Contact Person: ____

Telephone #: ____

E-mail: ____

ELIGIBLE CONTRACTORS CERTIFICATE

I, ________________________________, of _________________________________,
Name & Title Name of Firm

hereby certify that it **IS** / **IS NOT** (circle one) included on the List of Parties Excluded from Federal Procurement and Non-Procurement Programs.

SIGNATURE: ____

NAME: ____

FIRM: ____

TITLE: ____

DATE: _________________/_____/__________

CERTIFICATION FOR DISADVANTAGED BUSINESS ENTERPRISE

It is the policy of the U.S. Department of Transportation that disadvantaged business enterprises as defined in 49 CFR Part 26 shall have the maximum opportunity to participate in the performance of contracts financed in whole or in part with State and/or Federal funds under this agreement.

The supplier or Contractor agrees to ensure that disadvantaged business enterprises as defined above have the maximum opportunity to participate in the performance of contracts and subcontracts financed in whole or in part with Federal funds provided under this agreement. In this regard all recipients or contractors shall take necessary and reasonable steps in accordance with 49 CFR Part 26 to ensure that disadvantaged business enterprises have the maximum opportunity to compete and perform contracts. Recipients and their contractors shall not discriminate on the basis of race, creed, color, national origin, age or sex in the award of federal assisted contracts.

The District's DBE goal is 7%.

[ ] Contractor will meet the DBE goal for this contract. Proposer is certified according to requirements of DOT 49 CFR Part 26 as a DBE eligible for participation in DOT assisted contracts, and will be performing _____ percent (_____ %) of the contract work.

[ ] Contractor will meet the DBE goal for this contract. If awarded this contract, proposer will subcontract with the DBE(s) listed below which will be performing a total of _____ percent (_____%) of the total dollar amount of contract work. Each DBE listed below is certified according to requirements of DOT 49 CFR Part 26 for participation in DOT assisted contracts.

DBE Name and Address	Description of Work	Percent of Dollar Amount of Total Contract Work

(Attach additional sheets)

[ ] Contractor (if unable to meet the DBE goal of 7%) is committed to a minimum of ___% DBE utilization on this contract and will submit documentation demonstrating good faint efforts using the attached form.

SIGNATURE: ______________________________

NAME: ______________________________

FIRM: ______________________________

TITLE: ______________________________

DATE: ______________________________

Any contractor and/or sub-contractor utilized to meet the DBE Participation requirements must be certified through the <u>State of Connecticut Department of Transportation's</u> Unified Certification Program (UCP.)

DBE GOOD FAITH EFFORTS DOCUMENTATION FORM
ANNUAL DBE GOAL: 7%

If Contractor has indicated on the DBE Participation Form that it does not meet the DBE goal, proposer must submit this form with its DBE Participation Form as documentation of its good faith efforts to meet the goal. Failure to submit this form with its proposer may render this proposal non-responsive. The Greater Hartford Transit District may require that proposer provide additional substantiation of good faith efforts.

Date: ______________________________ Area of Expertise: _________________________________

Name: ____________________________________ Company Name:___________________________

Response: ____

____

Date: ______________________________ Area of Expertise: _________________________________

Name: ____________________________________ Company Name:___________________________

Response: ____

____

Date: ______________________________ Area of Expertise: _________________________________

Name: ____________________________________ Company Name:___________________________

Response: ____

____

Date: ______________________________ Area of Expertise: _________________________________

Name: ____________________________________ Company Name:___________________________

Response: ____

____

Date: ______________________________ Area of Expertise: _________________________________

Name: ____________________________________ Company Name:___________________________

Response: ____

DBE LETTER OF INTENT

(a separate form is to be submitted for each DBE firm)

Name of bidder/offeror's firm: ________________________________

Address: ____

City: ______________________________ State: _______ Zip: ______

Name of DBE firm: ____

Address: ____

City: _________________________________State: _______ Zip: _____

Telephone: ___________________

Description of work to be performed by DBE firm:

____

____

____

____

The bidder/offeror is committed to utilizing the above-named DBE firm for the work described above. The estimated dollar value of this work is $ _________________.

Affirmation

The above-named DBE firm affirms that it will perform the portion of the contract for the estimated dollar value as stated above and that the firm is DBE certified to perform the specific trades.

By _______________________________Date: _________________________

(Signature)

____

(Title)

If the bidder/offeror does not receive award of the prime contract, any and all representations in this Letter of Intent and Affirmation shall be null and void.

BUY AMERICA CERTIFICATION

The contractor agrees to comply with 49 U.S.C. 5323(j) and 49 C.F.R. Part 661, and any amendments thereto, which provide that Federal funds may not be obligated unless steel, iron, construction materials and manufactured products used in FTA-funded projects are produced in the United States, unless a waiver has been granted by FTA or the product is subject to a general waiver.

Certification requirement for procurement of steel, iron, or manufactured products.

Certificate of Compliance with 49 U.S.C. 5323(j)(1)

The bidder or offeror hereby certifies that it **WILL MEET** the requirements of 49 U.S.C. 5323(j)(1) and the applicable regulations in 49 C.F.R. Part 661 and any amendment thereto.

Date ____

Signature ____

Company Name ____

Title ____

Certificate of Non-Compliance with 49 U.S.C. 5323(j)(1)

The bidder or offeror hereby certifies that it **CANNOT COMPLY** with the requirements of 49 U.S.C. 5323(j)(1) and 49 C.F.R. 661, but it may qualify for an exception pursuant to 49 U.S.C. 5323(j)(2)(A), 5323(j)(2)(B), or 5323(j)(2)(D), and 49 C.F.R. 661.7.

Date ____

Signature ____

Company Name ____

Title ____

APPROVED EQUAL FORM

____
Bidder/ Equipment Manufacturer

IFB Equipment____ Section Number ________ Section Title _______________________

Bidder's Request:

The District's Response:

Approved: Denied: Noted: See Addendum:

Comments:

Procurement Officer: _____________________________ Date: _____________________

STATEMENT OF BIDDER'S QUALIFICATIONS

(To be submitted by the Bidder with the Bid)

All questions must be answered and the data given must be clear and comprehensive. This statement must be notarized. If necessary questions may be answered on separate attached sheets. The Bidder may submit any additional information it desires.

1. Name of Bidder: ____

2. Bidder's Tax Identification Number: _________________________________

3. Permanent Main Office Address: ____________________________________

   ____

4. When Organized: ____

5. Organizational structure of business entity (select one):

   _________ General partnership (GP)
   _________ Limited partnership (LP)
   _________ Limited liability corporation (LLC)
   _________ Limited liability partnership (LLP)
   _________ Corporation
   _________ Individual doing business under a trade name (sole proprietor)
   _________ Other (specify)

6. If a Corporation, Where Incorporated: _______________________________

7. How many years have you been engaged in construction under your present firm or trade name:____

8. Contracts on hand: (Schedule these, showing gross amount of each Contract and the appropriate anticipated dates of completion).

   ____

   ____

   ____

9. General character of work performed by you:

____

10. Have you ever failed to complete any work awarded to you? If so, where and why:

____

____

11. Have you ever defaulted on a Contract? If so, where and why.

____

____

12. List up to six past contracts of this type/size your firm has completed within the last three (3) years.

Project	Date	Contact Person	Phone No.

13. List your major equipment available for this Contract.

____

____

____

____

14. Experience in work similar in importance to this project.

____

____

____

15. Background and experience of the principal members of your organization, including the officers.

____

____

____

16. Give Bank reference.

____

____

____

17. Status of the business and its current standing with the Secretary of State's office:

Connecticut Businesses – Are all required filings current with the Secretary of State be able to issue a Certificate of Legal Existence?	Yes _____	No _____
Out-of-State (Foreign) Businesses – Have you filed a Certificate of Authority / Application of Registration with the Connecticut Secretary of State? If not, submit a copy of your Certificate of Good Standing from your state of incorporation.	Yes _____	No _____

18. Is your local organization an affiliate of a Parent company? If so, indicate the principal place of business of the parent company and the name of agent for service.

Business Name ______________________________

Address ______________________________

City ____________________ State ________ Zip _________

Name of Agent ______________________________

19. List of Affiliated Businesses (attach additional sheets as necessary):

Business Name	Address	Ownership Interest (%)

20. Based on the organizational structure of your business, provide a current listing of all corporate officers, principals, general or managing partners, limited partners, managers and members. If sole proprietorship or general partnership, attach trade name certificate filed with the town clerk's office.

21. Submit copies of all required business (trade and occupational) licenses with your response.

22. Your company may be asked to submit information relative to your company's financial statements and/or a Dun & Bradstreet report may be obtained prior to receiving an award. This information will be protected to the fullest extent required by law.

23. Additional information/documentation may be requested subsequent to your responding to this solicitation.

24. The undersigned hereby authorizes and requests any persons, firm, or corporation to furnish any information requested by the Greater Hartford Transit District in verification of the recitals comprising this statement of the Bidder's qualifications.

Dated at____________________ this ________ day of ________________ 20____.

____
(Name of Bidder)

By: ____

Title: ____

State of ____)
) SS

County of ____________________________________)

____ being duly sworn,

deposes and says that he/she is

________________________of _______________________________________and that he/she answers to the foregoing questions and all statements therein are true and correct.

Subscribed and sworn to before me this _______________ day of _________ 20___

____
(Notary Public)

My Commission Expires: ________________________________

EXHIBIT F
STATE OF CONNECTICUT
CONTRACT REQUIREMENTS

CONNECTICUT REQUIRED CERTIFICATIONS

All contract certifications required by the State of Connecticut must be included with your proposal. The instructions and affidavits forms are available at the State of Connecticut, Office of Policy and Management Internet site at:

http://www.ct.gov/opm/cwp/view.asp?A=2982&Q=386038

Check this State of Connecticut Internet site immediately before you submit your proposal in case of any recent changes to the State's contractual requirements. It is the responsibility of the proposer to ensure that any and all up-to-date contract certification forms are properly filled out and submitted with your proposal.

REQUIREMENTS OF THE STATE OF CONNECTICUT

The Agreement between the District and the Connecticut Department of Transportation has specific provisions that are passed on to all third-party contractors including, but not limited to, Civil Rights, Nondiscrimination, Affirmative Action/Equal Employment Opportunities, Disadvantaged Business Enterprise, Governors' Executive Orders, Code of Ethics, and all applicable federal regulations. These provisions and all applicable appendices of the Agreement are herein incorporated by reference and made a part of this contract.

____
Signed:

____
Authorized Corporate Official

____
Date

SMALL BUSINESS ENTERPRISE (SBE) CERTIFICATION

To be eligible for the State of Connecticut's SBE certification a company must meet the legal definition of a small business or that of a minority owned firm:

SMALL BUSINESS ENTERPRISE (SBE):
Been doing business under the same ownership or management and has maintained its principal place of business in Connecticut for at least one year immediately prior to the date of application; Gross revenues not exceeding $15,000,000 during its most recent fiscal year; and, 51% ownership held by a person(s) who exercises the operational authority over daily affairs of the business and has the power to direct policies and management and receives beneficial interests of the business.

MINORITY BUSINESS ENTERPRISE (MBE):
A small business (must meet the above-stated SBE criteria) with at least 51% ownership by one or more minority person(s) who exercises operational authority over daily affairs of the business, has the power to direct management and policies, and receives the beneficial interests of the business. A minority is a person(s) who is American Indian, Asian, Black, Hispanic, has origins in the Iberian Peninsula, a woman, or an individual with a disability.

Yes_____; My Company is certified by the State of Connecticut as a SBE; attach a copy of the SBE Certification.

No______; My Company is not certified by the State of Connecticut as a SBE.

SBE Certification

The contractor hereby acknowledges that **District** has established a contract goal of **zero percent (0%)** for this project, however the District does have an annual SBE goal of **25%**.

Firm Name: ____

Signature: ____

Title: ____

Date: ____

NOTE: This form is to be submitted with the Proposal. Please attach the names and addresses of any and all SBE eligible subcontractors who will perform work on this project, and the approximate dollar amounts to be paid to them. If there is no participation then this must be indicated on the form; the form executed and returned with this Proposal.

SBE LETTER OF INTENT

Name of bidder/offeror's firm: ________________________________
Address: ____
City: ______________________________ State: _______ Zip: ______

Name of DBE firm: ____
Address: ____
City: _________________________________State: _______ Zip: _____
Telephone: ___________________

Description of work to be performed by SBE firm:

____

____

____

____

The bidder/offeror is committed to utilizing the above-named SBE firm for the work described above. The estimated dollar value of this work is $ ___________

Affirmation
The above-named SBE firm affirms that it will perform the portion of the contract for the estimated dollar value as stated above and that the firm is SBE certified to perform the specific trades.

By ______________________________Date: _________________________
(Signature)

____
(Title)

If the bidder/offeror does not receive award of the prime contract, any and all representations in this Letter of Intent and Affirmation shall be null and void.

<u>Invitation for Bid</u>: ______________________________

<u>Bidder</u>: ______________________________

<u>District</u>: *Greater Hartford Transit District*

<u>Submission Date</u>: __________________, *2024*

<u>Gifts, Connecticut General Statutes §4-252</u>. ***Notice: The District shall not award or enter into any contract or agreement with Proposer if Proposer fails to make and comply with the representation requirements set forth in Connecticut General Statutes §4-252.*** Proposer hereby represents, warrants and certifies to the District that:

(1) no Gifts were made by: (A) Proposer, (B) any Principals and Key Personnel of Proposer, who participate substantially in preparing bids, proposals or negotiating state contracts, or (C) any agent of Proposal or Principals and Key Personnel, who participate substantially in preparing bids, proposals or negotiating state contracts to (i) any public official or employee of any state agency or quasi-public agency or of the District soliciting bids or proposals for a contract, who participates substantially in preparation of bid solicitations or requests for proposals for a contract or the negotiation or aware of a contract, or (ii) any public official or state employee of any other state agency or quasi-public agency who has supervisory or appointing authority over such state agency or quasi-public agency or the District;

(2) no Principals and Key Personnel of Proposer or agent of Proposer or Principals and Key Personnel, knows of any action by Proposer to circumvent such prohibition on Gifts by providing for any other Principals and Key Personnel, officials, employees or agents of Proposer to provide a Gift to any such public official or state employee or employee of the District; and

(3) Proposer is submitting bids or proposals without fraud or collusion with any person.

Initial capitalized terms used in this paragraph and not defined herein have the meanings ascribed thereto in C.G.S. §4-250 and §4-252.

<u>Nondiscrimination; Connecticut General Statutes §4a-60 & Connecticut General Statutes §4a-60a</u>. Proposer hereby represents, warrants and certifies to the District that the Proposer has a policy in placed that complies with, and will remain in compliance with throughout the term of any contract or agreement awarded in connection with the Request for Proposal, the nondiscrimination agreements and warranties set forth in Connecticut General Statutes §4a-60(a)(1) and §4a-60a(a)(1), as amended.

The authorized signatory of Proposer confirms, acknowledges and demonstrates their understanding of the obligations set forth in Connecticut General Statutes §4a-60 & §4a-60a by initialing here:

Print Name:______________________________ Initials:_______________

The District shall not award or enter into any contract or agreement with Proposer if Proposer has not included the nondiscrimination affirmation provision in the contract and otherwise complied with the requirements set forth in Connecticut General Statutes §4a-60 & §4-60a.

Campaign Financing Contributions; Connecticut General Statutes §9-612(f) & (g). Proposer has delivered to the District a completed SEEC Form 10 Notice in accordance with Connecticut General Statutes §9-612(g)(1), a copy of which can be obtained at the following internet link: ***https://seec.ct.gov/Portal/data/forms/ContrForms/seec_form_10_final.pdf***

Proposer hereby represents, warrants and certifies to the District:

(1) that Proposer has received a copy of the written notice advising state contractors and prospective state contractors of the contribution and solicitation prohibitions set forth in Connecticut General Statutes §9-612(f)(2)(A) & (B);

(2) that Proposer has not made any contributions to, or solicited any contributions on behalf of, any party committee, exploratory committee, candidate for state-wide office for the General Assembly, or political committee authorized to make contributions to or expenditures to or for, the benefit of such candidates, in the previous four years, that were determined by the State Elections Enforcement Commission to be violation of Connecticut General Statutes §9-612(f)(2)(A) & (B) without mitigating circumstances having been found to exist concerning such violation; and

(3) Proposer's chief executive officer or authorized signatory of this Request for Proposal submission has completed and delivered to the District the State of Connecticut Campaign Contribution Certification in accordance with Connecticut General Statutes §9-612, set forth on Schedule E-1 attached hereto and made a part hereof.

Notice: The District shall not enter into any contract or agreement with Proposer if Proposer fails to make and comply with the representation requirements set forth in Connecticut General Statutes §9-612.

Occupational Safety & Health; Connecticut General Statutes §31-57b. Proposer hereby represents, warrants and certifies to the District that Proposer is not in violation of, is in compliance with, and will remain in compliance with the requirements set forth in Connecticut General Statutes §31-57b throughout the terms of any contract or agreement awarded in connection with the Request for Proposal.

Notice: All representations, warranties and disclosures contained above are sworn as true to the best knowledge and belief of the below authorized signatory and any false statements made herein are punishable under the penalty for false statement as provided for in §53a-157b of the Connecticut General Statutes.

PROPOSER:

[ENTITY NAME]

By:________________________________

Name:

Title:

Sworn and subscribed before me on this _____ day of ____________________, 2024.

____

Notary Public/Commissioner of the Superior Court

SCHEDULE B-1

CAMPAIGN CONTRIBUTION CERTIFICATION

STATE OF CONNECTICUT

GIFT AND CAMPAIGN CONTRIBUTION CERTIFICATION

Written or electronic certification to accompany a State contract with a value of $50,000 or more in a calendar or fiscal year, pursuant to C.G.S. §§ 4-250 and 4-252(c); Governor M. Jodi Rell's Executive Orders No. 1, Para. 8, and No. 7C, Para. 10; and C.G.S. §9-612(g)(2)

INSTRUCTIONS:

Complete all sections of the form. Attach additional pages, if necessary, to provide full disclosure about any lawful campaign contributions made to campaigns of candidates for statewide public office or the General Assembly, as described herein. Sign and date the form, under oath, in the presence of a Commissioner of the Superior Court or Notary Public. Submit the completed form to the awarding State agency at the time of initial contract execution and if there is a change in the information contained in the most recently filed certification, such person shall submit an updated certification either (i) not later than thirty (30) days after the effective date of such change or (ii) upon the submittal of any new bid or proposal for a contract, whichever is earlier. <u>Such person shall also submit an accurate, updated certification not later than fourteen days after the twelve-month anniversary of the most recently filed certification or updated certification.</u>

CHECK ONE: ☐ Initial Certification ☐ 12 Month Anniversary Update (Multi-year contracts only.)

☐ Updated Certification because of change of information contained in the most recently filed certification or twelve-month anniversary update.

GIFT CERTIFICATION:

As used in this certification, the following terms have the meaning set forth below:

1) "Contract" means that contract between the State of Connecticut (and/or one or more of it agencies or instrumentalities) and the Contractor, attached hereto, or as otherwise described by the awarding State agency below;
2) If this is an Initial Certification, "Execution Date" means the date the Contract is fully executed by, and becomes effective between, the parties; if this is a twelve-month anniversary update, "Execution Date" means the date this certification is signed by the Contractor;
3) "Contractor" means the person, firm or corporation named as the contactor below;
4) "Applicable Public Official or State Employee" means any public official or state employee described in C.G.S. §4-252(c)(1)(i) or (ii);
5) **"Gift"** has the same meaning given that term in C.G.S. § 4-250(1);
6) "Principals or Key Personnel" means and refers to those principals and key personnel of the Contractor, and its or their agents, as described in C.G.S. §§ 4-250(5) and 4-252(c)(1)(B) and (C).

I, the undersigned, am a Principal or Key Personnel of the person, firm or corporation authorized to execute this certification on behalf of the Contractor. I hereby certify that, no gifts were made by (A) such person, firm, corporation, (B) any principals and key personnel of the person firm or corporation who participate substantially in preparing bids, proposals or negotiating state contracts or (C) any agent of such, firm, corporation, or principals or key personnel who participates substantially in preparing bids, proposals or negotiating state contracts, to (i) any public official or state employee of the state agency or quasi-public agency soliciting bids or proposals for state contracts who participates substantially in the preparation of bid solicitations or request for proposals for state contracts or the negotiation or award of state contracts or (ii) any public official or state employee of any other state agency, who has supervisory or appointing authority over such state agency or quasi-public agency.

I further certify that no Principals or Key Personnel know of any action by the Contractor to circumvent (or which would result in the circumvention of) the above certification regarding **Gifts** by providing for any other Principals, Key Personnel, officials, or employees of the Contractor, or its or their agents, to make a **Gift** to any Applicable Public Official or State Employee. I further certify that the Contractor made the bid or proposal for the Contract without fraud or collusion with any person.

CAMPAIGN CONTRIBUTION CERTIFICATION:

I further certify that, on or after December 31, 2006, neither the Contractor nor any of its principals, as defined in C.G.S. § 9-612(g)(1), has made any **campaign contributions** to, or solicited any contributions on behalf of, any exploratory committee, candidate committee, political committee, or party committee established by, or supporting or authorized to support, any candidate for statewide public office, in violation of C.G.S. § 9-612(g)(2)(A). I further certify that **all lawful campaign contributions** that have been made on or after December 31, 2006 by the Contractor or any of its principals, as defined in C.G.S. § 9-612(g)(1), to, or solicited on behalf of, any exploratory committee, candidate committee, political committee, or party committee established by, or supporting or authorized to support any candidates for statewide public office or the General Assembly, are listed below:

Lawful Campaign Contributions to Candidates for Statewide Public Office:

Contribution Date	Name of Contributor	Recipient	Value	Description

Lawful Campaign Contributions to Candidates for the General Assembly:

Contribution Date	Name of Contributor	Recipient	Value	Description

Sworn as true to the best of my knowledge and belief, subject to the penalties of false statement.

___________________________________ ____
Printed Contractor Name **Printed Name of Authorized Official**

____
Signature of Authorized Official

Subscribed and acknowledged before me this _______ day of ____________________, 20___.

____
Commissioner of the Superior Court (or Notary Public)

EXHIBIT G
CONNECTICUT DEPARTMENT OF LABOR PREVAILING WAGE BID PACKAGE

Minimum Rates and Classifications
for Building Construction

ID#: 23-54558

Connecticut Department of Labor
Wage and Workplace Standards

By virtue of the authority vested in the Labor Commissioner under provisions of Section 31-53 of the General Statutes of Connecticut, as amended, the following are declared to be the prevailing rates and welfare payments and will apply only where the contract is advertised for bid within 20 days of the date on which the rates are established. Any contractor or subcontractor not obligated by agreement to pay to the welfare and pension fund shall pay this amount to each employee as part of his/her hourly wages.

Project Number: IFB#02-024 Project Town: Hartford
State#: FAP#:

Project: Greater Hartford Transit District: HVAC Equipment Replacement (Union Station)

CLASSIFICATION	Hourly Rate	Benefits
1b) Asbestos/Toxic Waste Removal Laborers: Asbestos removal and encapsulation (except its removal from mechanical systems which are not to be scrapped), toxic waste removers, blasters.**See Laborers Group 7**		
1c) Asbestos Worker/Heat and Frost Insulator	45.56	32.65
2) Boilermaker	45.21	29.05
3a) Bricklayer, Cement Mason, Concrete Finisher (including caulking), Stone Masons	39.4	34.62 + a
3b) Tile Setter	37.1	30.52
3c) Tile and Stone Finishers	30.0	25.30
3d) Marble & Terrazzo Finishers	31.07	24.23
3e) Plasterer	42.77	29.63

As of: November 3, 2023

------LABORERS------

4) Group 1: General laborers, carpenter tenders, concrete specialists, wrecking laborers and fire watchers.	33.5	25.59
4) Group 1a: Acetylene Burners (Hours worked with a torch)	34.5	25.59
4a) Group 2: Mortar mixers, plaster tender, power buggy operators, powdermen, fireproofer/mixer/nozzleman (Person running mixer and spraying fireproof only).	33.75	25.59
4b) Group 3: Jackhammer operators/pavement breaker, mason tender (brick), mason tender (cement/concrete), forklift operators and forklift operators (masonry).	34.0	25.59
4c) **Group 4: Pipelayers (Installation of water, storm drainage or sewage lines outside of the building line with P6, P7 license) (the pipelayer rate shall apply only to one or two employees of the total crew who primary task is to actually perform the mating of pipe sections) P6 and P7 rate is $26.80.	34.5	25.59
4d) Group 5: Air track operator, sand blaster and hydraulic drills.	34.25	25.59
4e) Group 6: Blasters, nuclear and toxic waste removal.	36.5	25.59
4f) Group 7: Asbestos/lead removal and encapsulation (except it's removal from mechanical systems which are not to be scrapped).	36.5	25.59
4g) Group 8: Bottom men on open air caisson, cylindrical work and boring crew.	31.78	25.59
4h) Group 9: Top men on open air caisson, cylindrical work and boring crew.	31.24	25.59
4i) Group 10: Traffic Control Signalman	20.1	25.59

4j) Group 11: Toxic Waste Removers A or B With PPE	36.5	25.59
5) Carpenter, Acoustical Ceiling Installation, Soft Floor/Carpet Laying, Metal Stud Installation, Form Work and Scaffold Building, Drywall Hanging, Modular-Furniture Systems Installers, Lathers, Piledrivers, Resilient Floor Layers.	37.61	27.61
5a) Millwrights	38.02	28.41
6) Electrical Worker (including low voltage wiring) (Trade License required: E1,2 L-5,6 C-5,6 T-1,2 L-1,2 V-1,2,7,8,9)	43.75	32.47+3% of gross wage
7a) Elevator Mechanic (Trade License required: R-1,2,5,6)	61.42	37.335+a+b
-----LINE CONSTRUCTION----		
Groundman	26.5	6.5% + 9.00
Linemen/Cable Splicer	48.19	6.5% + 22.00
8) Glazier (Trade License required: FG-1,2)	41.18	24.55 + a
9) Ironworker, Ornamental, Reinforcing, Structural, and Precast Concrete Erection	42.37	40.02 + a
----OPERATORS----		
Group 1: Crane Handling or Erecting Structural Steel or Stone; Hoisting Engineer (2 drums or over). (Trade License Required)	52.78	27.80 + a
Group 1a: Front End Loader (7 cubic yards or over); Work Boat 26 ft. and Over	48.37	27.80 + a

Group 2: Cranes (100 ton rate capacity and over); Bauer Drill/Caisson. (Trade License Required)	52.41	27.80 + a
Group 2a: Cranes (under 100 ton rated capacity).	51.51	27.80 + a
Group 2b: Excavator over 2 cubic yards; Pile Driver ($3.00 premium when operator controls hammer)	48.0	27.80 + a
Group 3: Excavator; Gradall; Master Mechanic; Hoisting Engineer (all types of equipment where a drum and cable are used to hoist or drag material regardless of motive power of operation), Rubber Tire Excavator (Drott-1085 or similar);Grader Operator; Bulldozer Finegrade. (slopes, shaping, laser or GPS, etc.). (Trade License Required)	47.1	27.80 + a
Group 4: Trenching Machines; Lighter Derrick; CMI Machine or Similar; Koehring Loader (Skooper); Goldhofer.	46.64	27.80 + a
Group 5: Specialty Railroad Equipment; Asphalt Spreader, Asphalt Reclaiming Machine; Line Grinder; Concrete Pumps; Drills with Self Contained Power Units; Boring Machine; Post Hole Digger; Auger; Pounder; Well Digger; Milling Machine (over 24 mandrel).	45.92	27.80 + a
Group 5 continued: Side Boom; Combination Hoe and Loader; Directional Driller.	45.92	27.80 + a
Group 6: Front End Loader (3 up to 7 cubic yards); Bulldozer (rough grade dozer).	45.55	27.80 + a
Group 7: Asphalt Roller; Concrete Saws and Cutters (ride on types); Vermeer Concrete Cutter; Stump Grinder; Scraper; Snooper; Skidder; Milling Machine (24" and under mandrel).	45.14	27.80 + a
Group 8: Mechanic; Grease Truck Operator; Hydroblaster; Barrier Mover; Power Stone Spreader; Welding; Work Boat Under 26 ft.; Transfer Machine; Rigger Foreman.	44.67	27.80 + a
Group 9: Front End Loader (under 3 cubic yards); Skid Steer Loader regardless of attachments; (Bobcat or Similar); Forklift, Power Chipper; Landscape Equipment (including Hydroseeder); Vacuum Excavation	44.14	27.80 + a

Truck and Hydrovac Excavation Truck (27 HG pressure or greater).

Group 10: Vibratory hammer; ice machine; diesel and air, hammer, etc.	41.69	27.80 + a
Group 11: Conveyor, earth roller, power pavement breaker (whiphammer), robot demolition equipment.	41.69	27.80 + a
Group 12: Wellpoint Operator.	41.61	27.80 + a
Group 13: Compressor Battery Operator.	40.92	27.80 + a
Group 14: Elevator Operator; Tow Motor Operator (solid tire no rough terrain).	39.54	27.80 + a
Group 15: Generator Operator; Compressor Operator; Pump Operator; Welding Machine Operator; Heater Operator.	39.06	27.80 + a
Group 16: Maintenance Engineer.	38.28	27.80 + a
Group 17: Portable Asphalt Plant Operator; Portable Crusher Plant Operator; Portable Concrete Plant Operator; Portable Grout Plant Operator; Portable Water Filtration Plant Operator.	43.46	27.80 + a
Group 18: Power Safety Boat; Vacuum Truck; Zim Mixer; Sweeper; (Minimum for any job requiring a CDL license); Rigger; Signalman.	40.54	27.80 + a

------PAINTERS (Including Drywall Finishing)------

10a) Brush and Roller	37.62	24.55
10b) Taping Only/Drywall Finishing	38.37	24.55

10c) Paperhanger and Red Label	38.12	24.55
10e) Blast and Spray	40.62	24.55
11) Plumber (excluding HVAC pipe installation) (Trade License required: P-1,2,6,7,8,9 J-1,2,3,4 SP-1,2)	48.28	35.50
12) Well Digger, Pile Testing Machine	37.26	24.05 + a
13) Roofer (composition)	41.2	22.35
14) Roofer (slate & tile)	41.7	22.35
15) Sheetmetal Worker (Trade License required for HVAC and Ductwork: SM-1,SM-2,SM-3,SM-4,SM-5,SM-6)	41.89	43.22
16) Pipefitter (Including HVAC work) (Trade License required: S-1,2,3,4,5,6,7,8 B-1,2,3,4 D-1,2,3,4, G-1, G-2, G-8 & G-9)	48.28	35.50
------TRUCK DRIVERS------		
17a) 2 Axle, Helpers	32.16	30.51 + a
17b) 3 Axle, 2 Axle Ready Mix	32.27	30.51 + a
17c) 3 Axle Ready Mix	32.33	30.51 + a
17d) 4 Axle	32.39	30.51 + a
17e) 4 Axle Ready Mix	32.44	30.51 + a

As of: November 3, 2023

17f) Heavy Duty Trailer (40 Tons and Over)	34.66	30.51 + a
17g) Specialized Earth Moving Equipment (Other Than Conventional Type on-the-Road Trucks and Semi-Trailers, Including Euclids)	32.44	30.51 + a
17h) Heavy Duty Trailer up to 40 tons	33.39	30.51 + a
17i) Snorkle Truck	32.54	30.51 + a
18) Sprinkler Fitter (Trade License required: F-1,2,3,4)	47.55	32.27 + a
19) Theatrical Stage Journeyman	25.76	7.34

Welders: Rate for craft to which welding is incidental.
**Note: Hazardous waste removal work receives additional $1.25 per hour for truck drivers.*
***Note: Hazardous waste premium $3.00 per hour over classified rate*

Crane with 150 ft. boom (including jib) - $1.50 extra
Crane with 200 ft. boom (including jib) - $2.50 extra
Crane with 250 ft. boom (including jib) - $5.00 extra
Crane with 300 ft. boom (including jib) - $7.00 extra
Crane with 400 ft. boom (including jib) - $10.00 extra

All classifications that indicate a percentage of the fringe benefits must be calculated at the percentage rate times the "base hourly rate".

Apprentices duly registered under the Commissioner of Labor's regulations on "Work Training Standards for Apprenticeship and Training Programs" Section 31-51-d-1 to 12, are allowed to be paid the appropriate percentage of the prevailing journeymen hourly base and the full fringe benefit rate, providing the work site ratio shall not be less than one full-time journeyperson instructing and supervising the work of each apprentice in a specific trade.

The Prevailing wage rates applicable to this project are subject to annual adjustments each July 1st for the duration of the project.
Each contractor shall pay the annual adjusted prevailing wage rate that is in effect each July 1st, as posted by the Department of Labor.
It is the contractor's responsibility to obtain the annual adjusted prevailing wage rate increases directly from the Department of Labor's website.
The annual adjustments will be posted on the Department of Labor's Web page: www.ct.gov/dol. For those without internet access, please contact the division listed below.
The Department of Labor will continue to issue the initial prevailing wage rate schedule to the Contracting Agency for the project.
All subsequent annual adjustments will be posted on our Web Site for contractor access.
Contracting Agencies are under no obligation pursuant to State labor law to pay any increase due to the annual adjustment provision.

Effective October 1, 2005 - Public Act 05-50: any person performing the work of any mechanic, laborer, or worker shall be paid prevailing wage

All Person who perform work ON SITE must be paid prevailing wage for the appropriate mechanic, laborer, or worker classification.

All certified payrolls must list the hours worked and wages paid to All Persons who perform work ON SITE regardless of their ownership i.e.: (Owners, Corporate Officers, LLC Members, Independent Contractors, et. al)

Reporting and payment of wages is required regardless of any contractual relationship alleged to exist between the contractor and such person.

~~Unlisted classifications needed for work not included within the scope of the classifications listed may be added after award only as provided in the labor standards contract clause (29 CFR 5.5 (a) (1) (ii)).

Please direct any questions which you may have pertaining to classification of work and payment of prevailing wages to the Wage and Workplace Standards Division, telephone (860)263-6790.

As of: November 3, 2023

As of: November 3, 2023

QUI TRANSTULIT SUSTINET

CONNECTICUT DEPARTMENT OF LABOR

Partner of the American Job Center Network

THIS IS A PUBLIC WORKS PROJECT

Covered by the

PREVAILING WAGE LAW

CT General Statutes Section 31-53

If you have QUESTIONS regarding your wages
CALL (860) 263-6790

Section 31-55 of the CT State Statutes requires every contractor or subcontractor performing work for the state to post in a prominent place the prevailing wages as determined by the Labor Commissioner.

Sec. 31-53b. Worker training requirements for public works projects. Enforcement. Regulations. Exceptions. (a) Each contract for a public works project entered into on or after July 1, 2009, by the state or any of its agents, or by any political subdivision of the state or any of its agents, described in subsection (h) of section 31-53, shall contain a provision requiring that each contractor furnish proof with the weekly certified payroll form for the first week each employee begins work on such project that any person performing the work of a mechanic, laborer or worker pursuant to the classifications of labor under section 31-53 on such public works project, pursuant to such contract, has completed a course of at least ten hours in duration in construction safety and health approved by the federal Occupational Safety and Health Administration or, has completed a new miner training program approved by the Federal Mine Safety and Health Administration in accordance with 30 CFR 46 or, in the case of telecommunications employees, has completed at least ten hours of training in accordance with 29 CFR 1910.268, and, on or after July 1, 2012, that any plumber or electrician subject to the continuing education requirements of section 20-334d, who has completed a course of at least ten hours in duration in construction safety and health approved by the federal Occupational Safety and Health Administration five or more years prior to the date such electrician or plumber begins work on such public works project, has completed a supplemental refresher training course of at least four hours in duration in construction safety and health taught by a federal Occupational Safety and Health Administration authorized trainer.

(b) Any person required to complete a course or program under subsection (a) of this section who has not completed the course or program shall be subject to removal from the worksite if the person does not provide documentation of having completed such course or program by the fifteenth day after the date the person is found to be in noncompliance. The Labor Commissioner or said commissioner's designee shall enforce this section.

(c) Not later than January 1, 2012, the Labor Commissioner shall adopt regulations, in accordance with the provisions of chapter 54, to implement the provisions of subsections (a) and (b) of this section. Such regulations shall require that the ten-hour construction safety and health courses required under subsection (a) of this section be conducted in accordance with federal Occupational Safety and Health Administration Training Institute standards, or, in the case of a supplemental refresher training course, shall include, but not be limited to, an update of revised Occupational Safety and Health Administration standards and a review of required construction hazards training, or in accordance with Federal Mine Safety and Health Administration Standards or in accordance with 29 CFR 1910.268, as appropriate. The Labor Commissioner shall accept as sufficient proof of compliance with the provisions of subsection (a) or (b) of this section a student course completion card issued by the federal Occupational Safety and Health Administration Training Institute, or such other proof of compliance said commissioner deems appropriate, dated no earlier than five years before the commencement date of such public works project or, in the case of supplemental refresher training, a student course completion card issued by said Occupational Safety and Health Administration authorized trainer dated not earlier than five years prior to the date such electrician or plumber begins work on such public works project.

(d) This section shall not apply to employees of public service companies, as defined in section 16-1, or drivers of commercial motor vehicles driving the vehicle on the public works project and delivering or picking up cargo from public works projects provided they perform no labor relating to the project other than the loading and unloading of their cargo.

(P.A. 06-175, S. 1; P.A. 08-83, S. 1; P.A. 10-47, S. 2; P.A. 11-63, S. 1.)

History: P.A. 08-83 amended Subsec. (a) by making provisions applicable to public works project contracts entered into on or after July 1, 2009, replacing provision re total cost of work with reference to Sec. 31-53(g), requiring proof in certified payroll form that new mechanic, laborer or worker has completed a 10-hour or more construction safety course and adding provision re new miner training program, amended Subsec. (b) by substituting "person" for "employee" and adding "or program", amended Subsec. (c) by adding "or in accordance with Federal Mine Safety and Health Administration Standards" and setting new deadline of January 1, 2009, deleted former Subsec. (d) re "public building", added new Subsec. (d) re exemptions for public service company employees and delivery drivers who perform no labor other than delivery and made conforming and technical changes, effective January 1, 2009; P.A. 10-47 made a technical change in Subsec. (a); P.A. 11-63 amended Subsec. (a) by adding provision re supplemental refresher training course for plumbers and electricians subject to Sec. 20-334d, amended Subsec. (c) by adding provisions re regulations and subject matter of refresher training course and refresher training course student completion cards, and made technical changes, effective July 1, 2011.

Informational Bulletin

THE 10-HOUR OSHA CONSTRUCTION SAFETY AND HEALTH COURSE

(applicable to public building contracts entered into *on or after July 1, 2007*, where the total cost of all work to be performed is at least $100,000)

(1) This requirement was created by Public Act No. 06-175, which is codified in Section 31-53b of the Connecticut General Statutes (pertaining to the prevailing wage statutes);

(2) The course is required for public building construction contracts (projects funded in whole or in part by the state or any political subdivision of the state) entered into on or after July 1, 2007;

(3) It is required of private employees (not state or municipal employees) and apprentices who perform manual labor for a general contractor or subcontractor on a public building project where the total cost of all work to be performed is at least $100,000;

(4) The ten-hour construction course pertains to the ten-hour Outreach Course conducted in accordance with federal OSHA Training Institute standards, and, for telecommunications workers, a ten-hour training course conducted in accordance with federal OSHA standard, 29 CFR 1910.268;

(5) The internet website for the federal OSHA Training Institute is http://www.osha.gov/fso/ote/training/edcenters/fact_sheet.html;

(6) The statutory language leaves it to the contractor and its employees to determine who pays for the cost of the ten-hour Outreach Course;

(7) Within 30 days of receiving a contract award, a general contractor must furnish proof to the Labor Commissioner that all employees and apprentices performing manual labor on the project will have completed such a course;

(8) Proof of completion may be demonstrated through either: (a) the presentation of a *bona fide* student course completion card issued by the federal OSHA Training Institute; *or* (2) the presentation of documentation provided to an employee by a trainer certified by the Institute pending the actual issuance of the completion card;

(9) Any card with an issuance date more than 5 years prior to the commencement date of the construction project shall not constitute proof of compliance;

(10) Each employer shall affix a copy of the construction safety course completion card to the certified payroll submitted to the contracting agency in accordance with Conn. Gen. Stat. § 31-53(f) on which such employee's name first appears;

(11) Any employee found to be in non-compliance shall be subject to removal from the worksite if such employee does not provide satisfactory proof of course completion to the Labor Commissioner by the fifteenth day after the date the employee is determined to be in noncompliance;

(12) Any such employee who is determined to be in noncompliance may continue to work on a public building construction project for a maximum of fourteen consecutive calendar days while bringing his or her status into compliance;

(13) The Labor Commissioner may make complaint to the prosecuting authorities regarding any employer or agent of the employer, or officer or agent of the corporation who files a false certified payroll with respect to the status of an employee who is performing manual labor on a public building construction project;

(14) The statute provides the minimum standards required for the completion of a safety course by manual laborers on public construction contracts; any contractor can exceed these minimum requirements; and

(15) Regulations clarifying the statute are currently in the regulatory process, and shall be posted on the CTDOL website as soon as they are adopted in final form.

(16) Any questions regarding this statute may be directed to the Wage and Workplace Standards Division of the Connecticut Labor Department via the internet website of http://www.ctdol.state.ct.us/wgwkstnd/wgemenu.htm; or by telephone at (860)263-6790.

THE ABOVE INFORMATION IS PROVIDED EXCLUSIVELY AS AN EDUCATIONAL RESOURCE, AND IS NOT INTENDED AS A SUBSTITUTE FOR LEGAL INTERPRETATIONS WHICH MAY ULTMATELY ARISE CONCERNIG THE CONSTRUCTION OF THE STATUTE OR THE REGULATIONS.

November 29, 2006

Notice

To All Mason Contractors and Interested Parties
Regarding Construction Pursuant to Section 31-53 of the Connecticut General Statutes (Prevailing Wage)

The Connecticut Labor Department Wage and Workplace Standards Division is empowered to enforce the prevailing wage rates on projects covered by the above referenced statute.

Over the past few years the Division has withheld enforcement of the rate in effect for workers who operate a forklift on a prevailing wage rate project due to a potential jurisdictional dispute.

The rate listed in the schedules and in our Occupational Bulletin (see enclosed) has been as follows:

Forklift Operator:

- **Laborers (Group 4) Mason Tenders** - operates forklift solely to assist a mason to a maximum height of nine feet only.

- **Power Equipment Operator (Group 9) -** operates forklift to assist any trade and to assist a mason to a height over nine feet.

The U.S. Labor Department conducted a survey of rates in Connecticut but it has not been published and the rate in effect remains as outlined in the above Occupational Bulletin.

Since this is a classification matter and not one of jurisdiction, effective January 1, 2007 the Connecticut Labor Department will enforce the rate on each schedule in accordance with our statutory authority.

Your cooperation in filing appropriate and accurate certified payrolls is appreciated.

Sec. 31-55a. Annual adjustments to wage rates by contractors doing state work. Each contractor that is awarded a contract on or after October 1, 2002, for (1) the construction of a state highway or bridge that falls under the provisions of section 31-54, or (2) the construction, remodeling, refinishing, refurbishing, rehabilitation, alteration or repair of any public works project that falls under the provisions of section 31-53 shall contact the Labor Commissioner on or before July first of each year, for the duration of such contract, to ascertain the prevailing rate of wages on an hourly basis and the amount of payment or contributions paid or payable on behalf of each mechanic, laborer or worker employed upon the work contracted to be done, and shall make any necessary adjustments to such prevailing rate of wages and such payment or contributions paid or payable on behalf of each such employee, effective each July first.

(P.A. 02-69, S. 1.)

CONNECTICUT DEPARTMENT OF LABOR
WAGE AND WORKPLACE STANDARDS DIVISION

CONTRACTORS WAGE CERTIFICATION FORM
Construction Manager at Risk/General Contractor/Prime Contractor

I,_____________________________________of _____________________________________
Officer, Owner, Authorized Rep. Company Name

do hereby certify that the ____
Company Name

____
Street

____
City

and all of its subcontractors will pay all workers on the

____
Project Name and Number

____
Street and City

the wages as listed in the schedule of prevailing rates required for such project (a copy of which is attached hereto).

____
Signed

Subscribed and sworn to before me this ___________ day of _________________,______.

____
Notary Public

Return to:

Connecticut Department of Labor
Wage & Workplace Standards Division
200 Folly Brook Blvd.
Wethersfield, CT 06109

Rate Schedule Issued (Date): __________________

[New] In accordance with Section 31-53b(a) of the C.G.S. each contractor shall provide a copy of the OSHA 10 Hour Construction Safety and Health Card for each employee, to be attached to the first certified payroll on the project.

In accordance with Connecticut General Statutes, 31-53
Certified Payrolls with a statement of compliance
shall be submitted monthly to the contracting agency.

PAYROLL CERTIFICATION FOR PUBLIC WORKS PROJECTS

WEEKLY PAYROLL

Connecticut Department of Labor
Wage and Workplace Standards Division
200 Folly Brook Blvd.
Wethersfield, CT 06109

CONTRACTOR NAME AND ADDRESS:		SUBCONTRACTOR NAME & ADDRESS	WORKER'S COMPENSATION INSURANCE CARRIER POLICY # EFFECTIVE DATE: EXPIRATION DATE:
PAYROLL NUMBER	Week-Ending Date	PROJECT NAME & ADDRESS	

PERSON/WORKER, ADDRESS and SECTION	APPR RATE %	MALE/ FEMALE AND RACE*	WORK CLASSIFICATION Trade License Type & Number - OSHA 10 Certification Number	DAY AND DATE S	M	T	W	TH	F	S	Total ST Hours Total O/T Hours	BASE HOURLY RATE TOTAL FRINGE BENEFIT PLAN CASH	TYPE OF FRINGE BENEFITS Per Hour 1 through 6 (see back)	GROSS PAY FOR ALL WORK PERFORMED THIS WEEK	TOTAL DEDUCTIONS FICA	FEDERAL WITH-HOLDING	STATE WITH-HOLDING	LIST OTHER	GROSS PAY FOR THIS PREVAILING RATE JOB	CHECK # AND NET PAY
				HOURS WORKED EACH DAY																
												\$ Base Rate \$ Cash Fringe	1. \$ 2. \$ 3. \$ 4. \$ 5. \$ 6. \$							
												\$ Base Rate \$ Cash Fringe	1. \$ 2. \$ 3. \$ 4. \$ 5. \$ 6. \$							
												\$ Base Rate \$ Cash Fringe	1. \$ 2. \$ 3. \$ 4. \$ 5. \$ 6. \$							
												\$ Base Rate \$ Cash Fringe	1. \$ 2. \$ 3. \$ 4. \$ 5. \$ 6. \$							

12/9/2013 *IF REQUIRED
WWS-CP1

*SEE REVERSE SIDE

PAGE NUMBER ______OF

OSHA 10 ~ATTACH CARD TO 1ST CERTIFIED PAYROLL

***FRINGE BENEFITS EXPLANATION (P):**

Bona fide benefits paid to approved plans, funds or programs, except those required by Federal or State Law (unemployment tax, worker's compensation, income taxes, etc.).

Please specify the type of benefits provided:

1) Medical or hospital care __________________ 4) Disability___________________

2) Pension or retirement ____________________ 5) Vacation, holiday__________________

3) Life Insurance __________________________ 6) Other (please specify) _______________

CERTIFIED STATEMENT OF COMPLIANCE

For the week ending date of _________________________,

I, ____________________________of __________________________, (hereafter known as

Employer) in my capacity as ___________________________ (title) do hereby certify and state:

Section A:

1. All persons employed on said project have been paid the full weekly wages earned by them during the week in accordance with Connecticut General Statutes, section 31-53, as amended. Further, I hereby certify and state the following:

a) The records submitted are true and accurate;

b) The rate of wages paid to each mechanic, laborer or workman and the amount of payment or contributions paid or payable on behalf of each such person to any employee welfare fund, as defined in Connecticut General Statutes, section 31-53 (h), are not less than the prevailing rate of wages and the amount of payment or contributions paid or payable on behalf of each such person to any employee welfare fund, as determined by the Labor Commissioner pursuant to subsection Connecticut General Statutes, section 31-53 (d), and said wages and benefits are not less than those which may also be required by contract;

c) The Employer has complied with all of the provisions in Connecticut General Statutes, section 31-53 (and Section 31-54 if applicable for state highway construction);

d) Each such person is covered by a worker's compensation insurance policy for the duration of his employment which proof of coverage has been provided to the contracting agency;

e) The Employer does not receive kickbacks, which means any money, fee, commission, credit, gift, gratuity, thing of value, or compensation of any kind which is provided directly or indirectly, to any prime contractor, prime contractor employee, subcontractor, or subcontractor employee for the purpose of improperly obtaining or rewarding favorable treatment in connection with a prime contract or in connection with a prime contractor in connection with a subcontractor relating to a prime contractor; and

f) The Employer is aware that filing a certified payroll which he knows to be false is a class D felony for which the employer may be fined up to five thousand dollars, imprisoned for up to five years or both.

2. OSHA~The employer shall affix a copy of the construction safety course, program or training completion document to the certified payroll required to be submitted to the contracting agency for this project on which such persons name first appears.

_________________________ _________________________ _________________________

(Signature) (Title) Submitted on (Date)

*****THIS IS A PUBLIC DOCUMENT*****

*****DO NOT INCLUDE SOCIAL SECURITY NUMBERS*****

Weekly Payroll Certification For
Public Works Projects (Continued)

PAYROLL CERTIFICATION FOR PUBLIC WORKS PROJECTS

Week-Ending Date:
Contractor or Subcontractor Business Name:

WEEKLY PAYROLL

PERSON/WORKER, ADDRESS and SECTION	APPR RATE %	MALE/ FEMALE AND RACE*	WORK CLASSIFICATION Trade License Type & Number - OSHA 10 Certification Number	DAY AND DATE S	M	T	W	TH	F	S HOURS WORKED EACH DAY	Total ST Hours Total O/T Hours	BASE HOURLY RATE TOTAL FRINGE BENEFIT PLAN CASH	TYPE OF FRINGE BENEFITS Per Hour 1 through 6 (see back)	GROSS PAY FOR ALL WORK PERFORMED THIS WEEK	TOTAL DEDUCTIONS FICA	FEDERAL WITH-HOLDING	STATE WITH-HOLDING	LIST OTHER	GROSS PAY FOR THIS PREVAILING RATE JOB	CHECK # AND NET PAY
												$ Base Rate $ Cash Fringe	1. $ 2. $ 3. $ 4. $ 5. $ 6. $							
												$ Base Rate $ Cash Fringe	1. $ 2. $ 3. $ 4. $ 5. $ 6. $							
												$ Base Rate $ Cash Fringe	1. $ 2. $ 3. $ 4. $ 5. $ 6. $							
												$ Base Rate $ Cash Fringe	1. $ 2. $ 3. $ 4. $ 5. $ 6. $							
												$ Base Rate $ Cash Fringe	1. $ 2. $ 3. $ 4. $ 5. $ 6. $							

*IF REQUIRED

NOTICE: THIS PAGE MUST BE ACCOMPANIED BY A COVER PAGE (FORM # WWS-CP1)

[New] In accordance with Section 31-53b(a) of the C.G.S. each contractor shall provide a copy of the OSHA 10 Hour Construction Safety and Health Card for each employee, to be attached to the first certified payroll on the project.

In accordance with Connecticut General Statutes, 31-53
Certified Payrolls with a statement of compliance
shall be submitted monthly to the contracting agency.

PAYROLL CERTIFICATION FOR PUBLIC WORKS PROJECTS

WEEKLY PAYROLL

Connecticut Department of Labor
Wage and Workplace Standards Division
200 Folly Brook Blvd.
Wethersfield, CT 06109

CONTRACTOR NAME AND ADDRESS:			SUBCONTRACTOR NAME & ADDRESS	WORKER'S COMPENSATION INSURANCE CARRIER
Landon Corporation, 15 Connecticut Avenue, Northford, CT 06472			XYZ Corporation 2 Main Street Yantic, CT 06389	Travelers Insurance Company POLICY # #BAC8888928 EFFECTIVE DATE: 1/1/09 EXPIRATION DATE: 12/31/09
PAYROLL NUMBER 1	Week-Ending Date 9/26/09	PROJECT NAME & ADDRESS DOT 105-296, Route 82		

PERSON/WORKER, ADDRESS and SECTION	APPR RATE %	MALE/ FEMALE AND RACE*	WORK CLASSIFICATION / Trade License Type & Number - OSHA 10 Certification Number	S 20	M 21	T 22	W 23	TH 24	F 25	S 26	Total ST Hours / Total O/T Hours	BASE HOURLY RATE / TOTAL FRINGE BENEFIT PLAN CASH	TYPE OF FRINGE BENEFITS Per Hour 1 through 6 (see back)	GROSS PAY FOR ALL WORK PERFORMED THIS WEEK	FICA	FEDERAL WITH-HOLDING	STATE WITH-HOLDING	LIST OTHER	GROSS PAY FOR THIS PREVAILING RATE JOB	CHECK # AND NET PAY
Robert Craft 81 Maple Street Willimantic, CT 06226		M/C	Electrical Lineman E-1 1234567 Owner OSHA 123456		8	8	8	8	8		S-TIME 40 O-TIME	$ 30.75 Base Rate $ 8.82 Cash Fringe	1. $ 5.80 2. $ 3. $ 2.01 4. $ 5. $ 6. $	$1,582.80				P-xxxx	$1,582.80	#123 $ xxx.xx
Ronald Jones 212 Elm Street Norwich, CT 06360	65%	M/B	Electrical Apprentice OSHA 234567		8	8	8	8	8		S-TIME 40 O-TIME	$ 19.99 Base Rate $ 16.63 Cash Fringe	1. $ 2. $ 3. $ 4. $ 5. $ 6. $	$1,464.80	xx.xx	xxx.xx	xx.xx	G-xxx	$1,464.80	#124 $xxx.xx
Franklin T. Smith 234 Washington Rd. New London, CT 06320 SECTION B		M/H	Project Manager			8					S-TIME 8 O-TIME	$ Base Rate $ Cash Fringe	1. $ 2. $ 3. $ 4. $ 5. $ 6. $	$1,500.00	xx.xx	xx.xx	xx.xx	M-xx.x		#125 xxx.xx
											S-TIME O-TIME	$ Base Rate $ Cash Fringe	1. $ 2. $ 3. $ 4. $ 5. $ 6. $							

7/13/2009
WWS-CP1
*IF REQUIRED
*SEE REVERSE SIDE
PAGE NUMBER 1 OF 2

OSHA 10 ~ATTACH CARD TO 1ST CERTIFIED PAYROLL

***FRINGE BENEFITS EXPLANATION (P):**

Bona fide benefits paid to approved plans, funds or programs, except those required by Federal or State Law (unemployment tax, worker's compensation, income taxes, etc.).

Please specify the type of benefits provided:

1) Medical or hospital care Blue Cross 4) Disability________________

2) Pension or retirement ________________ 5) Vacation, holiday________________

3) Life Insurance Utopia 6) Other (please specify) ______________

CERTIFIED STATEMENT OF COMPLIANCE

For the week ending date of 9/26/09,

I, Robert Craft of XYZ Corporation, (hereafter known as

Employer) in my capacity as Owner (title) do hereby certify and state:

Section A:

1. All persons employed on said project have been paid the full weekly wages earned by them during the week in accordance with Connecticut General Statutes, section 31-53, as amended. Further, I hereby certify and state the following:

a) The records submitted are true and accurate;

b) The rate of wages paid to each mechanic, laborer or workman and the amount of payment or contributions paid or payable on behalf of each such employee to any employee welfare fund, as defined in Connecticut General Statutes, section 31-53 (h), are not less than the prevailing rate of wages and the amount of payment or contributions paid or payable on behalf of each such employee to any employee welfare fund, as determined by the Labor Commissioner pursuant to subsection Connecticut General Statutes, section 31-53 (d), and said wages and benefits are not less than those which may also be required by contract;

c) The Employer has complied with all of the provisions in Connecticut General Statutes, section 31-53 (and Section 31-54 if applicable for state highway construction);

d) Each such employee of the Employer is covered by a worker's compensation insurance policy for the duration of his employment which proof of coverage has been provided to the contracting agency;

e) The Employer does not receive kickbacks, which means any money, fee, commission, credit, gift, gratuity, thing of value, or compensation of any kind which is provided directly or indirectly, to any prime contractor, prime contractor employee, subcontractor, or subcontractor employee for the purpose of improperly obtaining or rewarding favorable treatment in connection with a prime contract or in connection with a prime contractor in connection with a subcontractor relating to a prime contractor; and

f) The Employer is aware that filing a certified payroll which he knows to be false is a class D felony for which the employer may be fined up to five thousand dollars, imprisoned for up to five years or both.

2. OSHA~The employer shall affix a copy of the construction safety course, program or training completion document to the certified payroll required to be submitted to the contracting agency for this project on which such employee's name first appears.

Robert Craft	owner	10/2/09
(Signature)	(Title)	Submitted on (Date)

Section B: Applies to CONNDOT Projects ONLY
That pursuant to CONNDOT contract requirements for reporting purposes only, all employees listed under Section B who performed work on this project are not covered under the prevailing wage requirements defined in Connecticut General Statutes Section 31-53.

Robert Craft	owner	10/2/09
(Signature)	(Title)	Submitted on (Date)

Note: CTDOL will assume all hours worked were performed under Section A unless clearly delineated as Section B WWS-CP1 as such. Should an employee perform work under both Section A and Section B, the hours worked and wages paid must be segregated for reporting purposes.

*****THIS IS A PUBLIC DOCUMENT*****
*****DO NOT INCLUDE SOCIAL SECURITY NUMBERS*****

Information Bulletin
Occupational Classifications

The Connecticut Department of Labor has the responsibility to properly determine *"job classification"* on prevailing wage projects covered under C.G.S. Section 31-53(d).

Note: This information is intended to provide a sample of some occupational classifications for guidance purposes only. It is not an all-inclusive list of each occupation's duties. This list is being provided only to highlight some areas where a contractor may be unclear regarding the proper classification. If unsure, the employer should seek guidelines for CTDOL.

Below are additional clarifications of specific job duties performed for certain classifications:

- ***ASBESTOS WORKERS***

Applies all insulating materials, protective coverings, coatings and finishes to all types of mechanical systems.

- ***ASBESTOS INSULATOR***

Handle, install apply, fabricate, distribute, prepare, alter, repair, dismantle, heat and frost insulation, including penetration and fire stopping work on all penetration fire stop systems.

- ***BOILERMAKERS***

Erects hydro plants, incomplete vessels, steel stacks, storage tanks for water, fuel, etc. Builds incomplete boilers, repairs heat exchanges and steam generators.

- ***BRICKLAYERS, CEMENT MASONS, CEMENT FINISHERS, MARBLE MASONS, PLASTERERS, STONE MASONS, PLASTERERS. STONE MASONS, TERRAZZO WORKERS, TILE SETTERS***

Lays building materials such as brick, structural tile and concrete cinder, glass, gypsum, terra cotta block. Cuts, tools and sets marble, sets stone, finishes concrete, applies decorative steel, aluminum and plastic tile, applies cements, sand, pigment and marble chips to floors, stairways, etc.

- ***<u>CARPENTERS, MILLWRIGHTS. PILEDRIVERMEN. LATHERS. RESILEINT FLOOR LAYERS, DOCK BUILDERS, DIKERS, DIVER TENDERS</u>***

Constructs, erects, installs and repairs structures and fixtures of wood, plywood and wallboard. Installs, assembles, dismantles, moves industrial machinery. Drives piling into ground to provide foundations for structures such as buildings and bridges, retaining walls for earth embankments, such as cofferdams. Fastens wooden, metal or rockboard lath to walls, ceilings and partitions of buildings, acoustical tile layer, concrete form builder. Applies firestopping materials on fire resistive joint systems only. Installation of curtain/window walls only where attached to wood or metal studs. Installation of insulated material of all types whether blown, nailed or attached in other ways to walls, ceilings and floors of buildings. Assembly and installation of modular furniture/furniture systems. Free-standing furniture is not covered. This includes free standing: student chairs, study top desks, book box desks, computer furniture, dictionary stand, atlas stand, wood shelving, two-position information access station, file cabinets, storage cabinets, tables, etc.

- **LABORER, CLEANING**

• The clean up of any construction debris and the general (heavy/light) cleaning, including sweeping, wash down, mopping, wiping of the construction facility and its furniture, washing, polishing, and dusting.

- **DELIVERY PERSONNEL**

• If delivery of supplies/building materials is to one common point and stockpiled there, prevailing wages <u>are not required</u>. If the delivery personnel are involved in the distribution of the material to multiple locations within the construction site then they would have to be paid prevailing wages for the type of work performed: laborer, equipment operator, electrician, ironworker, plumber, etc.

• An example of this would be where delivery of drywall is made to a building and the delivery personnel distribute the drywall from one "stockpile" location to further sub-locations on each floor. Distribution of material around a construction site is the job of a laborer or tradesman, and not a delivery personnel.

- ***<u>ELECTRICIANS</u>***

Install, erect, maintenance, alteration or repair of any wire, cable, conduit, etc., which generates, transforms, transmits or uses electrical energy for light, heat, power or other purposes, including the Installation or maintenance of telecommunication, LAN wiring or computer equipment, and low voltage wiring. ****License required per Connecticut General Statutes: E-1,2 L-5,6 C-5,6 T-1,2 L-1,2 V-1,2,7,8,9.***

- ***ELEVATOR CONSTRUCTORS***

Install, erect, maintenance and repair of all types of elevators, escalators, dumb waiters and moving walks. ****License required by Connecticut General Statutes: R-1,2,5,6.***

- ***FORK LIFT OPERATOR***

Laborers Group 4) Mason Tenders - operates forklift solely to assist a mason to a maximum height of nine (9) feet only.

Power Equipment Operator Group 9 - operates forklift to assist any trade, and to assist a mason to a height over nine (9) feet.

- ***GLAZIERS***

Glazing wood and metal sash, doors, partitions, and 2 story aluminum storefronts. Installs glass windows, skylights, store fronts and display cases or surfaces such as building fronts, interior walls, ceilings and table tops and metal store fronts. Installation of aluminum window walls and curtain walls is the "joint" work of glaziers and ironworkers, which require equal composite workforce.

- ***IRONWORKERS***

Erection, installation and placement of structural steel, precast concrete, miscellaneous iron, ornamental iron, metal curtain wall, rigging and reinforcing steel. Handling, sorting, and installation of reinforcing steel (rebar). Metal bridge rail (traffic), metal bridge handrail, and decorative security fence installation. Installation of aluminum window walls and curtain walls is the "joint" work of glaziers and ironworkers which require equal composite workforce.

- ***INSULATOR***

• Installing fire stopping systems/materials for "Penetration Firestop Systems": transit to cables, electrical conduits, insulated pipes, sprinkler pipe penetrations, ductwork behind radiation, electrical cable trays, fire rated pipe penetrations, natural polypropylene, HVAC ducts, plumbing bare metal, telephone and communication wires, and boiler room ceilings.

- ***LABORERS***

Acetylene burners, asphalt rakers, chain saw operators, concrete and power buggy operator, concrete saw operator, fence and guard rail erector (except metal bridge rail (traffic), decorative security fence (non-metal).

installation.), hand operated concrete vibrator operator, mason tenders, pipelayers (installation of storm drainage or sewage lines on the street only), pneumatic drill operator, pneumatic gas and electric drill operator, powermen and wagon drill operator, air track operator, block paver, curb setters, blasters, concrete spreaders.

- ***PAINTERS***

Maintenance, preparation, cleaning, blasting (water and sand, etc.), painting or application of any protective coatings of every description on all bridges and appurtenances of highways, roadways, and railroads. Painting, decorating, hardwood finishing, paper hanging, sign writing, scenic art work and drywall hhg for any and all types of building and residential work.

  - ***LEAD PAINT REMOVAL***

• Painter's Rate
1. Removal of lead paint from bridges.
2. Removal of lead paint as preparation of any surface to be repainted.
3. Where removal is on a Demolition project prior to reconstruction.

• Laborer's Rate
1. Removal of lead paint from any surface NOT to be repainted.
2. Where removal is on a *TOTAL* Demolition project only.

- ***PLUMBERS AND PIPEFITTERS***

Installation, repair, replacement, alteration or maintenance of all plumbing, heating, cooling and piping. ****License required per Connecticut General Statutes: P-1,2,6,7,8,9 J-1,2,3,4 SP-1,2 S-1,2,3,4,5,6,7,8 B-1,2,3,4 D-1,2,3,4.***

- ***POWER EQUIPMENT OPERATORS***

Operates several types of power construction equipment such as compressors, pumps, hoists, derricks, cranes, shovels, tractors, scrapers or motor graders, etc. Repairs and maintains equipment. ****License required, crane operators only, per Connecticut General Statutes.***

- ***ROOFERS***

Covers roofs with composition shingles or sheets, wood shingles, slate or asphalt and gravel to waterproof roofs, including preparation of surface. (demolition or removal of any type of roofing and or clean-up of any and all areas where a roof is to be relaid.)

- ***SHEETMETAL WORKERS***

Fabricate, assembles, installs and repairs sheetmetal products and equipment in such areas as ventilation, air-conditioning, warm air heating, restaurant equipment, architectural sheet metal work, sheetmetal roofing, and aluminum gutters. Fabrication, handling, assembling, erecting, altering, repairing, etc. of coated metal material panels and composite metal material panels when used on building exteriors and interiors as soffits, facia, louvers, partitions, canopies, cornice, column covers, awnings, beam covers, cladding, sun shades, lighting troughs, spires, ornamental roofing, metal ceilings, mansards, copings, ornamental and ventilation hoods, vertical and horizontal siding panels, trim, etc. The sheet metal classification also applies to the vast variety of coated metal material panels and composite metal material panels that have evolved over the years as an alternative to conventional ferrous and non-ferrous metals like steel, iron, tin, copper, brass, bronze, aluminum, etc. Fabrication, handling, assembling, erecting, altering, repairing, etc. of architectural metal roof, standing seam roof, composite metal roof, metal and composite bathroom/toilet partitions, aluminum gutters, metal and composite lockers and shelving, kitchen equipment, and walk-in coolers. To include testing and air –balancing ancillary to installation and construction.

- ***SPRINKLER FITTERS***

Installation, alteration, maintenance and repair of fire protection sprinkler systems.
License required per Connecticut General Statutes: F-1,2,3,4.

- ***TILE MARBLE AND TERRAZZO FINISHERS***

Assists and tends the tile setter, marble mason and terrazzo worker in the performance of their duties.

- **TRUCK DRIVERS**

~How to pay truck drivers delivering asphalt is under REVISION~

Truck Drivers are requires to be paid prevailing wage for time spent "working" directly on the site. These drivers remain covered by the prevailing wage for any time spent transporting between the actual construction location and facilities (such as fabrication, plants, mobile factories, batch plant, borrow pits, job headquarters, tool yards, etc.) dedicated exclusively, or nearly so, to performance of the contract or project, which are so located in proximity to the actual construction location that it is reasonable to include them. ***License required, drivers only, per Connecticut General Statutes.***

For example:

• Material men and deliverymen are not covered under prevailing wage as long as they are not directly involved in the construction process. If, they unload the material, they would then be covered by prevailing wage for the classification they are performing work in: laborer, equipment operator, etc.
• Hauling material off site is not covered provided they are not dumping it at a location outlined above.
• Driving a truck on site and moving equipment or materials on site would be considered covered work, as this is part of the construction process.

➢ *Any questions regarding the proper classification should be directed to:*
Public Contract Compliance Unit
Wage and Workplace Standards Division
Connecticut Department of Labor
200 Folly Brook Blvd, Wethersfield, CT 06109
(860) 263-6790.

Connecticut Department of Labor
Wage and Workplace Standards Division
FOOTNOTES

⇨ Please Note: If the "Benefits" listed on the schedule for the following occupations includes a letter(s) (+ a or + a+b for instance), refer to the information below.

Benefits to be paid at the appropriate prevailing wage rate for the listed occupation.

If the "Benefits" section for the occupation lists only a dollar amount, disregard the information below.

Bricklayers, Cement Masons, Cement Finishers, Concrete Finishers, Stone Masons
(Building Construction) and
(Residential- Hartford, Middlesex, New Haven, New London and Tolland Counties)

a. Paid Holiday: Employees shall receive 4 hours for Christmas Eve holiday provided the employee works the regularly scheduled day before and after the holiday. Employers may schedule work on Christmas Eve and employees shall receive pay for actual hours worked in addition to holiday pay.

Elevator Constructors: Mechanics

a. Paid Holidays: New Year's Day, Memorial Day, Independence Day, Labor Day, Veterans' Day, Thanksgiving Day, Christmas Day, plus the Friday after Thanksgiving.

b. Vacation: Employer contributes 8% of basic hourly rate for 5 years or more of service or 6% of basic hourly rate for 6 months to 5 years of service as vacation pay credit.

Glaziers

a. Paid Holidays: Labor Day and Christmas Day.

Power Equipment Operators
(Heavy and Highway Construction & Building Construction)

a. Paid Holidays: New Year's Day, Good Friday, Memorial day, Independence Day, Labor Day, Thanksgiving Day and Christmas Day, provided the employee works 3 days during the week in which the holiday falls, if scheduled, and if scheduled, the working day before and the working day after the holiday. Holidays falling on Saturday may be observed on Saturday, or if the employer so elects, on the preceding Friday.

Ironworkers

a. Paid Holiday: Labor Day provided employee has been on the payroll for the 5 consecutive work days prior to Labor Day.

Laborers (Tunnel Construction)

a. Paid Holidays: New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day and Christmas Day. No employee shall be eligible for holiday pay when he fails, without cause, to work the regular work day preceding the holiday or the regular work day following the holiday.

Roofers

a. Paid Holidays: July 4th, Labor Day, and Christmas Day provided the employee is employed 15 days prior to the holiday.

Sprinkler Fitters

a. Paid Holidays: Memorial Day, July 4th, Labor Day, Thanksgiving Day and Christmas Day, provided the employee has been in the employment of a contractor 20 working days prior to any such paid holiday.

Truck Drivers

(Heavy and Highway Construction & Building Construction)

a. Paid Holidays: New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day, Christmas day, and Good Friday, provided the employee has at least 31 calendar days of service and works the last scheduled day before and the first scheduled day after the holiday, unless excused.

EXHIBIT H
TECHNICAL SPECIFICATIONS AND SPECIAL PROVISIONS

SERVICE DESCRIPTION

a) Purpose

The District is requesting Competitive Sealed Bids from qualified firms for a licensed HVAC contractor to provide replacement of the commercial-grade HVAC Equipment, deemed as having met or nearing its useful life, at the Union Station Transportation Center Complex located at One Union Place, Hartford, CT, 06103.

b) Scope of Work

The scope of work for this project is based on, and is expected to be performed in accordance with, the HVAC equipment replacement plan as developed by the assigned Architectural and Engineering firm, AI Engineers, Inc. The specifics of the services are set forth in the Scope of Services, Bid Proposal Form and in the Exhibits attached hereto and made a part hereof.

Greater Hartford
Transit District

TECHNICAL SPECIFICATIONS

UNION STATION HVAC REPLACEMENT
1 UNION PLACE
CITY OF HARTFORD, CT

NOVEMBER O1, 2023

PREPARED BY:

AI Engineers

SECTION 001100 - TABLE OF CONTENTS

END OF SECTION 000110

SECTION 230130.52 - EXISTING HVAC AIR DISTRIBUTION SYSTEM CLEANING

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 cleaning existing HVAC air-distribution equipment, ducts, plenums, and system components.

B. Related Requirements:

1. Section 233113.00 "Metal Ducts" for cleaning newly installed metal ducts.
2. Section 233116.00 "Nonmetal Ducts" for cleaning newly installed nonmetal ducts.
3. Section 230593.00 "Testing, Adjusting, Balancing for HVAC" for system flow documentation before cleaning and balancing and following cleaning and restoration.
4. Section 233300.00 "Air Duct Accessories" for restoration of opened ducts and plenums with access doors.

1.3 DEFINITIONS

A. ACAC: American Council for Accredited Certification.

B. AIHA-LAP: American Industrial Hygiene Association Lab Accreditation Program

C. ASCS: Air systems cleaning specialist.

D. CESB: Council of Engineering and Scientific Specialty Boards.

E. CMI: Certified Microbial Investigator.

F. CMC: Certified Microbial Consultant.

G. CMR: Certified Microbial Remediator.

H. CMRS: Certified Microbial Remediation Supervisor.

I. EMLAP: Environmental Microbiology Laboratory Accreditation Program.

J. IEP: Indoor Environmental Professional.

K. IICRC: Institute of Inspection, Cleaning, and Restoration Certification.

L. NADCA: National Air Duct Cleaners Association.

1.4 ACTION SUBMITTALS

A. Product Data:

1. Cleaning agents
2. Antimicrobial surface treatments ("sealant" for sustainable design submittal purposes).

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. For an ASCS.
2. For an IEP.
3. For a CMR and a CMRS.

B. Field Quality-Control Reports:

1. Project's existing conditions.
2. Evaluations and recommendations, including cleanliness verification.
3. Strategies and procedures plan.

1.6 CLOSEOUT SUBMITTALS

A. Post-Project report.

1.7 QUALITY ASSURANCE

A. ASCS Qualifications: A certified member of NADCA.

1. Certification: Employ an ASCS certified by NADCA on a full-time basis.
2. Supervisor Qualifications: Certified as an ASCS by NADCA.

B. IEP Qualifications: CMI who is certified by ACAC and accredited by CESB.

C. CMR Qualifications: Certified by ACAC and accredited by CESB.

D. CMRS Qualifications: Certified by ACAC and accredited by CESB.

E. UL Compliance: Comply with UL 181 and UL 181A for fibrous-glass ducts.

PART 2 - PRODUCTS

2.1 HVAC CLEANING AGENTS

A. Description:

1. Formulated for each specific soiled coil condition that needs remedy.
2. Will not corrode or tarnish aluminum, copper, or other metals.

2.2 ANTIMICROBIAL SURFACE TREATMENT

A. Description: Specific product selected shall be as recommended by the IEP based on the specific antimicrobial needs of the specific Project conditions.

1. Formulated to kill and inhibit growth of microorganisms.
2. EPA-registered for use in HVAC systems and for the specific application in which it will be used.
3. Have no residual action after drying, with zero VOC off-gassing.
4. OSHA compliant.
5. Treatment shall dry clear to allow continued visual observation of the treated surface.

PART 3 - EXECUTION

3.1 PREPARATION

A. Inspect HVAC air-distribution equipment, ducts, plenums, and system components to determine appropriate methods, tools, and equipment required for performance of the Work.

B. Perform "Project Evaluation and Recommendation" according to NADCA ACR.

C. Cleaning Plan: Prepare a written plan for air-distribution system cleaning that includes strategies and step-by-step procedures. At a minimum, include the following:

1. Supervisor contact information.
2. Work schedule, including location, times, and impact on occupied areas.
3. Methods and materials planned for each HVAC component type.
4. Required support from other trades.
5. Equipment and material storage requirements.
6. Exhaust equipment setup locations.

D. Existing Conditions Report: Prepare a written report that documents existing conditions of the systems and equipment. Include documentation of existing conditions, including inspection results, photo images, laboratory results, and interpretations of the laboratory results by an IEP.

1. Prepare written report listing conditions detrimental to performance of the Work.

E. Proceed with work only after conditions detrimental to performance of the Work have been corrected.

F. Use the existing service openings, as required for proper cleaning, at various points of the HVAC system for physical and mechanical entry and for inspection.

G. Comply with NADCA ACR, "Guidelines for Constructing Service Openings in HVAC Systems" Section.

H. Mark the position of manual volume dampers and air-directional mechanical devices inside the system prior to cleaning.

3.2 CLEANING

A. Comply with NADCA ACR, including items identified as "recommended," "advised," and "suggested."

B. Perform electrical lockout and tagout according to Owner's standards or authorities having jurisdiction.

C. Remove non-adhered substances and deposits from within the HVAC system.

D. Complete cleaning in accordance with Owner-Contractor agreed-upon scope of work.

E. Systems and Components to Be Cleaned: All air-moving and -distribution equipment.

F. Collect debris removed during cleaning. Ensure that debris is not dispersed outside the HVAC system during the cleaning process.

G. Particulate Collection:

1. For particulate collection equipment, include adequate filtration to contain debris removed. Locate equipment downwind and away from all air intakes and other points of entry into the building.
2. HEPA filtration with 99.97 percent collection efficiency for particles sized 0.3 micrometer or larger shall be used where the particulate collection equipment is exhausting inside the building,

H. Control odors and mist vapors during the cleaning and restoration process.

I. Mark the position of manual volume dampers and air-directional mechanical devices inside the system prior to cleaning. Restore them to their marked position on completion of cleaning.

J. System components shall be cleaned so that all HVAC system components are visibly clean. On completion, all components must be returned to those settings recorded just prior to cleaning operations.

K. Clean all air-distribution devices, registers, grilles, and diffusers.

L. Clean non-adhered substance deposits according to NADCA ACR and the following:

1. Clean air-handling units, airstream surfaces, components, condensate collectors, and drains.
2. Ensure that a suitable operative drainage system is in place prior to beginning wash-down procedures.
3. Clean evaporator coils, reheat coils, and other airstream components.

M. Air-Distribution Systems:

1. Create service openings in the HVAC system as necessary to accommodate cleaning.
2. Mechanically clean air-distribution systems specified to remove all visible contaminants, so that the systems are capable of passing the HVAC System Cleanliness Tests (see NADCA ACR).

N. Debris removed from the HVAC system shall be disposed of according to applicable Federal, state, and local requirements.

O. Mechanical Cleaning Methodology:

1. Source-Removal Cleaning Methods: The HVAC system shall be cleaned using source-removal mechanical cleaning methods designed to extract contaminants from within the HVAC system and to safely remove these contaminants from the facility. No cleaning method, or combination of methods, shall be used that could potentially damage components of the HVAC system or negatively alter the integrity of the system.

   a. Use continuously operating vacuum-collection devices to keep each section being cleaned under negative pressure.
   b. Cleaning methods that require mechanical agitation devices to dislodge debris that is adhered to interior surfaces of HVAC system components shall be equipped to safely remove these devices. Cleaning methods shall not damage the integrity of HVAC system components or damage porous surface materials, such as duct and plenum liners.

2. Cleaning Mineral-Fiber Insulation Components:

   a. Fibrous-glass thermal or acoustical insulation elements present in equipment or ductwork shall be thoroughly cleaned with HEPA vacuuming equipment while the HVAC system is under constant negative pressure and shall not be permitted to get wet according to NADCA ACR.
   b. Cleaning methods used shall not cause damage to fibrous-glass components and will render the system capable of passing the HVAC System Cleanliness Tests (see NADCA ACR).
   c. Fibrous materials that become wet shall be discarded and replaced.

P. Coil Cleaning:

1. See NADCA ACR, "Coil Surface Cleaning" Section. Type 1, or Type 1 and Type 2, cleaning methods shall be used to render the coil visibly clean and capable of passing coil cleaning verification.
2. Coil drain pans shall be subject to NADCA ACR, "Non-Porous Surfaces Cleaning Verification." Ensure that condensate drain pans are operational.

3. Electric-resistance coils shall be de-energized, locked out, and tagged before cleaning.
4. Cleaning methods shall not cause any appreciable damage to, cause displacement of, inhibit heat transfer, or cause erosion of the coil surface or fins, and shall comply with coil manufacturer's written recommendations.
5. Rinse thoroughly with clean water to remove any latent residues.

Q. Application of Antimicrobial Treatment:

1. Apply antimicrobial agents and coatings if active fungal growth is determined by the IEP to be at Condition 2 or Condition 3 status according to IICRC S520, as analyzed by a laboratory accredited by AIHA-LAP with an EMLAP certificate, and with results interpreted by an IEP. Apply antimicrobial agents and coatings according to manufacturer's written recommendations and EPA registration listing after the removal of surface deposits and debris.
2. Apply antimicrobial treatments and coatings after the system is rendered clean.
3. Apply antimicrobial agents and coatings directly onto surfaces of interior ductwork.
4. Microbial remediation shall be performed by a qualified CMR and CMRS.

3.3 CLEANLINESS VERIFICATION

A. Verify cleanliness according to NADCA ACR, "Verification of HVAC System Cleanliness" Section.

B. Verify HVAC system cleanliness after mechanical cleaning and before applying any treatment or introducing any treatment-related substance to the HVAC system, including biocidal agents and coatings.

C. Surface-Cleaning Verification: Perform visual inspection for cleanliness. If no contaminants are evident through visual inspection, the HVAC system shall be considered clean. If visible contaminants are evident through visual inspection, those portions of the system where contaminants are visible shall be re-cleaned and subjected to re-inspection for cleanliness.

D. Verification of Coil Cleaning:

E. Verification of Coil Cleaning: Coil will be considered clean if the coil is free of foreign matter and chemical residue, based on a thorough visual inspection.

F. Prepare a written cleanliness verification report. At a minimum, include the following:

1. Written documentation of the success of the cleaning.
2. Site inspection reports, initialed by supervisor, including notation on areas of inspection, as verified through visual inspection.
3. Surface comparison test results if required.
4. Gravimetric analysis (nonporous surfaces only).
5. System areas found to be damaged.

3.4 RESTORATION

A. Restore and repair HVAC air-distribution equipment, ducts, plenums, and components according to NADCA ACR, "Restoration and Repair of Mechanical Systems" Section.

B. Restore service openings capable of future reopening. Comply with requirements in Section 233113 Metal Ducts.

C. Replace damaged insulation according to Section 230713 "Duct Insulation."

D. Ensure that closures do not hinder or alter airflow.

E. New closure materials, including insulation, shall match opened materials and shall have removable closure panels fitted with gaskets and fasteners.

F. Restore manual volume dampers and air-directional mechanical devices inside the system to their marked position on completion of cleaning.

G. Measure air flows through air-distribution system.

H. Measure static-pressure differential across each coil.

3.5 PROJECT CLOSEOUT

A. Post-Project Report:

1. Post-cleaning laboratory results if any.
2. Post-cleaning photo images.
3. Post-cleaning verification summary.

B. Drawings:

1. Deviations of existing system from Owner's record drawings.
2. Location of service openings.

END OF SECTION 230130.52

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC 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 general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

SECTION 230516 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

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. Packed expansion joints.
2. Grooved-joint expansion joints.
3. Alignment guides and anchors.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.
4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 CLOSEOUT SUBMITTALS

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

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

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

2.2 PACKED EXPANSION JOINTS

A. Flexible, Ball-Joint Packed Expansion Joints:

1. Standards: ASME Boiler and Pressure Vessel Code: Section II, "Materials"; ASME B31.9, "Building Services Piping," for materials and design of pressure-containing parts and bolting.
2. Material: Carbon-steel assembly with asbestos-free composition packing.
3. Design: Provide 360-degree rotation and angular deflection.
4. Minimum Pressure Rating: 250 psig at 400 deg F.
5. Angular Deflection for NPS 6 and Smaller: 30 degree minimum.
6. Angular Deflection for NPS 8 and Larger: 15 degree minimum.
7. Seal Type: Two carbon steel and graphite seals suitable for continuous operation at temperature up to 650 deg F.
8. Internal Ball: Plated with minimum 1-mil chrome cover.
9. Ball Socket: One- or two-piece design with integral socket/retainer.

    a. Stuffing Box: Incorporates containment seals and compression seals for containment of injectable packing.
    b. Packing Cylinders: Provides packing under full line pressure with check valves to prevent blowback.

10. End Connections for NPS 2 and Smaller: Threaded.
11. End Connections for NPS 2-1/2 and Larger: Flanged.

B. Slip-Joint Packed Expansion Joints:

1. Standard: ASTM F1007.

2. Material: Carbon steel with asbestos-free PTFE packing.
3. Design: With internal guide and injection ports for repacking under full system pressure. Housing shall be furnished with drain ports and lifting ring. Include drip connection if used for steam piping.
4. Configuration: Single joint, Single joint with base and double joint with base class(es), unless otherwise indicated.
5. Slip Tube for sizes NPS 1-1/2 through NPS 16: Schedule 80.
6. Slip Tube for sizes NPS 18 through NPS 24: Schedule 60.
7. Sliding Surface: 2 mil thick chrome finish.
8. End Connections: Flanged or welded ends to match piping system.

2.3 PACKLESS EXPANSION JOINTS

A. Metal, Compensator Packless Expansion Joints:

1. Minimum Pressure Rating: 150 psig, unless otherwise indicated.
2. Description: Totally enclosed, externally pressurized, multi-ply bellows isolated from fluid flow by an internal pipe sleeve and external housing.
3. Joint Axial Movement: 2 inches of compression and 1/2 inch of extension.
4. Configuration for Copper Tubing: Multi-ply, phosphor-bronze bellows with copper pipe ends.

    a. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint or threaded.
    b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Threaded.

5. Configuration for Steel Piping: Multi-ply, stainless-steel bellows; steel-pipe end connections; and carbon-steel shroud.

    a. End Connections for Steel Pipe NPS 2 and Smaller: Threaded.
    b. End Connections for Steel Pipe NPS 2-1/2 to NPS 4: Flanged, Threaded or Welded.

B. Rubber Union Connector Expansion Joints:

1. Material: Twin reinforced-rubber spheres with external restraining cables.
2. Minimum Pressure Rating: 150 psig at 170 deg F, unless otherwise indicated.
3. End Connections for NPS 2 and Smaller: Threaded.

C. Flexible-Hose Packless Expansion Joints:

1. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
2. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
3. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with solder-joint end connections.

a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.
b. Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F and 500 psig at 450 deg F ratings.

4. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4: Copper-alloy fittings with threaded end connections.

   a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.
   b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F and 315 psig at 450 deg F ratings.

5. Expansion Joints for Steel Piping NPS 2 and Smaller: Carbon-steel fittings with threaded end connections.

   a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F and 325 psig at 600 deg F ratings.
   b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F and 515 psig at 600 deg F ratings.

6. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Carbon-steel fittings with flanged or welded end connections.

   a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F ratings.
   b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F and 200 psig at 600 deg F ratings.

7. Expansion Joints for Steel Piping NPS 8 to NPS 12: Carbon-steel fittings with flanged or welded end connections.

   a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F and 90 psig at 600 deg F ratings.
   b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F and 120 psig at 600 deg F ratings.

8. Expansion Joints for Steel Piping NPS 14 and Larger: Carbon-steel fittings with flanged or welded end connections.

   a. Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F and 120 psig at 600 deg F ratings.

D. Metal-Bellows Packless Expansion Joints:

1. Standards: ASTM F1120 and EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
2. Type: Circular, corrugated bellows with external tie rods.
3. Minimum Pressure Rating: 150 psig, unless otherwise indicated.

4. Configuration: Single joint, Single joint with base and double joint with base class(es), unless otherwise indicated.
5. Expansion Joints for Copper Tubing: Single- or multi-ply phosphor-bronze bellows, copper pipe ends, and brass shrouds.

   a. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint or threaded.
   b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Solder joint or threaded.
   c. End Connections for Copper Tubing NPS 5 and Larger: Flanged.

6. Expansion Joints for Steel Piping: Single- or multi-ply stainless-steel bellows, steel pipe ends, and carbon-steel shroud.

   a. End Connections for Steel Pipe NPS 2 and Smaller: Threaded.
   b. End Connections for Steel Pipe NPS 2-1/2 and Larger: Flanged or Welded.

E. Externally Pressurized Metal-Bellows Packless Expansion Joints:

1. Minimum Pressure Rating: 150 psig, unless otherwise indicated.
2. Description:

   a. Totally enclosed, externally pressurized, multi-ply, stainless-steel bellows isolated from fluid flow by an internal pipe sleeve.
   b. Carbon-steel housing.
   c. Drain plugs and lifting lug for the NPS 3 and larger.

3. Permanent Locking Bolts: Set locking bolts to maintain joint lengths during installation. Temporary welding tabs that are removed after installation in lieu of locking bolts are not acceptable.
4. End Connection Configuration: Flanged; one raised, fixed and one floating flange.

F. Rubber Packless Expansion Joints:

1. Standards: ASTM F1123 and FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
2. Material: Fabric-reinforced rubber complying with FSA-PSJ-703.
3. Arch Type: Single or multiple arches with external control rods.
4. Spherical Type: Single or multiple spheres with external control rods.
5. Minimum Pressure Rating for NPS 1-1/2 to NPS 12: 225 psig at 170 deg F.
6. Material for Fluids Containing Acids, Alkalis, or Chemicals: Butyl rubber, Chlorosulfonyl-polyethylene rubber or Ethylene-propylene-diene terpolymer rubber.
7. Material for Fluids Containing Gas, Hydrocarbons, or Oil: Buna-N or Chlorosulfonated polyethylene synthetic rubber.
8. Material for Water: Butyl rubber, Buna-N, Chlorosulfonated polyethylene synthetic rubber, Chlorosulfonyl-polyethylene rubber, Ethylene-propylene-diene terpolymer rubber or Natural rubber.
9. End Connections: Full-faced, integral steel flanges with steel retaining rings.

2.4 GROOVED-JOINT EXPANSION JOINTS

A. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.

B. Standard: AWWA C606, for grooved joints.

C. Nipples: Galvanized, ASTM A53/A53M, Schedule 40, Type E or S, steel pipe with grooved ends.

D. Couplings: flexible type for steel-pipe dimensions. Include ferrous housing sections, Buna-N gasket suitable for diluted acid, alkaline fluids, and cold and hot water or ethylene-propylene-diene terpolymer rubber gasket suitable for cold and hot water, and bolts and nuts.

2.5 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

1. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A36/A36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A183, steel hex head.
3. Washers: ASTM F844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.

    a. Stud: Threaded, zinc-coated carbon steel.
    b. Expansion Plug: Zinc-coated steel.
    c. Washer and Nut: Zinc-coated steel.

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

    a. Bonding Material: ASTM C881/C881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
    b. Stud: ASTM A307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
    c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 INSTALLATION OF EXPANSION JOINTS

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

B. Install packed-type expansion joints with packing suitable for fluid service.

C. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."

D. Install rubber packless expansion joints according to FSA-PSJ-703.

E. Install grooved-joint expansion joints to grooved-end steel piping.

3.2 INSTALLATION OF PIPE LOOPS AND SWING CONNECTIONS

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

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

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

D. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.3 INSTALLATION OF ALIGNMENT GUIDES AND ANCHORS

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

C. Attach guides to pipe, and secure guides to building structure.

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

E. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 230516

SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

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. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.
6. Silicone sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.

B. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, anti-corrosion coated or zinc coated, with plain ends and integral welded waterstop collar.

C. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

D. PVC Pipe Sleeves: ASTM D1785, Schedule 40.

E. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

A. Description: Manufactured, Dura-coated, Duco-coated or galvanized cast-iron sleeve with integral cast flashing flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

A. Description:

1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
2. Designed to form a hydrostatic seal of 20-psig.
3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
4. Pressure Plates: Carbon steel.
5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, ASTM B633 of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

A. Description:

1. Manufactured plastic, sleeve-type, waterstop assembly, made for imbedding in concrete slab or wall.
2. Plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

A. Description: Nonshrink, recommended for interior and exterior sealing openings in nonfire-rated walls or floors.

B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.6 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C920, Type S, Grade NS, Class 25, use NT.

B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.

C. Silicone Foam: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.

   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

3. Using grout or silicone sealant, seal space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.

3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 3 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using waterproof silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.

B. Fire-Resistance-Rated, Horizontal Assembly, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal-system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings as new walls and slabs are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout or silicone sealant, seal space around outside of sleeve-seal fittings.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

3.6 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls Above Grade:

a. Piping Smaller Than NPS 6: Cast-iron sleeves, Steel pipe sleeves or Sleeve-seal fittings.
b. Piping NPS 6 and Larger: Cast-iron pipe sleeves, Steel pipe sleeves or Sleeve-seal fittings.

2. Exterior Concrete Walls Below Grade:

a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves with sleeve-seal system, Steel pipe sleeves with sleeve-seal system or Sleeve-seal fittings.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Cast-iron pipe sleeves with sleeve-seal system, Steel pipe sleeves with sleeve-seal system or Sleeve-seal fittings.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:

a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves with sleeve-seal system, Steel pipe sleeves with sleeve-seal system or Sleeve-seal fittings.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 and Larger: Cast-iron pipe sleeves with sleeve-seal system, Steel pipe sleeves with sleeve-seal system or Sleeve-seal fittings.

1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs Above Grade:

a. Piping Smaller Than NPS 6: Steel pipe sleeves, PVC-pipe sleeves, Stack-sleeve fittings, Sleeve-seal fittings, Molded-PE or -PP sleeves or Molded-PVC sleeves.
b. Piping NPS 6 and Larger: Steel pipe sleeves, PVC-pipe sleeves or Stack-sleeve fittings.

5. Interior Partitions:

a. Piping Smaller Than NPS 6: Steel pipe sleeves.
b. Piping NPS 6 and Larger: Galvanized-steel sheet sleeves.

END OF SECTION 230517

SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

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. Escutcheons.
2. Floor plates.

1.3 DEFINITIONS

A. Existing Piping to Remain: Existing piping that is not to be removed and that is not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

A. One-Piece, Steel Type: With polished, chrome-plated or polished brass finish and setscrew fastener.

B. One-Piece, Stainless-Steel Type: With polished stainless-steel finish.

C. One-Piece, Cast-Brass Type: With polished, chrome-plated or polished brass finish and setscrew fastener.

D. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped steel or brass with polished, chrome-plated finish and spring-clip fasteners.

E. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.

F. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed and exposed-rivet hinge; and spring-clip fasteners.

2.2 FLOOR PLATES

A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping and Relocated Existing Piping:

    a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
    b. Chrome-Plated Piping: One-piece steel, cast brass or split-plate steel with polished, chrome-plated finish.
    c. Insulated Piping: One-piece steel with polished, chrome-plated or polished brass finish.
    d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated or polished brass finish.
    e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated, or polished brass finish.
    f. Bare Piping in Unfinished Service Spaces: One-piece steel with polished, chrome-plated finish.
    g. Bare Piping in Equipment Rooms: One-piece steel with polished, chrome-plated finish.

2. Escutcheons for Existing Piping to Remain:

    a. Chrome-Plated Piping: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
    b. Insulated Piping: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
    c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
    d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
    e. Bare Piping in Unfinished Service Spaces: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
    f. Bare Piping in Equipment Rooms: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping and Relocated Existing Piping: Split floor plate.
2. Existing Piping to Remain: Split floor plate.

3.2 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION 230518

SECTION 230519 - METERS AND GAUGES FOR HVAC PIPING

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. Bimetallic-actuated thermometers.
2. Filled-system thermometers.
3. Liquid-in-glass thermometers.
4. Light-activated thermometers.
5. Duct-thermometer mounting brackets.
6. Thermowells.
7. Dial-type pressure gages.
8. Gage attachments.
9. Test plugs.
10. Test-plug kits.
11. Sight flow indicators.
12. Flowmeters.
13. Thermal-energy meters.

B. Related Requirements:

1. Section 232216 "Steam and Condensate Piping Specialties" for steam and condensate meters.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter and gage.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

A. Standard: ASME B40.200.

B. Case: Liquid-filled sealed type(s); stainless steel with 3-inch nominal diameter.

C. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F.

D. Connector Type(s): Union joint, adjustable angle, rigid, back or rigid, bottom, with unified-inch screw threads.

E. Connector Size: 1/2 inch, with ASME B1.1 screw threads.

F. Stem: 0.25 or 0.375 inch in diameter; stainless steel.

G. Window: Plain glass or plastic.

H. Ring: Stainless steel.

I. Element: Bimetal coil.

J. Pointer: Dark-colored metal.

K. Accuracy: Plus or minus 1.5 percent of scale range.

2.2 FILLED-SYSTEM THERMOMETERS

A. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:

1. Standard: ASME B40.200.
2. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
3. Element: Bourdon tube or other type of pressure element.
4. Movement: Mechanical, dampening type, with link to pressure element and connection to pointer.
5. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F .
6. Pointer: Dark-colored metal.
7. Window: Glass or plastic.
8. Ring: Metal.

9. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device, rigid, back and rigid, bottom; with ASME B1.1 screw threads.
10. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

11. Accuracy: Plus or minus 1 percent of scale range.

B. Direct-Mounted, Plastic-Case, Vapor-Actuated Thermometers:

1. Standard: ASME B40.200.
2. Case: Sealed type, plastic; 4-1/2-inch nominal diameter.
3. Element: Bourdon tube or other type of pressure element.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
5. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
6. Pointer: Dark-colored metal.
7. Window: Glass or plastic.
8. Ring: Metal or plastic.
9. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device, rigid, back and rigid, bottom; with ASME B1.1 screw threads.
10. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

11. Accuracy: Plus or minus 1 percent of scale range.

C. Remote-Mounted, Metal-Case, Vapor-Actuated Thermometers:

1. Standard: ASME B40.200.
2. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch nominal diameter with flange and holes for panel mounting.
3. Element: Bourdon tube or other type of pressure element.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
5. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
6. Pointer: Dark-colored metal.
7. Window: Glass or plastic.
8. Ring: Metal Stainless steel.
9. Connector Type(s): Union joint, back or bottom; with ASME B1.1 screw threads.
10. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

a. Design for Air-Duct Installation: With ventilated shroud.
b. Design for Thermowell Installation: Bare stem.

11. Accuracy: Plus or minus 1 percent of scale range.

D. Remote-Mounted, Plastic-Case, Vapor-Actuated Thermometers:

1. Standard: ASME B40.200.
2. Case: Sealed type, plastic; 4-1/2-inch nominal diameter with back or front flange and holes for panel mounting.
3. Element: Bourdon tube or other type of pressure element.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
5. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
6. Pointer: Dark-colored metal.
7. Window: Glass or plastic.
8. Ring: Metal or plastic.
9. Connector Type(s): Union joint, threaded, back or bottom; with ASME B1.1 screw threads.
10. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

a. Design for Air-Duct Installation: With ventilated shroud.
b. Design for Thermowell Installation: Bare stem.

11. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.3 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:

1. Standard: ASME B40.200.
2. Case: Cast aluminum; 6-inch nominal size.
3. Case Form: Back angle or Straight unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
6. Window: Glass or plastic.
7. Stem: Aluminum or brass and of length to suit installation.

a. Design for Air-Duct Installation: With ventilated shroud.
b. Design for Thermowell Installation: Bare stem.

8. Connector: 3/4 inch, with ASME B1.1 screw threads.
9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

B. Plastic-Case, Compact-Style, Liquid-in-Glass Thermometers:

1. Standard: ASME B40.200.
2. Case: Plastic; 6-inch nominal size.
3. Case Form: Back angle or Straight unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective with permanently etched scale markings graduated in deg F.
6. Window: Glass or plastic.
7. Stem: Aluminum or brass and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

8. Connector: 3/4 inch, with ASME B1.1 screw threads.
9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

C. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Standard: ASME B40.200.
2. Case: Cast aluminum; 7-inch nominal size unless otherwise indicated.
3. Case Form: Adjustable angle, Back angle or Straight unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
6. Window: Glass or plastic.
7. Stem: Aluminum and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

8. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

D. Plastic-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Standard: ASME B40.200.
2. Case: Plastic; 7-inch nominal size unless otherwise indicated.
3. Case Form: Adjustable angle, Back angle or Straight unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
6. Window: Glass or plastic.
7. Stem: Aluminum, brass, or stainless steel and of length to suit installation.

a. Design for Air-Duct Installation: With ventilated shroud.
b. Design for Thermowell Installation: Bare stem.

8. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.4 DUCT-THERMOMETER MOUNTING BRACKETS

A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.5 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion in piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CRES or CSA.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.6 DIAL-TYPE PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Standard: ASME B40.100.
2. Case: Liquid-filled, Sealed, Open-front, pressure relief or Solid-front, pressure relief type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: Brass, with NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic.
9. Ring: Metal.

10. Accuracy: Grade B, plus or minus 2 percent of middle half of scale range.

B. Direct-Mounted, Plastic-Case, Dial-Type Pressure Gages:

1. Standard: ASME B40.100.
2. Case: Sealed type; plastic; 4-1/2-inch nominal diameter.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: Brass, with NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic.
9. Accuracy: Grade B, plus or minus 2 percent of middle half of scale range.

C. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Standard: ASME B40.100.
2. Case: Liquid-filled Sealed type; cast aluminum or drawn steel; 4-1/2-inch nominal diameter with back or front flange and holes for panel mounting.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: Brass, with NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic.
9. Ring: Metal or Stainless steel.
10. Accuracy: Grade B, plus or minus 2 percent of middle half of scale range.

D. Remote-Mounted, Plastic-Case, Dial-Type Pressure Gages:

1. Standard: ASME B40.100.
2. Case: Sealed type; plastic; 4-1/2-inch nominal diameter with flange and holes for panel mounting.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: Brass, with NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic.
9. Accuracy: Grade B, plus or minus 2 percent of middle half of scale range.

2.7 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/2, ASME B1.20.1 pipe threads and piston or porous-metal-type surge-dampening device. Include extension for use on insulated piping.

B. Siphons: Loop-shaped section of brass, stainless-steel or steel pipe with NPS 1/2 pipe threads.

C. Valves: Brass ball or Brass or stainless-steel needle, with NPS 1/2, ASME B1.20.1 pipe threads.

2.8 TEST PLUGS

A. Description: Test-station fitting made for insertion in piping tee fitting.

B. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

C. Thread Size: NPS 1/2, ASME B1.20.1 pipe thread.

D. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

E. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

2.9 TEST-PLUG KITS

A. Furnish one test-plug kit(s) containing two thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

B. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F.

C. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F.

D. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch diameter dial and probe. Dial range shall be at least 0 to 200 psig.

E. Carrying Case: Metal or plastic, with formed instrument padding.

2.10 SIGHT FLOW INDICATORS

A. Description: Piping inline-installation device for visual verification of flow.

B. Construction: Bronze or stainless-steel body, with sight glass and ball, flapper, or paddle wheel indicator, and threaded or flanged ends.

C. Minimum Pressure Rating: 125 psig or as required.

D. Minimum Temperature Rating: 200 deg F.

E. End Connections for NPS 2 and Smaller: Threaded.

F. End Connections for NPS 2-1/2 and Larger: Flanged.

2.11 FLOWMETERS

A. Orifice Flowmeters:

1. Description: Flowmeter with sensor, hoses or tubing, fittings, valves, indicator, and conversion chart.
2. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
3. Sensor: Wafer-orifice-type, calibrated, flow-measuring element; for installation between pipe flanges.

   a. Design: Differential-pressure-type measurement for gas, oil, steam or water.
   b. Construction: Cast-iron body, brass valves with integral check valves and caps, and calibrated nameplate.
   c. Minimum Pressure Rating: 300 psig.
   d. Minimum Temperature Rating: 250 deg F.

4. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected sensor and having 6-inch diameter, or equivalent, dial with fittings and copper tubing for connecting to sensor.

   a. Scale: Gallons per minute.
   b. Accuracy: Plus or minus 1 percent between 20 and 80 percent of scale range.

B. Pitot-Tube Flowmeters:

1. Description: Flowmeter with sensor and indicator.
2. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
3. Sensor: Insertion type; for inserting probe in piping and measuring flow directly in gallons per minute.

   a. Design: Differential-pressure-type measurement for water.
   b. Construction: Stainless-steel probe of length to span inside of pipe, with integral transmitter and direct-reading scale.
   c. Minimum Pressure Rating: 150 psig.
   d. Minimum Temperature Rating: 250 deg F.

4. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
5. Integral Transformer: For low-voltage power connection.
6. Accuracy: Plus or minus 3 percent.

7. Display: Shows rate of flow, with register to indicate total volume in gallons.
8. Operating Instructions: Include complete instructions with each flowmeter.

C. Turbine Flowmeters:

1. Description: Flowmeter with sensor and indicator.
2. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
3. Sensor: Impeller turbine; for inserting in pipe fitting or for installing in piping and measuring flow directly in gallons per minute.

    a. Design: Device or pipe fitting with inline turbine and integral direct-reading scale for gas, oil, steam or water as required.
    b. Construction: Bronze or stainless-steel body, with plastic turbine or impeller.
    c. Minimum Pressure Rating: 150 psig.
    d. Minimum Temperature Rating: 180 deg F.

4. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
5. Accuracy: Plus or minus 1-1/2 percent.
6. Display: Shows rate of flow, with register to indicate total volume in gallons.
7. Operating Instructions: Include complete instructions with each flowmeter.

D. Venturi Flowmeters:

1. Description: Flowmeter with calibrated flow-measuring element, hoses or tubing, fittings, valves, indicator, and conversion chart.
2. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
3. Sensor: Venturi-type, calibrated, flow-measuring element; for installation in piping.

    a. Design: Differential-pressure-type measurement for gas, oil, steam or water as required.
    b. Construction: Bronze, brass, or factory-primed steel, with brass fittings and attached tag with flow conversion data.
    c. Minimum Pressure Rating: 250 psig.
    d. Minimum Temperature Rating: 250 deg F.
    e. End Connections for NPS 2 and Smaller: Threaded.
    f. End Connections for NPS 2-1/2 and Larger: Flanged or welded.
    g. Flow Range: Flow-measuring element and flowmeter shall cover operating range of equipment or system served.

4. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.

    a. Scale: Gallons per minute.
    b. Accuracy: Plus or minus 1 percent between 20 and 80 percent of scale range.

5. Display: Shows rate of flow, with register to indicate total volume in gallons.
6. Conversion Chart: Flow rate data compatible with sensor.
7. Operating Instructions: Include complete instructions with each flowmeter.

E. Vortex-Shedding Flowmeters:

1. Description: Flowmeter with sensor and indicator.
2. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
3. Sensor: Inline type; for installing between pipe flanges and measuring flow directly in gallons per minute.

    a. Design: Flow obstruction device, vortex-measurement type for gas, steam and liquids.
    b. Construction: Stainless-steel body, with integral transmitter and direct-reading scale.
    c. Minimum Pressure Rating: 1000 psig.
    d. Minimum Temperature Rating: 500 deg F.
    e. Integral Transformer: For low-voltage power operation.

4. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
5. Accuracy: Plus or minus 0.25 percent for liquids and 0.75 percent for gases.
6. Display: Shows rate of flow, with register to indicate total volume in gallons.
7. Operating Instructions: Include complete instructions with each flowmeter.

2.12 THERMAL-ENERGY METERS

A. Impeller-Turbine, Thermal-Energy Meters:

1. Description: System with strainer, flow sensor, temperature sensors, transmitter, indicator, and connecting wiring.
2. Flow Sensor: Impeller turbine with corrosion-resistant-metal body and transmitter; for installing in piping.

    a. Design: Total thermal-energy measurement.
    b. Minimum Pressure Rating: 150 psig.
    c. Minimum Temperature Range: 40 to 250 deg F.

3. Temperature Sensors: Insertion-type transducer.
4. Indicator: Solid-state, integrating-type meter with integral battery pack; for wall mounting.

    a. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units.
    b. Battery Pack: Five-year lithium battery.

5. Accuracy: Plus or minus 1 percent.

6. Display: Visually indicates total fluid volume in gallons and thermal-energy flow in kilowatts per hour or British thermal units.
7. Strainer: Full size of main line piping.
8. Operating Instructions: Include complete instructions with each thermal-energy meter system.

B. Ultrasonic, Thermal-Energy Meters:

1. Description: Meter with flow sensor, temperature sensors, transmitter, indicator, and connecting wiring.
2. Flow Sensor: Transit-time ultrasonic type with transmitter.
3. Temperature Sensors: Insertion-type or strap-on transducer.
4. Indicator: Solid-state, integrating-type meter with integral battery pack.

   a. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units.
   b. Battery Pack: Five-year lithium battery.

5. Accuracy: Plus or minus 1 percent.
6. Display: Visually indicates total fluid volume in gallons and thermal-energy flow in kilowatts per hour or British thermal units.
7. Operating Instructions: Include complete instructions with each thermal-energy meter system.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending one-third of pipe diameter and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

I. Install remote-mounted pressure gages on panel.

J. Install valve and snubber in piping for each pressure gage for fluids (except steam).

K. Install valve and syphon fitting in piping for each pressure gage for steam.

L. Install test plugs in piping tees.

M. Install flow indicators in piping systems in accessible positions for easy viewing.

N. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

O. Install flowmeter elements in accessible positions in piping systems.

P. Install wafer-orifice flowmeter elements between pipe flanges.

Q. Install differential-pressure-type flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.

R. Install permanent indicators on walls or brackets in accessible and readable positions.

S. Install connection fittings in accessible locations for attachment to portable indicators.

T. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

U. Install thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler.
3. Two inlets and two outlets of each chiller.
4. Inlet and outlet of each hydronic coil in air-handling units.
5. Two inlets and two outlets of each hydronic heat exchanger.
6. Inlet and outlet of each thermal-storage tank.
7. Outside-, return-, supply-, and mixed-air ducts.

V. Install pressure gages in the following locations:

1. Discharge of each pressure-reducing valve.
2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
3. Suction and discharge of each pump.

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow space for service and maintenance of meters, gages, machines, and equipment.

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

D. Connect thermal-energy meter transmitters to meters.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each hydronic zone shall be one of the following:

1. Liquid-filled Sealed, bimetallic-actuated type.
2. Direct or Remote-mounted, metal or plastic-case, vapor-actuated type.
3. Compact Industrial-style, liquid-in-glass type.
4. Direct or Remote-mounted, light-activated type.
5. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

B. Thermometers at inlet and outlet of each hydronic boiler shall be one of the following:

1. Liquid-filled Sealed, bimetallic-actuated type.
2. Direct or Remote-mounted, metal or plastic-case, vapor-actuated type.
3. Compact Industrial-style, liquid-in-glass type.
4. Direct or Remote-mounted, light-activated type.
5. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

C. Thermometers at inlets and outlets of each chiller shall be one of the following:

1. Liquid-filled Sealed, bimetallic-actuated type.
2. Direct or Remote-mounted, metal or plastic-case, vapor-actuated type.
3. Compact Industrial-style, liquid-in-glass type.
4. Direct or Remote-mounted, light-activated type.
5. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

D. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be one of the following:

1. Liquid-filled Sealed, bimetallic-actuated type.
2. Direct or Remote-mounted, metal plastic-case, vapor-actuated type.
3. Compact Industrial-style, liquid-in-glass type.
4. Direct or Remote-mounted, light-activated type.
5. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

E. Thermometers at inlets and outlets of each hydronic heat exchanger shall be one of the following:

1. Liquid-filled Sealed, bimetallic-actuated type.
2. Direct or Remote-mounted, metal or plastic-case, vapor-actuated type.
3. Compact Industrial-style, liquid-in-glass type.
4. Direct or Remote-mounted, light-activated type.
5. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

F. Thermometers at inlet and outlet of each hydronic heat-recovery unit shall be one of the following:

1. Liquid-filled Sealed, bimetallic-actuated type.
2. Direct or Remote-mounted, metal or plastic-case, vapor-actuated type.
3. Compact Industrial-style, liquid-in-glass type.
4. Direct or Remote-mounted, light-activated type.
5. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

G. Thermometers at inlet and outlet of each thermal-storage tank shall be one of the following:

1. Liquid-filled Sealed, bimetallic-actuated type.
2. Direct or Remote-mounted, metal or plastic-case, vapor-actuated type.
3. Compact Industrial-style, liquid-in-glass type.
4. Direct or Remote-mounted, light-activated type.
5. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

H. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be one of the following:

1. Liquid-filled Sealed, bimetallic-actuated type.
2. Direct or Remote-mounted, metal or plastic-case, vapor-actuated type.
3. Compact Industrial-style, liquid-in-glass type.
4. Direct or Remote-mounted, light-activated type.

I. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 100 deg F.

B. Scale Range for Condenser-Water Piping: 20 to 240 deg F.

C. Scale Range for Heating, Hot-Water Piping: 20 to 240 deg F.

D. Scale Range for Steam and Steam-Condensate Piping: 20 to 240 deg F.

E. Scale Range for Air Ducts: 0 to 250 deg F.

3.6 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each pressure-reducing valve shall be one of the following:

1. Liquid-filled Sealed Open-front, pressure-relief or Solid-front, pressure-relief, direct or remote-mounted, metal case.
2. Sealed, direct or remote-mounted, plastic case.
3. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

B. Pressure gages at inlet and outlet of each chiller chilled-water and condenser-water connection shall be one of the following:

1. Liquid-filled Sealed Open-front, pressure-relief or Solid-front, pressure-relief, direct or remote-mounted, metal case.
2. Sealed, direct or remote-mounted, plastic case.
3. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

C. Pressure gages at suction and discharge of each pump shall be one of the following:

1. Liquid-filled Sealed Open-front, pressure-relief or Solid-front, pressure-relief, direct or remote-mounted, metal case.
2. Sealed, direct or remote-mounted, plastic case.
3. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 100 psi.

B. Scale Range for Condenser-Water Piping: 0 to 100 psi.

C. Scale Range for Heating, Hot-Water Piping: 0 to 100 psi.

D. Scale Range for Steam Piping: 0 to 30 psi or 0-100 psi.

3.8 FLOWMETER SCHEDULE

A. Flowmeters for Chilled-Water Piping: Orifice, Pitot-tube, Turbine, Venturi or Vortex-shedding type.

B. Flowmeters for Condenser-Water Piping: Orifice, Pitot-tube, Turbine, Venturi or Vortex-shedding type.

C. Flowmeters for Heating, Hot-Water Piping: Orifice, Pitot-tube, Turbine, Venturi or Vortex-shedding type.

D. Flowmeters for Steam and Steam-Condensate Piping: Orifice, Turbine, Venturi or Vortex-shedding type.

3.9 THERMAL-ENERGY METER SCHEDULE

A. Thermal-Energy Meters for Chilled-Water Piping: Impeller-turbine or Ultrasonic type.

B. Thermal-Energy Meters for Condenser-Water Piping: Impeller-turbine or Ultrasonic type.

C. Thermal-Energy Meters for Heating, Hot-Water Piping: Impeller-turbine or Ultrasonic type.

D. Thermal-Energy Meters for Steam and Steam-Condensate Piping: Impeller-turbine or Ultrasonic type.

END OF SECTION 230519

SECTION 230523.11 - GLOBE VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze angle valves.
2. Bronze globe valves.
3. Iron globe valves.
4. Chainwheels.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle and globe valves closed to prevent rattling.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher-than-ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points unless specifically indicated for this purpose in manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. ASME Compliance:

1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.5 for metric flanges or iron valves.
4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
5. ASME B16.18 for cast-copper soldered fittings.
6. ASME B16.22 for wrought-copper and copper-alloy soldered fittings.
7. ASME B31.1 for power piping valves.
8. ASME B31.9 for building services piping valves.

B. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are unacceptable.

C. See HVAC valve schedule articles for applications of valves.

D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream piping unless otherwise indicated.

F. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions.

2.3 BRONZE ANGLE VALVES

A. Bronze Angle Valves, Class 125:

1. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig.
c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: PTFE.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

B. Bronze Angle Valves, Class 150:

1. Description:

    a. Standard: MSS SP-80, Type 1.
    b. CWP Rating: 300 psig.
    c. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.
    d. Ends: Threaded.
    e. Stem: Bronze.
    f. Disc: PTFE or Stainless steel.
    g. Packing: Asbestos free.
    h. Handwheel: Malleable iron, bronze, or aluminum.

2.4 BRONZE GLOBE VALVES

A. Bronze Globe Valves, Class 125:

1. Description:

    a. Standard: MSS SP-80, Type 1.
    b. CWP Rating: 200 psig.
    c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
    d. Ends: Threaded or solder joint.
    e. Stem: Bronze.
    f. Disc: PTFE.
    g. Packing: Asbestos free.
    h. Handwheel: Malleable iron, bronze, or aluminum.

B. Bronze Globe Valves, Class 150:

1. Description:

    a. Standard: MSS SP-80, Type 2.
    b. CWP Rating: 300 psig.
    c. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.
    d. Ends: Threaded.
    e. Stem: Bronze.
    f. Disc: PTFE or Stainless steel.
    g. Packing: Asbestos free.
    h. Handwheel: Malleable iron, bronze, or aluminum.

2.5 IRON GLOBE VALVES

A. Iron Globe Valves, Class 125:

1. Description:

a. Standard: MSS SP-85, Type I.
b. CWP Rating: 200 psig.
c. Body Material: ASTM A126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: Bronze.
f. Packing and Gasket: Asbestos free.
g. Operator: Handwheel or chainwheel.

B. Iron Globe Valves, Class 250:

1. Description:

a. Standard: MSS SP-85, Type I.
b. CWP Rating: 500 psig.
c. Body Material: ASTM A126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: Bronze.
f. Packing and Gasket: Asbestos free.
g. Operator: Handwheel or chainwheel.

2.6 CHAINWHEELS

A. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to handwheels.

1. Sprocket Rim with Chain Guides: Ductile or cast iron, Aluminum or Bronze, of type and size required for valve. Include zinc or epoxy coating.
2. Chain: Hot-dip-galvanized steel, Brass or Stainless steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves. Remove defective valves from site.

3.2 INSTALLATION OF VALVES

A. Install valves with unions or flanges at each piece of equipment arranged to allow space for service, maintenance, and equipment removal without system shutdown.

B. Provide support of piping adjacent to valves such that no force is imposed on valves.

C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.

D. Install valves so that stems are horizontal or slope upward from centerline of pipe.

E. Install valves in position that does not project into aisles or block access to other equipment.

F. Install valves in position to allow full stem and manual operator movement.

G. Verify that joints of each valve have been properly installed and sealed to ensure that there is no leakage or damage.

H. Install chainwheels on manual operators for globe valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

I. Install valve tags. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

J. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve manufacturer's recommended maximum.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

B. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.

3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.5 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze angle or globe valves, Class 125 or Class 150, bronze or PTFE disc, with soldered or threaded ends.

B. Pipe NPS 2-1/2 and Larger: Iron globe valves, Class 125 or Class 250, with flanged ends.

3.6 CONDENSER-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze angle or globe valves, Class 125 or Class 150, with bronze or PTFE disc and soldered or threaded ends.

B. Pipe NPS 2-1/2 and Larger: Iron globe valves, Class 125 or Class 250, with flanged ends.

3.7 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze angle or globe valves, Class 125 or Class 150, with bronze or PTFE disc, and soldered or threaded ends.

B. Pipe NPS 2-1/2 and Larger: Iron globe valves, Class 125 or Class 250, with flanged ends.

3.8 LOW-PRESSURE STEAM VALVE SCHEDULE - 15 PSIG OR LESS

A. Pipe NPS 2 and Smaller: Bronze angle or globe valves, Class 125 or Class 150, bronze or PTFE disc, and soldered or threaded ends.

B. Pipe NPS 2-1/2 and Larger: Iron globe valves, Class 125 or Class 250, with flanged ends.

3.9 HIGH-PRESSURE STEAM VALVE SCHEDULE - MORE THAN 15 PSIG

A. Pipe NPS 2 and Smaller: Bronze angle or globe valves, Class 125 or Class 150, with bronze or PTFE disc and soldered or threaded ends.

B. Pipe Sizes NPS 2-1/2 and Larger: Iron globe valves, Class 125 or Class 250.

3.10 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze angle or globe valves, Class 125 or Class 150, with bronze or PTFE disc, and with soldered or threaded ends.

B. Pipe NPS 2-1/2 and Larger: Iron globe valves, Class 125 or Class 250.

END OF SECTION 230523.11

SECTION 230523.12 - BALL VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Brass ball valves.
2. Bronze ball valves.
3. Steel ball valves.
4. Iron ball valves.
5. Stainless steel ball valves.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. RPTFE: Reinforced polytetrafluoroethylene.

C. SWP: Steam working pressure.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, and weld ends.
3. Set ball valves open to minimize exposure of functional surfaces.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. ASME Compliance:

1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.5 for flanges on steel valves.
4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
5. ASME B16.18 for cast copper solder-joint connections.
6. ASME B16.22 for wrought copper and copper alloy solder-joint connections.
7. ASME B16.34 for flanged and threaded end connections.
8. ASME B31.1 for power piping valves.
9. ASME B31.9 for building services piping valves.

B. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

C. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

D. Valve Sizes: Same as upstream piping unless otherwise indicated.

E. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 4 and larger.
2. Hand Lever: For quarter-turn valves smaller than NPS 4.

F. Valves in Insulated Piping:

1. Provide 2-inch extended neck stems.
2. Extended operating handles with nonthermal-conductive covering material, and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.3 BRASS BALL VALVES

A. Brass Ball Valves, One Piece:

1. Standard: MSS SP-110.
2. CWP Rating: 400 psig.
3. Body Design: One piece.
4. Body Material: Forged brass.
5. Ends: Threaded.
6. Seats: PTFE.
7. Stem: Brass.
8. Ball: Chrome-plated brass.
9. Port: Reduced.

B. Brass Ball Valves, Two Piece with Full Port and Brass Trim, Threaded or Soldered Ends:

1. Standard: MSS SP-110.
2. SWP Rating: 150 psig.
3. CWP Rating: 600 psig.
4. Body Design: Two piece.
5. Body Material: Forged brass.
6. Ends: Threaded or soldered.
7. Seats: PTFE.
8. Stem: Brass.
9. Ball: Chrome-plated brass.
10. Port: Full.

C. Brass Ball Valves, Two Piece with Full Port and Brass Trim, Press Ends:

1. Standard: MSS SP-110; IAPMO/ANSI Z1157.
2. CWP Rating: 600 psig.
3. Body Design: Two piece.
4. Body Material: Forged brass.
5. Ends: Press.
6. Seats: PTFE or RPTFE.
7. Stem: Brass.
8. Ball: Chrome-plated brass.
9. Port: Full.
10. O-Ring Seal: Buna-N or EPDM.

D. Brass Ball Valves, Two Piece with Full Port and Stainless Steel Trim, Threaded Ends or Soldered Ends:

1. Standard: MSS SP-110.
2. SWP Rating: 150 psig.
3. CWP Rating: 600 psig.
4. Body Design: Two piece.
5. Body Material: Forged brass.
6. Ends: Threaded or soldered.
7. Seats: PTFE.
8. Stem: Stainless steel.

9. Ball: Stainless steel, vented.
10. Port: Full.

E. Brass Ball Valves, Two Piece with Full Port and Stainless Steel Trim, Press Ends:

1. Standard: MSS SP-110; IAPMO/ANSI Z1157.
2. CWP Rating: Minimum 200 psig.
3. Body Design: Two piece.
4. Body Material: Forged brass.
5. Ends: Press.
6. Press-End Connections Rating: Minimum 200 psig.
7. Seats: PTFE or RPTFE.
8. Stem: Stainless steel.
9. Ball: Stainless steel, vented.
10. Port: Full.
11. O-Ring Seal: Buna-N or EPDM.

F. Brass Ball Valves, Two Piece with Regular Port and Brass Trim, Threaded or Soldered Ends:

1. Standard: MSS SP-110.
2. SWP Rating: 150 psig.
3. CWP Rating: 600 psig.
4. Body Design: Two piece.
5. Body Material: Forged brass.
6. Ends: Threaded or soldered.
7. Seats: PTFE.
8. Stem: Brass.
9. Ball: Chrome-plated brass.
10. Port: Regular.

G. Brass Ball Valves, Two Piece with Regular Port and Stainless Steel Trim, Threaded or Soldered Ends:

1. Standard: MSS SP-110.
2. SWP Rating: 150 psig.
3. CWP Rating: 600 psig.
4. Body Design: Two piece.
5. Body Material: Brass or bronze.
6. Ends: Threaded or soldered.
7. Seats: PTFE.
8. Stem: Stainless steel.
9. Ball: Stainless steel, vented.
10. Port: Regular.

H. Brass Ball Valves, Three Piece with Full Port and Brass Trim, Threaded or Soldered Ends:

1. Standard: MSS SP-110.
2. SWP Rating: 150 psig.
3. CWP Rating: 600 psig.
4. Body Design: Three piece.
5. Body Material: Forged brass.
6. Ends: Threaded or soldered ends.
7. Seats: PTFE.
8. Stem: Brass.
9. Ball: Chrome-plated brass.
10. Port: Full.

I. Brass Ball Valves, Three Piece with Full Port and Stainless Steel Trim, Threaded or Soldered Ends:

1. Standard: MSS SP-110.
2. SWP Rating: 150 psig.
3. CWP Rating: 600 psig.
4. Body Design: Three piece.
5. Body Material: Forged brass.
6. Ends: Threaded or soldered.
7. Seats: PTFE.
8. Stem: Stainless steel.
9. Ball: Stainless steel, vented.
10. Port: Full.

2.4 BRONZE BALL VALVES

A. Bronze Ball Valves, One Piece with Bronze Trim, Threaded Ends:

1. Standard: MSS SP-110.
2. CWP Rating: 400 psig.
3. Body Design: One piece.
4. Body Material: Bronze.
5. Ends: Threaded.
6. Seats: PTFE.
7. Stem: Bronze.
8. Ball: Chrome-plated brass.
9. Port: Reduced.

B. Bronze Ball Valves, One Piece with Stainless Steel Trim, Threaded Ends:

1. Standard: MSS SP-110.
2. CWP Rating: 600 psig.
3. Body Design: One piece.
4. Body Material: Bronze.
5. Ends: Threaded.

6. Seats: PTFE.
7. Stem: Stainless steel.
8. Ball: Stainless steel, vented.
9. Port: Reduced.

C. Bronze Ball Valves, Two Piece with Full Port and Bronze or Brass Trim, Threaded or Soldered Ends:

1. Standard: MSS SP-110.
2. SWP Rating: 150 psig.
3. CWP Rating: 600 psig.
4. Body Design: Two piece.
5. Body Material: Bronze.
6. Ends: Threaded or soldered.
7. Seats: PTFE.
8. Stem: Bronze.
9. Ball: Chrome-plated brass.
10. Port: Full.

D. Bronze Ball Valves, Two Piece with Full Port, and Bronze or Brass Trim, Press Ends:

1. Standard: MSS SP-110; IAPMO/ANSI Z1157.
2. CWP Rating: Minimum 200 psig.
3. Body Design: Two piece.
4. Body Material: Bronze.
5. Ends: Press.
6. Press-End Connections Rating: Minimum 200 psig.
7. Seats: PTFE or RTPFE.
8. Stem: Bronze or brass.
9. Ball: Chrome-plated brass.
10. Port: Full.
11. O-Ring Seal: EPDM or Buna-N.

E. Bronze Ball Valves, Two Piece with Full Port and Stainless Steel Trim, Threaded or Soldered Ends:

1. Standard: MSS SP-110.
2. SWP Rating: 150 psig.
3. CWP Rating: 600 psig.
4. Body Design: Two piece.
5. Body Material: Bronze.
6. Ends: Threaded or soldered.
7. Seats: PTFE.
8. Stem: Stainless steel.
9. Ball: Stainless steel, vented.
10. Port: Full.

F. Bronze Ball Valves, Two Piece with Regular Port and Bronze or Brass Trim, Threaded Ends:

1. Standard: MSS SP-110.
2. SWP Rating: 150 psig.
3. CWP Rating: 600 psig.
4. Body Design: Two piece.
5. Body Material: Bronze.
6. Ends: Threaded.
7. Seats: PTFE.
8. Stem: Bronze.
9. Ball: Chrome-plated brass.
10. Port: Regular.

G. Bronze Ball Valves, Two Piece with Regular Port and Stainless Steel Trim, Threaded Ends:

1. Standard: MSS SP-110.
2. SWP Rating: 150 psig.
3. CWP Rating: 600 psig.
4. Body Design: Two piece.
5. Body Material: Bronze.
6. Ends: Threaded.
7. Seats: PTFE.
8. Stem: Stainless steel.
9. Ball: Stainless steel, vented.
10. Port: Regular.

H. Bronze Ball Valves, Three Piece with Full Port and Bronze or Brass Trim, Threaded Ends:

1. Standard: MSS SP-110.
2. SWP Rating: 150 psig.
3. CWP Rating: 600 psig.
4. Body Design: Three piece.
5. Body Material: Bronze.
6. Ends: Threaded.
7. Seats: PTFE.
8. Stem: Bronze.
9. Ball: Chrome-plated brass.
10. Port: Full.

I. Bronze Ball Valves, Three Piece with Full Port Stainless Steel Trim, Threaded Ends:

1. Standard: MSS SP-110.
2. SWP Rating: 150 psig.
3. CWP Rating: 600 psig.
4. Body Design: Three piece.
5. Body Material: Bronze.

6. Ends: Threaded.
7. Seats: PTFE.
8. Stem: Stainless steel.
9. Ball: Stainless steel, vented.
10. Port: Full.

J. Bronze Ball Valves, Three Piece with Regular Port and Bronze or Brass Trim, Threaded or Soldered Ends:

1. Standard: MSS SP-110; MSS SP-145.
2. CWP Rating: 600 psig.
3. Body Design: Three piece.
4. Body Material: Bronze.
5. Ends: Threaded.
6. Seats: PTFE.
7. Stem: Bronze.
8. Ball: Chrome-plated brass.
9. Port: Regular.

K. Bronze Ball Valves, Three Piece with Regular Port, and Stainless Steel Trim, Threaded or Soldered Ends:

1. Standard: MSS SP-110.
2. SWP Rating: 150 psig.
3. CWP Rating: 600 psig.
4. Body Design: Three piece.
5. Body Material: Bronze.
6. Ends: Threaded or soldered.
7. Seats: PTFE.
8. Stem: Stainless steel.
9. Ball: Stainless steel, vented.
10. Port: Regular.

2.5 STEEL BALL VALVES

A. Steel Ball Valves with Full Port and Stainless Steel Trim, Class 150:

1. Standard: MSS SP-72.
2. CWP Rating: 285 psig.
3. Body Design: Split body.
4. Body Material: Carbon steel, ASTM A216/A216M, Type WCB.
5. Ends: Flanged.
6. Seats: PTFE.
7. Stem: Stainless steel.
8. Ball: Stainless steel, vented.
9. Port: Full.

B. Steel Ball Valves with Full Port and Stainless Steel Trim, Class 300:

1. Standard: MSS SP-72.
2. CWP Rating: 720 psig.
3. Body Design: Split body.
4. Body Material: Carbon steel, ASTM A216/A216M, Type WCB.
5. Ends: Flanged.
6. Seats: PTFE.
7. Stem: Stainless steel.
8. Ball: Stainless steel, vented.
9. Port: Full.

2.6 IRON BALL VALVES

A. Iron Ball Valves, Class 125:

1. Standard: MSS SP-72.
2. CWP Rating: 200 psig.
3. Body Design: Split body.
4. Body Material: ASTM A126, gray iron.
5. Ends: Flanged.
6. Seats: PTFE.
7. Stem: Stainless steel.
8. Ball: Stainless steel.
9. Port: Full.

2.7 STAINLESS STEEL BALL VALVES

A. Stainless Steel Ball Valves, Two Piece with Full Port, Threaded or Flanged Ends:

1. Standard: MSS SP-110.
2. CWP Rating: 200 psig.
3. Body Design: Split body.
4. Body Material: Type 316 stainless steel.
5. Ends: Threaded or flanged.
6. Seats: PTFE.
7. Stem: Type 316 stainless steel.
8. Ball: Type 316 stainless steel.
9. Port: Full.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves. Remove defective valves from site.

3.2 INSTALLATION OF VALVES

A. Install valves with unions or flanges at each piece of equipment arranged to allow space for service, maintenance, and equipment removal without system shutdown.

B. Provide support of piping adjacent to valves such that no force is imposed upon valves.

C. Locate valves for easy access.

D. Install valves in horizontal piping with stem at or above center of pipe.

E. Install valves in position to allow full valve actuation movement.

F. Valve Tags: Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

G. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve manufacturer's recommended maximum.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves exhibiting leakage.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified SWP classes or CWP ratings are unavailable, provide the same types of valves with higher SWP classes or CWP ratings.

B. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option or press-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.
7. For Stainless Steel Piping, NPS 2 and Smaller: Threaded ends.
8. For Stainless Steel Piping,NPS 2-1/2 to NPS 4: Flanged ends.

3.5 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Brass or bronze ball valves, one, two or three piece, with brass, bronze or stainless steel trim, full, regular or reduced port as required by flow requirements, and threaded, solder or press-connection-joint ends.

1. Valves may be provided with solder-joint ends instead of threaded ends.

B. Pipe NPS 2-1/2 and Larger:

1. Iron ball valves, Class 125.

    a. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.

2. Steel ball valves, Class 150.

3.6 CONDENSER-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Brass or bronze ball valves, one, two or three piece with brass, bronze or stainless steel trim, full, regular or reduced port as required by flow requirements, and threaded, solder or press-connection-joint ends.

1. Valves may be provided with solder-joint ends instead of threaded ends.

B. Pipe NPS 2-1/2 and Larger:

1. Iron ball valves, Class 125.

a. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.

2. Steel ball valves, Class 150.

3.7 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Brass or bronze ball valves, one, two or three piece with brass, bronze or stainless steel trim, full, regular or reduced port as required by flow requirements, and threaded, solder or press-connection-joint ends.

B. Pipe NPS 2-1/2 and Larger:

1. Iron ball valves, Class 125.

a. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.

2. Steel ball valves, Class 150.

3.8 LOW-PRESSURE STEAM VALVE SCHEDULE - 15 PSIG OR LESS

A. Pipe NPS 2 and Smaller: Brass or bronze ball valves, one, two or three piece, with brass, bronze or stainless steel trim, full, regular or reduced port as required by flow requirements, and threaded connection.

B. Pipe NPS 2-1/2 and Larger:

1. Iron ball valves, Class 125.

a. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.

2. Steel ball valves, Class 150.

3.9 LOW-PRESSURE CLEAN STEAM VALVE SCHEDULE - 15 PSIG OR LESS

A. Pipe NPS 2 and Smaller: Stainless steel ball valves, two piece with full port, and threaded ends.

B. Pipe NPS 2-1/2 and Larger: Stainless steel ball valves, two piece with full port, and flanged ends.

3.10 HIGH-PRESSURE STEAM VALVE SCHEDULE - MORE THAN 15 PSIG

A. Pipe NPS 2 and Smaller: Brass or bronze ball valves, one, two or three piece with brass, bronze or stainless steel trim, full, regular or reduced port as required by flow requirements, and threaded connection.

B. Pipe NPS 2-1/2 and Larger:

1. Iron ball valves, Class 125.

a. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.

2. Steel ball valves, Class 300.

3.11 HIGH-PRESSURE CLEAN STEAM VALVE SCHEDULE - MORE THAN 15 PSIG

A. Pipe NPS 2 and Smaller: Stainless steel ball valves, two piece with full port, and threaded ends.

B. Pipe NPS 2-1/2 and Larger: Stainless steel ball valves, two piece with full port, and flanged ends.

3.12 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Brass or bronze ball valves, one, two or three piece with brass, bronze or stainless steel trim, full, regular or reduced port as required by flow requirements, and threaded connection.

B. Pipe NPS 2-1/2 and Larger:

1. Iron ball valves, Class 125.

a. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.

2. Steel ball valves, Class 300.

3.13 CLEAN STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Stainless steel ball valves, two piece with full port, and threaded ends.

B. Pipe NPS 2-1/2 and Larger: Stainless steel ball valves, two piece with full port, and flanged ends.

END OF SECTION 230523.12

SECTION 230523.13 - BUTTERFLY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Iron, single-flange (lug-type) butterfly valves.
2. Iron, flangeless (wafer-type) butterfly valves.
3. Ductile-iron, grooved-end butterfly valves.
4. High-performance butterfly valves.
5. Chainwheels.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: ABS, Buna-N, or nitrile butadiene rubber.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set butterfly valves closed or slightly open.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. ASME Compliance:

1. ASME B16.1 for flanges on iron valves.
2. ASME B16.5 for flanges on steel valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B31.1 for power piping valves.
5. ASME B31.9 for building services valves.

B. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

C. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

D. Valve Sizes: Same as upstream piping unless otherwise indicated.

E. Valve Actuator Types:

1. Gear Actuator: For valves NPS 8 and larger.
2. Hand Lever: For valves NPS 6 and smaller.
3. Chainwheel: Device for attachment to gear, stem, or other actuator of size and with chain for mounting height, according to "Installation of Valves" Article.

F. Valves in Insulated Piping: Provide with 2-inch extended neck stems.

2.3 IRON, SINGLE-FLANGE (LUG-TYPE) BUTTERFLY VALVES

A. Iron, Single-Flange (Lug-Type) Butterfly Valves with Aluminum-Bronze Disc:

1. Standard: MSS SP-67, Type I.
2. CWP Rating: 150 psig or as required.
3. Body Design: Single flange (lug type), suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
4. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
5. Seat: EPDM or NBR.
6. Stem: One- or two-piece stainless steel.
7. Disc: Aluminum bronze.

B. Iron, Single-Flange (Lug-Type) Butterfly Valves with Ductile-Iron Disc:

1. Standard: MSS SP-67, Type I.
2. CWP Rating: 150 psig or as required.
3. Body Design: Single flange (lug type), suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
4. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
5. Seat: EPDM or NBR.
6. Stem: One- or two-piece stainless steel.
7. Disc: Nickel-plated or -coated ductile iron.

C. Iron, Single-Flange (Lug-Type) Butterfly Valves with Stainless Steel Disc:

1. Standard: MSS SP-67, Type I.
2. CWP Rating: 150 psig or as required.
3. Body Design: Single flange (lug type), suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
4. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
5. Seat: EPDM or NBR.
6. Stem: One- or two-piece stainless steel.
7. Disc: Stainless steel.

2.4 IRON, FLANGELESS (WAFER-TYPE) BUTTERFLY VALVES

A. Iron, Flangeless (Wafer-Type) Butterfly Valves with Aluminum-Bronze Disc:

1. Standard: MSS SP-67, Type I.
2. CWP Rating: 150 psig or as required.
3. Body Design: Flangeless (wafer type), suitable for bidirectional dead-end service at rated pressure.
4. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
5. Seat: EPDM or NBR.
6. Stem: One- or two-piece stainless steel.
7. Disc: Aluminum bronze.

B. Iron, Flangeless (Wafer-Type) Butterfly Valves with Ductile-Iron Disc:

1. Standard: MSS SP-67, Type I.
2. CWP Rating: 150 psig or as required.
3. Body Design: Flangeless (wafer type), suitable for bidirectional dead-end service at rated pressure.
4. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
5. Seat: EPDM or NBR.
6. Stem: One- or two-piece stainless steel.
7. Disc: Nickel-plated or -coated ductile iron.

C. Iron, Flangeless (Wafer-Type) Butterfly Valves with Stainless Steel Disc:

1. Standard: MSS SP-67, Type I.
2. CWP Rating: 150 psig or as required.
3. Body Design: Flangeless (wafer type), suitable for bidirectional dead-end service at rated pressure.
4. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
5. Seat: EPDM or NBR.
6. Stem: One- or two-piece stainless steel.
7. Disc: Stainless steel.

2.5 DUCTILE-IRON, GROOVED-END BUTTERFLY VALVES

A. Ductile-Iron, Grooved-End Butterfly Valves, 175 CWP:

1. Standard: MSS SP-67, Type I.
2. CWP Rating: 175 psig.
3. Body Material: Coated, ductile iron.
4. Stem: Two-piece stainless steel.
5. Disc: Coated, ductile iron.
6. Seal: EPDM.

B. Ductile-Iron, Grooved-End Butterfly Valves, 300 CWP:

1. Standard: MSS SP-67, Type I.
2. NPS 8 and Smaller CWP Rating: 300 psig.
3. NPS 10 and Larger CWP Rating: 200 psig.
4. Body Material: Coated, ductile iron.
5. Stem: Two-piece stainless steel.
6. Disc: Coated, ductile iron.
7. Seal: EPDM.

2.6 HIGH-PERFORMANCE BUTTERFLY VALVES

A. Single-Flange (Lug-Type), High-Performance Butterfly Valves, Class 150:

1. Standard: MSS SP-68.
2. CWP Rating: 285 psig at 100 deg F.
3. Body Design: Single flange (lug type), suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
4. Body Material: Carbon or stainless steel.
5. Seat: Reinforced PTFE or metal.
6. Stem: Stainless steel; offset from seat plane.
7. Disc: Type 316 stainless steel.
8. Service: Bidirectional.

B. Single-Flange (Lug-Type) High-Performance Butterfly Valves, Class 300:

1. Standard: MSS SP-68.
2. CWP Rating: 720 psig at 100 deg F.
3. Body Design: Single flange (lug type), suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
4. Body Material: Carbon or stainless steel.
5. Seat: Reinforced PTFE or metal.
6. Stem: Stainless steel; offset from seat plane.
7. Disc: Type 316 stainless steel.
8. Service: Bidirectional.

2.7 CHAINWHEELS

A. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to hand wheels.

1. Sprocket Rim with Chain Guides: Ductile or cast iron, Aluminum or Bronze, of type and size required for valve. Include zinc or epoxy coating.
2. Chain: Hot-dip, galvanized steel, Brass or Stainless steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine mating flange faces for damage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

D. Do not attempt to repair defective valves; replace with new valves. Remove defective valves from site.

3.2 INSTALLATION OF VALVES

A. Install valves with unions or flanges at each piece of equipment arranged to allow space for service, maintenance, and equipment removal without system shutdown.

B. Provide support of piping adjacent to valves such that no force is imposed upon valves.

C. Locate valves for easy access.

D. Install valves in horizontal piping with stem at or above center of pipe.

E. Install valves in position to allow full valve actuation movement.

F. Install chainwheels on manual actuators for butterfly valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

G. Valve Tags: Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service, but before final adjusting and balancing. If leakage cannot be repaired, replace valve.

3.4 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2-1/2 and Larger:

1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: Aluminum-bronze, Ductile-iron or Stainless steel disc, 200 CWP, and EPDM or NBR seat.
2. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: Aluminum-bronze, Ductile-iron or Stainless steel disc, 150 CWP, and EPDM or NBR seat.
3. Ductile-Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 175 or as required CWP.
4. High-Performance Butterfly Valves: Single flange, carbon-steel body, and Class 150 or as required.

3.5 CONDENSER-WATER VALVE SCHEDULE

A. Pipe NPS 2-1/2 and Larger:

1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: Aluminum-bronze, Ductile-iron or Stainless steel disc, 200 CWP, and EPDM or NBR seat.
2. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: Aluminum-bronze, Ductile-iron or Stainless steel disc, 150 CWP, and EPDM or NBR seat.
3. Ductile-Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 175 or as required CWP.
4. High-Performance Butterfly Valves: Single flange, carbon-steel body, and Class 150 or as required.

3.6 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2-1/2 and Larger:

1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: Aluminum-bronze, Ductile-iron or Stainless steel disc, 200 CWP, and EPDM or NBR seat.
2. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: Aluminum-bronze, Ductile-iron or Stainless steel disc, 150 CWP, and EPDM or NBR seat.
3. Ductile-Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 175 or as required CWP.
4. High-Performance Butterfly Valves: Single flange, carbon-steel body, and Class 150 or as required.

3.7 LOW-PRESSURE STEAM VALVE SCHEDULE - 15 PSIG OR LESS

A. Pipe NPS 2-1/2 and Larger: High-performance butterfly valves, single flange (lug type), carbon-steel body, and Class 150 or as required.

3.8 LOW-PRESSURE CLEAN STEAM VALVE SCHEDULE - 15 PSIG OR LESS

A. Pipe NPS 2-1/2 and Larger: High-performance butterfly valves, single flange (lug type), carbon-steel or stainless steel body, and Class 150 or as required.

3.9 HIGH-PRESSURE STEAM VALVE SCHEDULE - MORE THAN 15 PSIG

A. Pipe NPS 2-1/2 and Larger: High-performance butterfly valves, single flange (lug type), carbon-steel body, and Class 150 Class 300.

3.10 HIGH-PRESSURE CLEAN STEAM VALVE SCHEDULE - MORE THAN 15 PSIG

A. Pipe NPS 2-1/2 and Larger: High-performance butterfly valves, single flange (lug type), carbon-steel or stainless steel body, and Class 150 or as required.

3.11 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2-1/2 and Larger: High-performance butterfly valves, single flange (lug type), carbon-steel body, and Class 150 or as required.

3.12 CLEAN-STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2-1/2 and Larger: High-performance butterfly valves, single flange (lug type), carbon-steel or stainless steel body, and Class 150 or as required.

END OF SECTION 230523.13

SECTION 230523.14 - CHECK VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze lift check valves.
2. Bronze swing check valves.
3. Iron swing check valves.
4. Iron swing check valves with closure control.
5. Iron, grooved-end swing check valves.
6. Iron, center-guided check valves.
7. Iron, plate-type check valves.
8. Plastic check valves.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene-propylene-diene monomer.

C. NBR: Nitrile butadiene rubber (also known as "Buna-N").

D. SWP: Steam working pressure.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, press connections, and weld ends.
3. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use stems or other components as lifting or rigging points unless specifically indicated for this purpose in manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. ASME Compliance:

1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.5 for flanges for metric standard piping.
4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
5. ASME B16.18 for cast copper solder joint.
6. ASME B16.22 for wrought copper solder joint.
7. ASME B16.51 for press joint.
8. ASME B31.1 for power piping valves.
9. ASME B31.9 for building services piping valves.

B. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

C. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are unacceptable.

D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream piping unless otherwise indicated.

F. Valve Bypass and Drain Connections: MSS SP-45.

2.3 BRONZE LIFT CHECK VALVES

A. Bronze Lift Check Valves with Bronze Disc, Class 125:

1. Description:

   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig.
   c. Body Design: Vertical flow.
   d. Body Material: ASTM B61 or ASTM B62, bronze.

e. Ends: Threaded.
f. Disc: Bronze.

B. Bronze Lift Check Valves with Nonmetallic Disc, Class 125:

1. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 200 psig.
c. Body Design: Vertical flow.
d. Body Material: ASTM B61 or ASTM B62, bronze.
e. Ends: Threaded.
f. Disc: NBR or PTFE.

2.4 BRONZE SWING CHECK VALVES

A. Bronze Swing Check Valves with Bronze Disc, Class 125:

1. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

B. Bronze Swing Check Valves with Nonmetallic Disc, Class 125:

1. Description:

a. Standard: MSS SP-80, Type 4.
b. CWP Rating: 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B62, bronze.
e. Ends: Threaded.
f. Disc: PTFE.

C. Bronze Swing Check Valves with Bronze Disc, Class 150:

1. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 300 psig.
c. Body Design: Horizontal flow.

d. Body Material: ASTM B62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

D. Bronze Swing Check Valves with Nonmetallic Disc, Class 150:

1. Description:

a. Standard: MSS SP-80, Type 4.
b. CWP Rating: 300 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B62, bronze.
e. Ends: Threaded.
f. Disc: PTFE.

E. Bronze Swing Check Valves, Press Ends:

1. Description:

a. Standard: MSS SP-80.
b. CWP Rating: Minimum 200 psig.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B584, bronze.
e. Ends: Press.
f. Press Ends Connection Rating: Minimum 200 psig
g. Disc: Brass or bronze.

2.5 IRON SWING CHECK VALVES

A. Iron Swing Check Valves with Metal Seats, Class 125:

1. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.

B. Iron Swing Check Valves with Nonmetallic-to-Metal Seats, Class 125:

1. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Composition.
h. Seat Ring: Bronze.
i. Disc Holder: Bronze.
j. Disc: PTFE.
k. Gasket: Asbestos free.

C. Iron Swing Check Valves with Metal Seats, Class 250:

1. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.

2.6 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Iron Swing Check Valves with Lever- and Spring-Closure Control, Class 125:

1. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.
i. Closure Control: Factory-installed, exterior lever and spring.

B. Iron Swing Check Valves with Lever and Weight-Closure Control, Class 125:

1. Description:

a. Standard: MSS SP-71, Type I.

b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.
i. Closure Control: Factory-installed, exterior lever and weight.

2.7 IRON, GROOVED-END SWING CHECK VALVES

A. Iron, Grooved-End Swing Check Valves, 300 CWP:

1. Description:

a. CWP Rating: 300 psig.
b. Body Material: ASTM A536, ductile iron.
c. Seal: EPDM.
d. Disc: Spring-operated, ductile iron or stainless steel.

2.8 IRON, CENTER-GUIDED CHECK VALVES

A. Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat, Class 125:

1. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A126, gray iron.
e. Style: Compact wafer.
f. Seat: Bronze.

B. Iron, Globe, Center-Guided Check Valves with Metal Seat, Class 125:

1. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A126, gray iron.
e. Style: Globe, spring loaded.
f. Ends: Flanged.
g. Seat: Bronze.

C. Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat, Class 150:

1. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
c. NPS 14 to NPS 24, CWP Rating: 250 psig.
d. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
e. Style: Compact wafer.
f. Seat: Bronze.

D. Iron, Globe, Center-Guided Check Valves with Metal Seat, Class 150:

1. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
c. NPS 14 to NPS 24, CWP Rating: 250 psig.
d. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
e. Style: Globe, spring loaded.
f. Ends: Flanged.
g. Seat: Bronze.

E. Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat, Class 250:

1. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Material: ASTM A126, gray iron.
e. Style: Compact wafer, spring loaded.
f. Seat: Bronze.

F. Iron, Globe, Center-Guided Check Valves with Metal Seat, Class 250:

1. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Material: ASTM A126, gray iron.
e. Style: Globe, spring loaded.
f. Ends: Flanged.
g. Seat: Bronze.

G. Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat, Class 300:

1. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 400 psig.
d. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
e. Style: Compact wafer, spring loaded.
f. Seat: Bronze.

H. Iron, Globe, Center-Guided Check Valves with Metal Seat, Class 300:

1. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 400 psig.
d. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
e. Style: Globe, spring loaded.
f. Ends: Flanged.
g. Seat: Bronze.

I. Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat, Class 125:

1. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A126, gray iron.
e. Style: Compact wafer.
f. Seat: EPDM or NBR.

J. Iron, Globe, Center-Guided Check Valves with Resilient Seat, Class 125:

1. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A126, gray iron.
e. Style: Globe, spring loaded.
f. Ends: Flanged.
g. Seat: EPDM or NBR.

K. Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat, Class 150:

1. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
c. NPS 14 to NPS 24, CWP Rating: 250 psig.
d. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
e. Style: Compact wafer.
f. Seat: EPDM or NBR.

L. Iron, Globe, Center-Guided Check Valves with Resilient Seat, Class 150:

1. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
c. NPS 14 to NPS 24, CWP Rating: 250 psig.
d. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
e. Style: Globe, spring loaded.
f. Ends: Flanged.
g. Seat: EPDM or NBR.

M. Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat, Class 250:

1. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Material: ASTM A126, gray iron.
e. Style: Compact wafer, spring loaded.
f. Seat: EPDM or NBR.

N. Iron, Globe, Center-Guided Check Valves with Resilient Seat, Class 250:

1. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Material: ASTM A126, gray iron.
e. Style: Globe, spring loaded.
f. Ends: Flanged.
g. Seat: EPDM or NBR.

O. Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat, Class 300:

1. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 400 psig.
d. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
e. Style: Compact wafer, spring loaded.
f. Seat: EPDM or NBR.

P. Iron, Globe, Center-Guided Check Valves with Resilient Seat, Class 300:

1. Description:

a. Standard: MSS SP-125.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 400 psig.
d. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
e. Style: Globe, spring loaded.
f. Ends: Flanged.
g. Seat: EPDM or NBR.

2.9 IRON, PLATE-TYPE CHECK VALVES

A. Iron, Dual-Plate Check Valves with Metal Seat, Class 125:

1. Description:

a. Standard: API 594.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Design: Wafer, spring-loaded plates.
e. Body Material: ASTM A126, gray iron.
f. Seat: Bronze.

B. Iron, Dual-Plate Check Valves with Metal Seat, Class 150:

1. Description:

a. Standard: API 594.
b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
c. NPS 14 to NPS 24, CWP Rating: 250 psig.
d. Body Design: Wafer, spring-loaded plates.
e. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.

f. Seat: Bronze.

C. Iron, Dual-Plate Check Valves with Metal Seat, Class 250:

1. Description:

a. Standard: API 594.
b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Design: Wafer, spring-loaded plates.
e. Body Material: ASTM A126, gray iron.
f. Seat: Bronze.

D. Iron, Dual-Plate Check Valves with Metal Seat, Class 300:

1. Description:

a. Standard: API 594.
b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
c. NPS 14 to NPS 24, CWP Rating: 400 psig.
d. Body Design: Wafer, spring-loaded plates.
e. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
f. Seat: Bronze.

E. Iron, Single-Plate Check Valves with Resilient Seat, Class 125:

1. Description:

a. Standard: API 594.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Design: Wafer, spring-loaded plate.
e. Body Material: ASTM A126, gray iron.
f. Seat: EPDM or NBR.

F. Iron, Dual-Plate Check Valves with Resilient Seat, Class 125:

1. Description:

a. Standard: API 594.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Design: Wafer, spring-loaded plates.
e. Body Material: ASTM A126, gray iron.
f. Seat: EPDM or NBR.

G. Iron, Dual-Plate Check Valves with Resilient Seat, Class 150:

1. Description:

   a. Standard: API 594.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
   c. NPS 14 to NPS 24, CWP Rating: 250 psig.
   d. Body Design: Wafer, spring-loaded plates.
   e. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
   f. Seat: EPDM or NBR.

H. Iron, Wafer, Single-Plate Check Valves with Resilient Seat, Class 250:

1.
2. Description:

   a. Standard: API 594.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
   c. NPS 14 to NPS 24, CWP Rating: 300 psig.
   d. Body Design: Wafer, spring-loaded plate.
   e. Body Material: ASTM A126, gray iron.
   f. Seat: EPDM or NBR.

I. Iron, Dual-Plate Check Valves with Resilient Seat, Class 250:

1.
2. Description:

   a. Standard: API 594.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
   c. NPS 14 to NPS 24, CWP Rating: 300 psig.
   d. Body Design: Wafer, spring-loaded plates.
   e. Body Material: ASTM A126, gray iron.
   f. Seat: EPDM or NBR.

J. Iron, Dual-Plate Check Valves with Resilient Seat, Class 300:

1.
2. Description:

   a. Standard: API 594.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
   c. NPS 14 to NPS 24, CWP Rating: 400 psig.
   d. Body Design: Wafer, spring-loaded plates.
   e. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
   f. Seat: EPDM or NBR.

2.10 PLASTIC CHECK VALVES

A. CPVC Ball Check Valves:

1.
2. Description:

a. Pressure Rating and Temperature: 125 psig or as required at 73 deg F.
b. Body Material: CPVC.
c. Body Design: Union-type ball check.
d. End Connections for Valves NPS 2 and Smaller: Detachable, socket or threaded.
e. End Connections for Valves NPS 2-1/2 to NPS 4: Detachable, socket or threaded or flange.
f. Ball: CPVC.
g. Seals: EPDM- or FKM-rubber O-rings.

B. PVC Ball Check Valves:

1.
2. Description:

a. Pressure Rating and Temperature: 125 psig or as required at 73 deg F.
b. Body Material: PVC.
c. Body Design: Union-type ball check.
d. End Connections for Valves NPS 2 and Smaller: Detachable, socket or threaded.
e. End Connections for Valves NPS 2-1/2 to NPS 4: Detachable,socket, threaded or flange.
f. Ball: PVC.
g. Seals: EPDM- or FKM-rubber O-rings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Examine press fittings to verify they have been properly pressed.

F. Do not attempt to repair defective valves; replace with new valves.

3.2 INSTALLATION OF VALVES

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Provide support of piping adjacent to valves such that no force is imposed upon valves.

C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.

D. Install valves with stem at or above center of pipe.

E. Install valves in position that does not project into aisles or block access to other equipment.

F. Install valves in position to allow full stem and manual operator movement.

G. Verify that joints of each valve have been properly installed and sealed to ensure that there is no leakage or damage.

H. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
3. Lift Check Valves: With stem upright and plumb.

I. Install valve tags. Comply with requirements for valve tags and schedules in Section 230553 "Identification for HVAC Piping and Equipment."

J. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve of manufacturer's recommended maximum.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Pump-Discharge Check Valves:

   a. NPS 2 and Smaller: Bronze swing check valves with bronze or nonmetallic disc.

b. NPS 2-1/2 and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal or resilient-seat check valves.

B. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. End Connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends, except where solder-joint or press valve-end option is indicated in valve schedules.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends, except where threaded valve-end option is indicated in valve schedules.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends, except where threaded valve-end option is indicated in valve schedules.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.
7. For Grooved-End Copper Tubing and Steel Piping, except Steam and Steam Condensate Piping: Valve ends may be grooved.
8. Wafer-Type Valves: Flanged connections.

3.5 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: May be provided with solder-joint or press ends instead of threaded ends.
2. Bronze swing check valves with bronze or nonmetallic disc, Class 125 or as required.

B. Pipe NPS 2-1/2 and Larger:

1. NPS 2-1/2 to NPS 4: Iron valves may be provided with threaded ends instead of flanged ends.
2. NPS 2-1/2 to NPS 12: Iron swing check valves with lever and spring or weight-closure control, Class 125.
3. NPS 3 to NPS 12: Iron, grooved-end swing check valves, 300 CWP.
4. Iron swing check valves with metal or nonmetallic-to-metal seats, Class 125 or as required.
5. Iron, compact-wafer or globe, center-guided check valves metal or resilient seat, Class 125 or as required.
6. Iron, single-plate check valves with resilient seat, Class 125.
7. Iron, dual-plate check valves with metal seat, Class 125 or as required.
8. Iron, dual-plate check valves with resilient seat, Class 125 or as required.

C. CPVC Pipe NPS 4 and Smaller: CPVC ball check valve.

D. PVC Pipe NPS 4 and Smaller: PVC ball check valve.

3.6 CONDENSER-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: May be provided with solder-joint or press ends instead of threaded ends.
2. Bronze swing check valves with bronze or nonmetallic disc, Class 125 or as required.

B. Pipe NPS 2-1/2 and Larger:

1. NPS 2-1/2 to NPS 4: Iron valves may be provided with threaded ends instead of flanged ends.
2. NPS 2-1/2 to NPS 12: Iron swing check valves with lever and spring or weight-closure control, Class 125.
3. NPS 3 to NPS 12: Iron, grooved-end swing check valves, 300 CWP.
4. NPS 2-1/2 to NPS 24: Iron, compact-wafer or globe, center-guided check valves with metal or resilient seat, Class 125 or as required.
5. Iron swing check valves with metal or nonmetallic-to-metal seats, Class 125 or as required.
6. Iron, single plate-check valves with resilient seat, Class 125 or as required.
7. Iron, dual-plate-check valves with metal seat, Class 125 or as required.
8. Iron, dual plate check valves with resilient seat, Class 125 or as required.

C. CPVC Pipe NPS 4 and Smaller: CPVC ball check valve.

D. PVC Pipe NPS 4 and Smaller: PVC ball check valve.

3.7 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: May be provided with solder-joint or press ends instead of threaded ends.
2. Bronze swing check valves with bronze or nonmetallic disc, Class 125 or as required.

B. Pipe NPS 2-1/2 and Larger:

1. NPS 2-1/2 to NPS 4: Iron valves may be provided with threaded ends instead of flanged ends.
2. NPS 2-1/2 to NPS 12: Iron swing check valves with lever and spring or weight-closure control, Class 125.
3. NPS 3 to NPS 12: Iron, grooved-end check valves, 300 CWP.
4. Iron swing check valves with metal or nonmetallic-to-metal seats, Class 125 or as required.
5. Iron, compact-wafer or globe, center-guided check valves with metal or resilient seat, Class 125 or as required.
6. Iron, single-plate check valves with resilient seat, Class 125 or as required.
7. Iron, dual-plate check valves with metal seat, Class 125 or as required.
8. Iron, dual-plate check valves with resilient seat, Class 125 or as required.

C. CPVC Pipe NPS 4 and Smaller: CPVC ball check valve.

D. PVC Pipe NPS 4 and Smaller: PVC ball check valve.

3.8 LOW-PRESSURE STEAM VALVE SCHEDULE - 15 PSIG OR LESS

A. Pipe NPS 2 and Smaller:

1. Bronze swing check valves with bronze or nonmetallic disc, Class 125 or as required.

B. Pipe NPS 2-1/2 and Larger:

1. NPS 2-1/2 to NPS 4: Iron valves may be provided with threaded ends instead of flanged ends.
2. Iron swing check valves with metal or nonmetallic-to-metal seats; Class 125 or as required.
3. NPS 2-1/2 to NPS 12: Iron swing check valves with lever and spring or weight-closure control, Class 125.

3.9 HIGH-PRESSURE STEAM VALVE SCHEDULE - MORE THAN 15 PSIG

A. Pipe NPS 2 and Smaller:

1. Bronze swing check valves with bronze or nonmetallic disc, Class 125 or as required.

B. Pipe NPS 2-1/2 and Larger:

1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Iron swing check valves with metal or nonmetallic-to-metal seats, Class 125 or as required.
3. NPS 2-1/2 to NPS 12: Iron swing check valves with lever and spring or weight-closure control, Class 125.

3.10 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze swing check valves with bronze or nonmetallic disc, Class 125 or as required.

B. Pipe NPS 2-1/2 and Larger:

1. NPS 2-1/2 to NPS 4: Iron valves may be provided with threaded ends instead of flanged ends.
2. Iron swing check valves with metal or nonmetallic-to-metal seats, Class 125 or as required.
3. Iron swing check valves with lever and spring or weight-closure control, Class 125.

END OF SECTION 230523.14

SECTION 230523.15 - GATE VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze gate valves.
2. Iron gate valves.
3. Plastic gate valves.
4. Chainwheels.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

B. NRS: Nonrising stem.

C. OS&Y: Outside screw and yoke.

D. RS: Rising stem.

E. SWP: Steam working pressure.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, press connections, and weld ends.
3. Set gate valves closed to prevent rattling.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels, stems, or other components as lifting or rigging points unless specifically indicated for this purpose in manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. ASME Compliance:

1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.5 for flanges on metric standard piping.
4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
5. ASME B16.18 for cast copper solder joint.
6. ASME B16.22 for wrought copper solder joint.
7. ASME B16.34 for flanged, threaded, and welding ends.
8. ASME B16.51 for press joint.
9. ASME B31.1 for power piping valves.
10. ASME B31.9 for building services piping valves.

B. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

C. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are unacceptable.

D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream piping unless otherwise indicated.

F. RS Valves in Insulated Piping: With 2-inch stem extensions.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.3 BRONZE GATE VALVES

A. Bronze Gate Valves, NRS, Class 125:

1. Description:

a. Standard: MSS SP-80, Type 1.

b. CWP Rating: 200 psig.
c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded or solder joint.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

B. Bronze Gate Valves, RS, Class 125:

1. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 200 psig.
c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded or solder joint.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

C. Bronze Gate Valves, NRS, Class 150:

1. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

D. Bronze Gate Valves, RS, Class 150:

1. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

E. Bronze Gate Valves, Press Ends:

1. Description:

a. Standard: MSS SP-80.
b. CWP Rating: Minimum 200 psig.
c. Body Material: Bronze with integral seat and union-ring bonnet.
d. Ends: Press.
e. Press Ends Connection Rating: Minimum 200 psig.
f. Stem: Brass or bronze RS or NRS.
g. Disc: Solid wedge; bronze.
h. Packing: Graphite.
i. Port: Full.
j. Handwheel: Malleable iron, bronze, or aluminum.

2.4 IRON GATE VALVES

A. Iron Gate Valves, NRS, Class 125:

1. Description:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

B. Iron Gate Valves, OS&Y, Class 125:

1. Description:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

C. Iron Gate Valves, NRS, Class 250:

1. Description:

   a. Standard: MSS SP-70, Type I.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
   c. NPS 14 to NPS 24, CWP Rating: 300 psig.
   d. Body Material: ASTM A126, gray iron with bolted bonnet.
   e. Ends: Flanged.
   f. Trim: Bronze.
   g. Disc: Solid wedge.
   h. Packing and Gasket: Asbestos free.

D. Iron Gate Valves, OS&Y, Class 250:

1. Description:

   a. Standard: MSS SP-70, Type I.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
   c. NPS 14 to NPS 24, CWP Rating: 300 psig.
   d. Body Material: ASTM A126, gray iron with bolted bonnet.
   e. Ends: Flanged.
   f. Trim: Bronze.
   g. Disc: Solid wedge.
   h. Packing and Gasket: Asbestos free.

2.5 PLASTIC GATE VALVES

A. CPVC Gate Valves:

1. Description:

   a. Pressure Rating and Temperature: 125 psig or as required at 73 deg F.
   b. Body Material: CPVC.
   c. Body Design: Nonrising stem.
   d. End Connections for Valves NPS 2 and Smaller: Socket or threaded.
   e. End Connections for Valves NPS 2-1/2 to NPS 4: Socket or threaded Threaded or Flanged.
   f. Gate and Stem: Plastic.
   g. Seals: EPDM rubber.
   h. Handle: Wheel.

B. PVC Gate Valves:

1. Description:

   a. Pressure Rating and Temperature: 125 psig or as required at 73 deg F.
   b. Body Material: PVC.

c. Body Design: Nonrising stem.
d. End Connections for Valves NPS 2 and Smaller: Socket or threaded.
e. End Connections for Valves NPS 2-1/2 to NPS 4: Socket, Threaded or Flanged.
f. Gate and Stem: Plastic.
g. Seals: EPDM rubber.
h. Handle: Wheel.

2.6 CHAINWHEELS

A. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to handwheels.

1. Sprocket Rim with Chain Guides: Ductile or cast iron, Aluminum or Bronze, of type and size required for valve. Include zinc or epoxy coating.
2. Chain: Hot-dip galvanized steel, Brass or Stainless steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Examine press joint surfaces. Verify that they are clean and free from dents and burrs and that O-ring seals are in place and undamaged.

F. Do not attempt to repair defective valves; replace with new valves.

3.2 INSTALLATION OF VALVES

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Provide support of piping adjacent to valves such that no force is imposed upon valves.

C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.

D. Install valves so that stems are horizontal or slope upward from centerline of pipe.

E. Install valves in position that does not project into aisles or block access to other equipment.

F. Install valves in position to allow full stem and manual operator movement.

G. Verify that joints of each valve have been properly installed and sealed to ensure that there is no leakage or damage.

H. Install chainwheels on manual operators for gate valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

I. Install valve tags. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

J. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve of manufacturer's recommended maximum.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Shutoff Service: Gate valves.

B. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends, except where solder-joint or press valve-end option is indicated in valve schedules.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends, except where threaded valve-end option is indicated in valve schedules.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends, except where threaded valve-end option is indicated in valve schedules.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.

7. For Grooved-End Copper Tubing and Steel Piping, except for Steam and Steam Condensate Piping: Valve ends may be grooved.

3.5 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze valves, NRS or RS, Class 125 or as required, with soldered, threaded or press ends.

B. Pipe NPS 2-1/2 and Larger: Iron gate valves, NRS or OS&Y, Class 125 or as required.

C. CPVC Pipe NPS 4 and Smaller: CPVC gate valve.

D. PVC Pipe NPS 4 and Smaller: PVC gate valve.

3.6 CONDENSER-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze valves, NRS or RS, Class 125 or as required, with soldered, threaded or press ends.

B. Pipe NPS 2-1/2 and Larger: Iron gate valves, NRS or OS&Y, Class 125 or as required.

C. CPVC Pipe NPS 4 and Smaller: CPVC gate valve.

D. PVC Pipe NPS 4 and Smaller: PVC gate valve.

3.7 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze valves, NRS or RS, Class 125 or as required with soldered, threaded or press ends.

B. Pipe NPS 2-1/2 and Larger: Iron gate valves, NRS, OS&Y, Class 125 or as required.

C. CPVC Pipe NPS 4 and Smaller: CPVC gate valve.

D. PVC Pipe NPS 4 and Smaller: PVC gate valve.

3.8 LOW-PRESSURE STEAM VALVE SCHEDULE - 15 PSIG OR LESS

A. Pipe NPS 2 and Smaller: Bronze gate valves, NRS or RS, Class 125 or as required.

B. Pipe NPS 2-1/2 and Larger: Iron gate valves, NRS or OS&Y, Class 125 or as required.

3.9 HIGH-PRESSURE STEAM VALVE SCHEDULE - MORE THAN 15 PSIG

A. Pipe NPS 2 and Smaller: Bronze gate valves, NRS or RS, Class 125 or as required.

B. Pipe NPS 2-1/2 and Larger: Iron gate valves, NRS or OS&Y, Class 125 or as required.

3.10 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze gate valves, NRS or RS, Class 125 or as required.

B. Pipe NPS 2-1/2 and Larger: Iron gate valves, NRS or OS&Y, Class 125 or as required.

END OF SECTION 230523.15

SECTION 230523.16 - PLUG VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Lubricated plug valves.
2. Eccentric plug valves.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set plug valves open to minimize exposure of functional surfaces.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher-than-ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels, stems, or other components as lifting or rigging points unless specifically indicated for this purpose in manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. ASME Compliance:

1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.5 for flanges on metric standard piping.
4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
5. ASME B16.34 for flanged, threaded, and welding ends.
6. ASME B31.1 for power piping valves.
7. ASME B31.9 for building services piping valves.

B. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

C. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are unacceptable.

D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream piping unless otherwise indicated.

F. Valve Actuator Types: Wrench. Furnish Owner with one wrench for every 10 plug valves, for each size square plug-valve head.

2.3 LUBRICATED PLUG VALVES

A. Class 125, Lubricated Plug Valves with Threaded Ends:

1. Description:

a. Standard: MSS SP-78, Type I single gland.
b. NPS 2-1/2 to NPS 4, CWP Rating: 200 psig.
c. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
d. Plug: Cast iron or bronze with sealant groove.

B. Class 125, Lubricated Plug Valves with Flanged Ends:

1. Description:

a. Standard: MSS SP-78, Type I single gland or Type II regular gland.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. NPS 14 to NPS 24, CWP Rating: 150 psig.
d. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
e. Plug: Cast iron or bronze with sealant groove.

C. Class 125, Cylindrical, Lubricated Plug Valves with Threaded Ends:

1. Description:

a. Standard: MSS SP-78, Type IV.
b. NPS 2-1/2 to NPS 4, CWP Rating: 200 psig.
c. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
d. Plug: Cast iron or bronze with sealant groove.

D. Class 125, Cylindrical, Lubricated Plug Valves with Flanged Ends:

1. Description:

a. Standard: MSS SP-78, Type IV.
b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
c. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
d. Plug: Cast iron or bronze with sealant groove.

E. Class 250, Lubricated Plug Valves with Threaded Ends:

1. Description:

a. Standard: MSS SP-78, Type I single gland or Type II regular gland.
b. NPS 2-1/2 to NPS 4, CWP Rating: 400 psig.
c. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
d. Plug: Cast iron or bronze with sealant groove.

F. Class 250, Lubricated Plug Valves with Flanged Ends:

1. Description:

a. Standard: MSS SP-78, Type I single gland or Type II regular gland.
b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
c. NPS 14 to NPS 24, CWP Rating: 300 psig.
d. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
e. Plug: Cast iron or bronze with sealant groove.

G. Class 250, Cylindrical, Lubricated Plug Valves with Threaded Ends:

1. Description:

a. Standard: MSS SP-78, Type IV.
b. NPS 2-1/2 to NPS 4, CWP Rating: 400 psig.
c. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
d. Plug: Cast iron or bronze with sealant groove.

H. Class 250, Cylindrical, Lubricated Plug Valves with Flanged Ends:

1. Description:

a. Standard: MSS SP-78, Type IV.
b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
c. Body Material: ASTM A48/A48M or ASTM A126, Grade 40 cast iron with lubrication-sealing system.
d. Plug: Cast iron or bronze with sealant groove.

2.4 ECCENTRIC PLUG VALVES

A. 175 CWP, Eccentric Plug Valves with Resilient Seating.

1. Description:

a. Standard: MSS SP-108.
b. CWP Rating: 175 psig minimum.
c. Body and Plug: ASTM A48/A48M, gray iron; ASTM A126, gray iron; or ASTM A536, ductile iron.
d. Bearings: Oil-impregnated bronze or stainless steel.
e. Ends: Flanged.
f. Stem-Seal Packing: Asbestos free.
g. Plug, Resilient-Seating Material: Suitable for potable-water service unless otherwise indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 INSTALLATION OF VALVES

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Provide support of piping adjacent to valves such that no force is imposed upon valves.

C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.

D. Install valves so that center of rotation is horizontal or slopes upward from centerline of pipe.

E. Install valves in position that does not project into aisles or block access to other equipment.

F. Install valves in position to allow full stem and manual operator movement.

G. Verify that joints of each valve have been properly installed and sealed to ensure that there is no leakage or damage.

H. Install chainwheels on manual operators for plug valves NPS 4and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

I. Install valve tags. Comply with requirements for valve tags and schedules in Section 230553 "Identification for HVAC Piping and Equipment."

J. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve of manufacturer's recommended maximum.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Shutoff Service: Plug valves.

B. If valves with CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

C. End Connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends, except where threaded valve-end option is indicated in valve schedules.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends, except where threaded valve-end option is indicated in valve schedules.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.
7. For Grooved-End Copper Tubing and Steel Piping, except Steam and Steam Condensate Piping: Valve ends may be grooved.

3.5 HOT-WATER AND CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2-1/2 and Larger:

1. Lubricated Plug Valves: Class 125 or Class 250, regular gland or cylindrical, threaded or flanged.
2. Eccentric Plug Valves: 175 CWP, resilient seating.

3.6 CONDENSER-WATER VALVE SCHEDULE

A. Pipe NPS 2-1/2 and Larger: Lubricated plug valves, Class 125 or Class 250, regular gland or cylindrical, threaded or flanged.

3.7 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2-1/2 and Larger: Lubricated plug valves, Class 125 or Class 250, regular gland or cylindrical, threaded or flanged.

END OF SECTION 230523.16

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING 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. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Fiberglass pipe hangers.
4. Metal framing systems.
5. Fiberglass strut systems.
6. Thermal-hanger shield inserts.
7. Fastener systems.
8. Pipe stands.
9. Equipment stands.
10. Equipment supports.

B. Related Requirements:

1. Section 230548.13 "Vibration Controls for HVAC" for vibration isolation devices.
2. Section 233113 "Metal Ducts" for duct hangers and supports.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
3. Nonmetallic Coatings: Plastic coated, or epoxy powder-coated.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.

B. Stainless Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe and Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-plated steel or stainless steel.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 FIBERGLASS PIPE HANGERS

A. Clevis-Type, Fiberglass Pipe Hangers:

1. Description: Similar to MSS SP-58, Type 1, factory-fabricated steel pipe hanger except hanger is made of fiberglass or fiberglass-reinforced resin.
2. Hanger Rods: Continuous-thread rod, washer, and nuts made of fiberglass, polyurethane or stainless steel.
3. Flammability: ASTM D635, ASTM E84, and UL 94.

B. Strap-Type, Fiberglass Pipe Hangers:

1. Description: Similar to MSS SP-58, Type 9 or Type 10, steel pipe hanger except hanger is made of fiberglass-reinforced resin.

    a. Flammability: ASTM D635, ASTM E84, and UL 94.

2. Hanger Rod and Fittings: Continuous-thread rod, washer, and nuts made of stainless steel.

2.5 PLASTIC PIPE HANGERS

A. Description: Similar to MSS SP-58, Types 1 through 58, factory-fabricated steel pipe hanger except hanger is made of plastic.

B. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel or stainless steel.

C. Flammability: ASTM D635, ASTM E84, and UL 94.

2.6 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Channels: Continuous slotted carbon-steel, stainless steel, Type 304, stainless steel, Type 316 or extruded-aluminum channel with inturned lips.
4. Channel Width: Selected for applicable load criteria.
5. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel or stainless steel.
7. Metallic Coating: No coating, Plain, Pregalvanized G90, Electroplated zinc, Hot-dip galvanized or Gold (yellow zinc dichromate) galvanized as required.
8. Paint Coating: Green epoxy, acrylic, or urethane.

9. Plastic Coating: PVC.

B. Non-MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Channels: Continuous slotted carbon-steel or stainless steel channel with inturned lips.
4. Channel Width: Select for applicable load criteria.
5. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel or stainless steel.
7. Metallic Coating: Plain, Pregalvanized G90 or Hot-dip galvanized.
8. Paint Coating: Green epoxy, acrylic, or urethane.
9. Plastic Coating: PVC.

2.7 FIBERGLASS STRUT SYSTEMS

A. Description: Structural-grade, factory-formed, glass-fiber-resin channels and angles for supporting multiple parallel pipes.

1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
2. Channels: Continuous slotted fiberglass-reinforced plastic channel with inturned lips.
3. Channel Width: Selected for applicable load criteria.
4. Fittings and Accessories: Products provided by channel and angle manufacturer and designed for use with those items.
5. Fitting and Accessory Materials: Same as those for channels and angles, except metal items may be stainless steel.
6. Rated Strength: Selected to suit applicable load criteria.
7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

2.8 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with 100-psi or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength and vapor barrier.

B. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C533, Type I calcium silicate with 100-psi, ASTM C552, Type II cellular glass with 100-psi or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.9 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type anchors for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Indoor Applications: Zinc-coated or stainless steel.
2. Outdoor Applications: Stainless steel.

2.10 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand:

1. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
3. Hardware: Galvanized steel or polycarbonate.
4. Accessories: Protection pads.

C. Low-Profile, Single Base, Single-Pipe Stand:

1. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
3. Vertical Members: Two, galvanized or stainless-steel, continuous-thread 1/2-inch rods.
4. Horizontal Member: Adjustable horizontal, galvanized or stainless-steel pipe support channels.
5. Pipe Supports: Roller, Strut clamps, Clevis hanger or Swivel hanger.
6. Hardware: Galvanized or Stainless steel.

7. Accessories: Protection pads.
8. Height: 12 inches above roof.

D. High-Profile, Single Base, Single-Pipe Stand:

1. Description: Single base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: Single vulcanized rubber or molded polypropylene.
3. Vertical Members: Two, galvanized or stainless-steel, continuous-thread 1/2-inch rods.
4. Horizontal Member: One, adjustable height, galvanized- or stainless-steel pipe support slotted channel or plate.
5. Pipe Supports: Roller, Clevis hanger or Swivel hanger.
6. Hardware: Galvanized or Stainless steel.
7. Accessories: Protection pads, 1/2-inch continuous-thread galvanized-steel rod or 1/2-inch continuous-thread stainless steel rod.
8. Height: 36 inches above roof.

E. High-Profile, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: Two or more; vulcanized rubber or molded polypropylene.
3. Vertical Members: Two or more, galvanized or stainless-steel channels.
4. Horizontal Members: One or more, adjustable height, galvanized or stainless-steel pipe support.
5. Pipe Supports: Roller, Strut clamps, Clevis hanger or Swivel hanger.
6. Hardware: Galvanized or Stainless steel.
7. Accessories: Protection pads, 1/2-inch continuous-thread rod.
8. Height: 36 inches above roof.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.11 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.12 OUTDOOR EQUIPMENT STANDS

1. Description: Individual foot supports with elevated adjustable channel cross bars and clamps/fasteners/bolts for ground or roof supported outdoor equipment components,

without roof membrane penetration, in a pre-fabricated system that can be modularly-assembled on site.

2. Foot Material: Rubber or polypropylene.
3. Rails Material: Hot dip galvanized carbon steel.

2.13 MATERIALS

A. Aluminum: ASTM B221.

B. Carbon Steel: ASTM A1011/A1011M.

C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; galvanized.

D. Stainless Steel: ASTM A240/A240M.

E. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.

F. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

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

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-58. Install hangers and attachments as required to properly support piping from building structure.

D. Metal or Fiberglass Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems.

E. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

F. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

G. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

H. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

I. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

J. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

K. Install lateral bracing with pipe hangers and supports to prevent swaying.

L. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

M. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

N. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

O. Insulated Piping:

1. Attach clamps and spacers to piping.

   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.

5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.7 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers and metal framing systems and attachments for general service applications.

F. Use stainless steel pipe hangers and fiberglass pipe hangers and fiberglass strut systems and stainless steel or corrosion-resistant attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper or stainless steel attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.

16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is unnecessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.

7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include

auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

a. Horizontal (MSS Type 54): Mounted horizontally.
b. Vertical (MSS Type 55): Mounted vertically.
c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

R. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 230529

SECTION 230548.13 - VIBRATION CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

1.2 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Restrained-spring isolators.
7. Housed-restrained-spring isolators.
8. Pipe-riser resilient support.
9. Resilient pipe guides.
10. Air-spring isolators.
11. Restrained-air-spring isolators.
12. Elastomeric hangers.
13. Spring hangers.
14. Snubbers.
15. Restraints - rigid type.
16. Restraints - cable type.
17. Restraint accessories.
18. Post-installed concrete anchors.
19. Concrete inserts.
20. Vibration isolation equipment bases.
21. Restrained isolation roof-curb rails.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. OSHPD: Office of Statewide Health Planning and Development (for the State of California owned and regulated medical facilities).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device component.
3. Annotate to indicate application of each product submitted and compliance with requirements.
4. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints.

B. Qualification Data: For testing agency.

C. Welding certificates.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For [air-spring mounts] [and] [restrained-air-spring mounts] to include in operation and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct testing indicated, be an NRTL as defined by OSHA in 29 CFR 1910.7 and be acceptable to authorities having jurisdiction.

B. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
2. Size: Factory or field cut to match requirements of supported equipment.
3. Minimum deflection as indicated on Drawings.
4. Pad Material: Oil- and water-resistant rubber.
5. Infused nonwoven cotton or synthetic fibers-optional.
6. Load-bearing metal plates adhered to pads-optional.
7. Sandwich-Core Material-optional: [Resilient] [and] [elastomeric].
    a. Infused nonwoven cotton or synthetic fibers-optional.

2.2 ELASTOMERIC ISOLATION MOUNTS

A. Elastomeric Isolation Mounts:

1. Mounting Plates:

    a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded[with threaded studs or bolts].
    b. Baseplate-optional: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

2. Minimum deflection as indicated on Drawings.
3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.3 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:

1. Description: All-directional isolator with restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

    a. Housing: Cast-ductile iron or welded steel.
    b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2. Minimum deflection as indicated on Drawings.

2.4 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators:

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psi.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
7. Minimum deflection as indicated on Drawings.

2.5 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Minimum deflection as indicated on Drawings.
6. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

    a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi.
    b. Top housing with [attachment and leveling bolt], [threaded mounting holes and internal leveling device] or [elastomeric pad].

2.6 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:

1. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

    a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi.
    b. Top plate with [threaded mounting holes] or [elastomeric pad].
    c. Internal leveling bolt that acts as blocking during installation.

2. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Minimum deflection as indicated on Drawings.

2.7 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:

1. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with [adjustable] or [non-adjustable] snubbers to limit vertical movement.

   a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi.
   b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Minimum deflection as indicated on Drawings.

2.8 PIPE-RISER RESILIENT SUPPORT

A. All-Directional, Acoustical Pipe Anchor Consisting of Two Steel Tubes Separated by a Minimum 1/2-inch- Thick Neoprene:

1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
2. Maximum Load Per Support: 500 psi on isolation material providing equal isolation in all directions.
3. Minimum deflection as indicated on Drawings.

2.9 RESILIENT PIPE GUIDES

A. Telescopic Arrangement of Two Steel Tubes or Post and Sleeve Arrangement Separated by a Minimum 1/2-inch- Thick Neoprene:

1. Factory-Set Height Guide with Shear Pin-optional: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.10 AIR-SPRING ISOLATORS

A. Freestanding, Single or Multiple, Compressed-Air Bellows:

1. Bellows Assembly: Upper and lower powder-coated steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows or similar elastomeric material.
2. Maximum Natural Frequency: 3 Hz.
3. Operating Pressure Range: 25 to 100 psi.
4. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
5. Minimum deflection as indicated on Drawings.
6. Automatic leveling valve-optional.

2.11 RESTRAINED-AIR-SPRING ISOLATORS

A. Freestanding, Single or Multiple, Compressed-Air Bellows with Vertical-Limit Stop Restraint:

1. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
    a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi.
    b. Top plate with [threaded mounting holes] or [elastomeric pad].
    c. Internal leveling bolt that acts as blocking during installation.
2. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
3. Minimum deflection as indicated on Drawings.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Bellows Assembly: Upper and lower powder-coated steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows or similar elastomeric material.
8. Maximum Natural Frequency: 3 Hz.
9. Operating Pressure Range: 25 to 100 psi.
10. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
11. Automatic leveling valve-optional.

2.12 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:

1. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
2. Damping Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel-to-steel contact.
3. Minimum deflection as indicated on Drawings.

2.13 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Minimum deflection as indicated on Drawings.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.

2.14 SNUBBERS

A. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Post-Installed Concrete Anchor Bolts: Secure to concrete surface with post-installed concrete anchors. Anchors to be prequalified in accordance with ACI 355.2 testing and designated in accordance with [ACI 318-08 Appendix D for 2009 IBC], [ACI 318-11 Appendix D for 2012 IBC] or [ACI 318-14 Ch. 17 for 2015 or 2018 IBC].

2. Preset Concrete Inserts: Prequalified in accordance with ICC-ES AC446 testing.
3. Anchors in Masonry: Design in accordance with TMS 402.
4. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
5. Resilient Cushion: Maximum 1/4-inch air gap, and minimum 1/4 inch thick.

2.15 RESTRAINTS - RIGID TYPE

A. Description: Shop- or field-fabricated bracing assembly made of AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe as per NFPA 13, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.16 RESTRAINTS - CABLE TYPE

A. Restraint Cables: [ASTM A1023/A1023M galvanized or ASTM A603 galvanized-steel] or [ASTM A492 stainless steel] cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with fittings attached by means of poured socket, swaged socket, or mechanical (Flemish eye) loop.

B. Restraint cable assembly and cable fittings must comply with [ASCE/SEI 19-10] or [ASCE/SEI 19-16]. All cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

2.17 RESTRAINT ACCESSORIES

A. Hanger-Rod Stiffener: [Steel tube or steel slotted-support-system sleeve with internally bolted connections] or [Reinforcing steel angle clamped] to hanger rod.

B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to [rigid channel bracings] [and] [restraint cables].

C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.18 POST-INSTALLED CONCRETE ANCHORS

A. Mechanical Anchor Bolts:

1. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength for anchor and as tested according to ASTM E488/E488M.

B. Adhesive Anchor Bolts:

1. Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.

C. Provide post-installed concrete anchors that have been prequalified for use in wind-load applications. Post-installed concrete anchors must comply with all requirements of [ASCE/SEI 7-05, Ch. 13], [ASCE/SEI 7-10, Ch. 13] or [ASCE/SEI 7-16, Ch. 13].

1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

D. Expansion-type anchor bolts are not permitted for equipment in excess of 10 hp that is not vibration isolated.

1. Undercut expansion anchors are permitted.

2.19 CONCRETE INSERTS

A. Provide preset concrete inserts that are prequalified in accordance with ICC-ES AC466 testing.

B. Comply with ANSI/MSS SP-58.

2.20 VIBRATION ISOLATION EQUIPMENT BASES

A. Steel Rails: Factory-fabricated, welded, structural-steel rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide rails.

a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Rails shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

B. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Concrete Inertia Base: [Factory-fabricated] [or] [field-fabricated], welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases shall have shape to accommodate supported equipment.

3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.21 RESTRAINED ISOLATION ROOF-CURB RAILS

A. Description: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment.

B. Upper Frame: Shall provide continuous and captive support for equipment.

C. Lower Support Assembly: Shall be formed sheet metal section containing adjustable and removable steel springs that support upper frame. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials and shall be insulated with a minimum of 2 inches of rigid glass-fiber insulation on inside of assembly.

1. Adjustable, restrained-spring isolators shall be mounted on elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with integrity of roof.
2. Minimum deflection as indicated on Drawings.

D. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by [an agency acceptable to authorities having jurisdiction].

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to wind-load forces.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength is adequate to carry static and wind force loads within specified loading limits.

3.3 INSTALLATION OF VIBRATION CONTROL DEVICES

A. Provide vibration control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Device Schedules on Drawings, where Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.

B. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

C. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

D. Equipment Restraints:

1. Install snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

E. Piping Restraints:

1. Comply with requirements in MSS SP-127.
1. Space lateral supports a maximum of [40 feet] o.c., and longitudinal supports a maximum of [80 feet] o.c.
2. Brace a change of direction longer than 12 feet.

F. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

I. Post-Installed Concrete Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 INSTALLATION OF AIR-SPRING ISOLATORS

A. Independent Isolator Installation:

1. Install automatic leveling valve into each air isolator.
2. Inflate each isolator to [height] [and] [pressure] specified on Drawings.

B. Pressure-Regulated Isolator Installation:

1. Connect all pressure regulators to a single dry, filtered [constant] air supply.
2. Inflate isolators to [height] [and] [or] [pressure] specified on Drawings.

3.5 ACCOMMODATION OF DIFFERENTIAL MOTION

A. Provide flexible connections in piping systems where they cross structural joints and other point where differential movement may occur. Provide adequate flexibility to accommodate differential movement as determined in accordance with ASCE/SEI 7. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties" for piping flexible connections.

3.6 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT BASES

A. Coordinate dimensions of equipment bases with requirements of isolated equipment specified in this and other Sections. Where dimensions of base are indicated on Drawings, they may require adjustment to accommodate isolated equipment.

3.7 ADJUSTING

A. Adjust isolators after system is at operating weight.

B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

3.8 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections[with the assistance of a factory-authorized service representative].

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports.

END OF SECTION 230548.13

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Warning tape.
4. Pipe labels.
5. Duct labels.
6. Stencils.
7. Valve tags.
8. Warning tags.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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: Provide for each piping system. Include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-inch, stainless steel, 0.025-inch, aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, with predrilled or stamped holes for attachment hardware.
2. Letter and Background Color: As indicated for specific application under Part 3.
3. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
4. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of 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.
5. Fasteners: Stainless steel rivets or self-tapping screws.
6. 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, 1/16 inch thick, with predrilled holes for attachment hardware.
2. Letter and Background Color: As indicated for specific application under Part 3.
3. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of 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.
6. Fasteners: Stainless steel rivets or self-tapping screws.
7. 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.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, with predrilled holes for attachment hardware.

B. Letter and Background Color: As indicated for specific application under Part 3.

C. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.

D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

E. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of 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.

F. Fasteners: Stainless steel rivets or self-taping screws.

G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

H. Arc-Flash Warning Signs: Provide arc-flash warning signs in locations and with content in accordance with requirements of OSHA and NFPA70E and other applicable codes and standards.

I. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 WARNING TAPE

A. Material: Vinyl.

B. Minimum Thickness: 0.005 inch.

C. Letter, Pattern, and Background Color: As indicated for specific application under Part 3.

D. Waterproof Adhesive Backing: Suitable for indoor or outdoor use.

E. Maximum Temperature: 160 deg F.

F. Minimum Width: 2 inches.

2.4 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service and showing flow direction in accordance with ASME A13.1.

B. Letter and Background Color: As indicated for specific application under Part 3.

C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.

D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings. Also include:

1. Pipe size.
2. Flow-Direction Arrows: Include flow-direction arrows on main distribution piping. Arrows may be either integral with label or applied separately.
3. Lettering Size: Size letters in accordance with ASME A13.1 for piping At least 1/2 inch for viewing distances of up to 72 inches and proportionately larger lettering for greater viewing distances.

2.5 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

B. Letter and Background Color: As indicated for specific application under Part 3.

C. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

E. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of 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.

F. Fasteners: Stainless steel rivets or self-tapping screws.

G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

H. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings. Also include the following:

1. Duct size.
2. Flow-Direction Arrows: Include flow-direction arrows on main distribution ducts. Arrows may be either integral with label or may be applied separately.
3. Lettering Size: Size letters in accordance with ASME A13.1 for piping At least 1/2 inch for viewing distances of up to 72 inches and proportionately larger lettering for greater viewing distances.

2.6 STENCILS

A. Stencils for Piping:
1. Lettering Size: Size letters in accordance with ASME A13.1 for piping At least 1/2 inch for viewing distances of up to 72 inches and proportionately larger lettering for greater viewing distances.
2. Stencil Material: Aluminum, brass, or fiberboard.
3. Stencil Paint: Exterior, gloss, alkyd enamel or acrylic enamel in colors complying with recommendations in ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.
4. Identification Paint: Exterior, alkyd enamel or acrylic enamel. Paint may be in pressurized spray-can form.
5. Letter and Background Color: As indicated for specific application under Part 3.

B. Stencils for Ducts:

1. Lettering Size: Minimum letter height of 1-1/4 inches for viewing distances of up to 15 ft. and proportionately larger lettering for greater viewing distances.
2. Stencil Material: Fiberboard or metal.
3. Stencil Paint: Exterior, gloss, alkyd enamel or acrylic enamel. Paint may be in pressurized spray-can form.
4. Identification Paint: Exterior, alkyd enamel or acrylic enamel. Paint may be in pressurized spray-can form.
5. Letter and Background Color: Color as indicated for specific application under Part 3.

C. Stencils for Access Panels and Door Labels, Equipment Labels, and Similar Operational Instructions:

1. Lettering Size: Minimum letter height of 1/2 inch for viewing distances of up to 72 inches and proportionately larger lettering for greater viewing distances.
2. Stencil Material: Fiberboard or metal.
3. Stencil Paint: Exterior, gloss, alkyd enamel or acrylic enamel. Paint may be in pressurized spray-can form.
4. Identification Paint: Exterior, alkyd enamel or acrylic enamel. Paint may be in pressurized spray-can form.
5. Letter and Background Color: As indicated for specific application under Part 3.

2.7 VALVE TAGS

A. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.04-inch, stainless steel, 0.024-inch, aluminum, 0.031-inch or anodized aluminum, 0.031-inch minimum thickness, with predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire, link chain or beaded chain or S-hook.

B. Letter and Background Color: As indicated for specific application under Part 3.

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. Include valve-tag schedule in operation and maintenance data.

2.8 WARNING TAGS

A. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.

1. Size: 3 by 5-1/4 inches minimum.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption, such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Letter and Background Color: As indicated for specific application under Part 3.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 INSTALLATION, GENERAL 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.

D. Locate identifying devices so that they are readily visible from the point of normal approach.

3.3 INSTALLATION OF EQUIPMENT LABELS, WARNING SIGNS, AND LABELS

A. Permanently fasten labels on each item of mechanical equipment.

B. Sign and Label Colors:

1. White letters on an ANSI Z535.1 safety-blue background.

C. Locate equipment labels where accessible and visible.

D. Arc-Flash Warning Signs: Provide arc-flash warning signs on electrical disconnects and other equipment where arc-flash hazard exists, as indicated on Drawings, and in accordance with requirements of OSHA and NFPA 70E, and other applicable codes and standards.

3.4 INSTALLATION OF WARNING TAPE

A. Warning Tape Color and Pattern: Yellow background with black diagonal stripes.

B. Install warning tape on pipes and ducts, with cross-designated walkways providing less than 6 ft. of clearance.

C. Locate tape so as to be readily visible from the point of normal approach.

3.5 INSTALLATION OF PIPE LABELS

A. Install pipe labels showing service and flow direction with permanent adhesive on pipes.

B. Stenciled Pipe Label Option: Stenciled labels showing service and flow direction may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, with painted, color-coded bands or rectangles on each piping system.

1. Identification Paint: Use for contrasting background.
2. Stencil Paint: Use for pipe marking.

C. 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. Within 3 ft. of each valve and control device.
2. At access doors, manholes, and similar access points that permit view of concealed piping.
3. Within 3 ft. of equipment items and other points of origination and termination.
4. Spaced at maximum intervals of 25 ft. along each run. Reduce intervals to 10 ft. in areas of congested piping, ductwork, and equipment.

D. Do not apply plastic pipe labels or plastic tapes directly to bare pipes conveying fluids at temperatures of 125 deg F or higher. Where these pipes are to remain uninsulated, use a short section of insulation or use stenciled labels.

E. Flow-Direction Arrows: Use arrows to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

F. Pipe-Label Color Schedule:

1. Chilled-Water Piping: White letters on an ANSI Z535.1 safety-green background.
2. Condenser-Water Piping: White letters on anANSI Z535.1 safety-green background.
3. Heating Water Piping: White letters on an ANSI Z535.1 safety-green background.
4. Refrigerant Piping: White letters on an ANSI Z535.1 safety-blue background.
5. Low-Pressure Steam Piping: Black letters on an ANSI Z535.1 safety-yellow background or White letters on an ANSI Z535.1 safety-green background.
6. High-Pressure Steam Piping: Black letters on an ANSI Z535.1 safety-yellow background or White letters on an ANSI Z535.1 safety-green background.
7. Steam Condensate Piping: Black letters on an ANSI Z535.1 safety-yellow background or White letters on an ANSI Z535.1 safety-green background.
8. Toxic and Corrosive Fluids: Black letters on an ANSI Z535.1 safety-orange background.
9. Flammable Fluids: Black letters on an ANSI Z535.1 safety-yellow background.
10. Combustible Fluids: White letters on an ANSI Z535.1 safety-brown background.
11. Potable and Other Water: White letters on an ANSI Z535.1 safety-green background.
12. Compressed Air: White letters on an ANSI Z535.1 safety-blue background.

3.6 INSTALLATION OF DUCT LABELS

A. Install plastic-laminated self-adhesive duct labels showing service and flow direction with permanent adhesive on air ducts.

1. Provide labels in the following color codes:

   a. For air supply ducts: White letters on blue background.
   b. For air return ducts: White letters on blue background.
   c. For exhaust-, outside-, relief-, return-, and mixed-air ducts: White letters on blue background.

B. Stenciled Duct-Label Option: Stenciled labels showing service and flow direction may be provided instead of plastic-laminated duct labels, at Installer's option.

1. For all air ducts: Black letters on white background.

C. Locate label near each point where ducts enter into and exit from concealed spaces and at maximum intervals of 20 ft. where exposed or are concealed by removable ceiling system.

D. Stenciled Access Panels and Door Labels, Equipment Labels, and Similar Operational Instructions:

1. Black letters on White background.

3.7 INSTALLATION OF VALVE TAGS

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule in the operating and maintenance manual.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in "Valve-Tag Size and Shape" Subparagraph below.

1. Valve-Tag Size and Shape:

   a. Chilled Water: 1-1/2 inches, round.
   b. Condenser Water: 1-1/2 inches, round.
   c. Refrigerant: 1-1/2 inches, round.
   d. Hot Water: 1-1/2 inches, round.
   e. Gas: 1-1/2 inches, round.
   f. Low-Pressure Steam: 1-1/2 inches, round.
   g. High-Pressure Steam: 1-1/2 inches, round.
   h. Steam Condensate: 1-1/2 inches, round.

2. Valve-Tag Colors:

   a. For each piping system, use the same lettering and background coloring system on valve tags as used for the Pipe Label Schedule text and background.

3.8 INSTALLATION OF WARNING TAGS

A. Warning Tag Color: Black letters on an ANSI Z535.1 safety-yellow background.

B. Attach warning tags, with proper message, to equipment and other items where scheduled.

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Testing, Adjusting, and Balancing of Air Systems:

    a. Constant-volume air systems.
    b. Dual-duct systems.
    c. Variable-air-volume systems.
    d. Multizone systems.
    e. Induction-unit systems.

2. Testing, Adjusting, and Balancing of Hydronic Piping Systems:

    a. Constant-flow hydronic systems.
    b. Variable-flow hydronic systems.
    c. Primary-secondary hydronic systems.

3. Testing, adjusting, and balancing of fuel oil systems for HVAC.
4. Testing, adjusting, and balancing of steam and condensate piping systems.
5. Testing, adjusting, and balancing of equipment.
6. Testing, adjusting, and balancing of existing HVAC systems and equipment.
7. Procedures for exhaust hoods.
8. Sound tests.
9. Vibration tests.
10. Duct leakage tests verification.
11. Pipe leakage tests verification.
12. UFAD plenum leakage tests verification.
13. HVAC-control system verification.
14. Smoke-control system tests.
15. Stair-pressurization system tests.
16. Elevator-pressurization system tests.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

F. TDH: Total dynamic head.

G. UFAD: Underfloor air distribution.

1.4 PREINSTALLATION MEETINGS

A. TAB Conference: Conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan, to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.

1. Minimum Agenda Items:

a. The Contract Documents examination report.
b. The TAB plan.
c. Needs for coordination and cooperation of trades and subcontractors.
d. Proposed procedures for documentation and communication flow.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report, as specified in Part 3.

C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures, as specified in "Preparation" Article.

D. System Readiness Checklists: Within 60 days of Contractor's Notice to Proceed, submit system readiness checklists, as specified in "Preparation" Article.

E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

F. Certified TAB reports.

G. Sample report forms.

H. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.6 QUALITY ASSURANCE

A. TAB Specialists Qualifications, Certified by AABC:

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
2. TAB Technician: Employee of the TAB specialist and certified by AABC.

B. TAB Specialists Qualifications, Certified by NEBB or TABB:

1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB or TABB.
2. TAB Technician: Employee of the TAB specialist and certified by NEBB or TABB.

C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

E. Code and AHJ Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

1.7 FIELD CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for HVAC to verify that they are properly separated from adjacent areas and sealed.

F. Examine equipment performance data, including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine temporary and permanent strainers. Verify that temporary strainer screens used during system cleaning and flushing have been removed and permanent strainer baskets are installed and clean.

L. Examine control valves for proper installation for their intended function of isolating, throttling, diverting, or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.

Q. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:

   a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
   b. Duct systems are complete with terminals installed.
   c. Volume, smoke, and fire dampers are open and functional.
   d. Clean filters are installed.
   e. Fans are operating, free of vibration, and rotating in correct direction.
   f. Variable-frequency controllers' startup is complete and safeties are verified.
   g. Automatic temperature-control systems are operational.
   h. Ceilings are installed.
   i. Windows and doors are installed.
   j. Suitable access to balancing devices and equipment is provided.

2. Hydronics:

   a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
   b. Piping is complete with terminals installed.
   c. Water treatment is complete.
   d. Systems are flushed, filled, and air purged.
   e. Strainers are pulled and cleaned.
   f. Control valves are functioning in accordance with the sequence of operation.
   g. Shutoff and balance valves have been verified to be 100 percent open.
   h. Pumps are started and proper rotation is verified.
   i. Pump gauge connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
   j. Variable-frequency controllers' startup is complete and safeties are verified.
   k. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system in accordance with the procedures contained in AABC's "National Standards for Total System Balance", ASHRAE 111 or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.

B. Cut insulation, ducts, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
3. Where holes for probes are required in piping or hydronic equipment, install pressure and temperature test plugs to seal systems.
4. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 TESTING, ADJUSTING, AND BALANCING OF HVAC EQUIPMENT

A. Test, adjust, and balance HVAC equipment indicated on Drawings, including, but not limited to, the following:

1. Motors.
2. Pumps.
3. Fans and ventilators.
4. Air curtains.
5. Terminal units.
6. Commercial kitchen hoods.
7. Boilers.
8. Deaerators.
9. Furnaces.
10. Radiant heaters.
11. Unit heaters.
12. Solar collectors.
13. Heat exchangers.
14. Condensing units.
15. Condensers.
16. Water chillers.
17. Cooling towers.

18. Energy-recovery units.
19. Air-handling units.
20. Heating and ventilating units.
21. Rooftop air-conditioning units.
22. Heating-only makeup air units.
23. Dedicated outdoor-air units.
24. Packaged air conditioners.
25. Self-contained air conditioners.
26. Computer-room air conditioners.
27. Split-system air conditioners.
28. Variable-refrigerant-flow systems.
29. Heat pumps.
30. Valance heating and cooling units.
31. Chilled beams.
32. Coils.
33. Fan coil units.
34. Unit ventilators.
35. Radiators.
36. Convectors.
37. Finned-tube radiation heaters.
38. Radiant-heating cables piping and panels.
39. Humidifiers.
40. Dehumidification units.

3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' Record drawings duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
    c. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

2. Measure fan static pressures as follows:

    a. Measure static pressure directly at the fan outlet or through the flexible connection.
    b. Measure static pressure directly at the fan inlet or through the flexible connection.
    c. Measure static pressure across each component that makes up the air-handling system.
    d. Report artificial loading of filters at the time static pressures are measured.

3. Review Contractor-prepared shop drawings and Record drawings to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, speed, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.7 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:

    a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
    b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
    c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
    d. Adjust controls so that terminal is calling for minimum airflow.
    e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
    f. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.

5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.

    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.

b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow, so that connected total matches fan selection and simulates actual load in the building.
c. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
d. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

6. Measure fan static pressures as follows:

a. Measure static pressure directly at the fan outlet or through the flexible connection.
b. Measure static pressure directly at the fan inlet or through the flexible connection.
c. Measure static pressure across each component that makes up the air-handling system.
d. Report any artificial loading of filters at the time static pressures are measured.

7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

a. Balance the return-air ducts and inlets.
b. Verify that terminal units are meeting design airflow under system maximum flow.

8. Re-measure the inlet static pressure at the most critical terminal unit, and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls Contractor.
9. Verify final system conditions as follows:

a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
b. Re-measure and confirm that total airflow is within design.
c. Re-measure final fan operating data, speed, volts, amps, and static profile.
d. Mark final settings.
e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
f. Verify tracking between supply and return fans.

3.8 PROCEDURES FOR MULTIZONE SYSTEMS

A. Position the unit's automatic zone dampers for maximum flow through the cooling coil.

B. The procedures for multizone systems will utilize the zone balancing dampers to achieve the indicated airflow within the zone.

C. After balancing, place the unit's automatic zone dampers for maximum heating flow. Retest zone airflows and record any variances.

D. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

    a. Set outside-air, return-air and relief-air dampers for proper position that simulates minimum outdoor air conditions.
    b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
    c. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

2. Measure fan static pressures as follows:

    a. Measure static pressure directly at the fan outlet or through the flexible connection.
    b. Measure static pressure directly at the fan inlet or through the flexible connection.
    c. Measure static pressure across each component that makes up the air-handling system.
    d. Report artificial loading of filters at the time static pressures are measured.

3. Review Record drawings to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from Architect Owner Construction Manager Commissioning Authority for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

E. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

F. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlet and outlet airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

G. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
2. Re-measure and confirm that total airflow is within design.

3. Re-measure all final fan operating data, speed, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.9 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and other equipment. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and equipment flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' Record drawings piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:

1. Check expansion tank for proper setting.
2. Check highest vent for adequate pressure.
3. Check flow-control valves for proper position.
4. Locate start-stop and disconnect switches, electrical interlocks, and motor controllers.
5. Verify that motor controllers are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

D. Measure and record upstream and downstream pressure of each piece of equipment.

E. Measure and record upstream and downstream pressure of pressure-reducing valves.

F. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.

1. Check settings and operation of each safety valve. Record settings.

3.10 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Adjust pumps to deliver total design flow.

1. Measure total water flow.

   a. Position valves for full flow through coils.
   b. Measure flow by main flow meter, if installed.
   c. If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.

2. Measure pump TDH as follows:

   a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.

b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
c. Convert pressure to head and correct for differences in gauge heights.
d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

3. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

B. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

C. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

D. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

E. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

F. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

G. Verify that memory stops have been set.

3.11 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:

1. Verify that the pressure-differential sensor(s) is located as indicated.
2. Determine whether there is diversity in the system.

C. For systems with no flow diversity:

1. Adjust pumps to deliver total design flow.

a. Measure total water flow.

1) Position valves for full flow through coils.
2) Measure flow by main flow meter, if installed.
3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.

b. Measure pump TDH as follows:

1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3) Convert pressure to head and correct for differences in gauge heights.
4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
5) With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

2. Adjust flow-measuring devices installed in mains and branches to design water flows.

a. Measure flow in main and branch pipes.
b. Adjust main and branch balance valves for design flow.
c. Re-measure each main and branch after all have been adjusted.

3. Adjust flow-measuring devices installed at terminals for each space to design water flows.

a. Measure flow at terminals.

b. Adjust each terminal to design flow.
c. Re-measure each terminal after it is adjusted.
d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
e. Perform temperature tests after flows have been balanced.

4. For systems with pressure-independent valves at terminals:

a. Measure differential pressure and verify that it is within manufacturer's specified range.
b. Perform temperature tests after flows have been verified.

5. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.
b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

6. Prior to verifying final system conditions, determine the system pressure-differential set point(s).
7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
8. Mark final settings and verify that all memory stops have been set.
9. Verify final system conditions as follows:

a. Re-measure and confirm that total flow is within design.
b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
c. Mark final settings.

D. For systems with flow diversity:

1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves, as approved by Architect.
3. Adjust pumps to deliver total design flow.

a. Measure total water flow.

1) Position valves for full flow through coils.
2) Measure flow by main flow meter, if installed.
3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.

b. Measure pump TDH as follows:

1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.

2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3) Convert pressure to head and correct for differences in gauge heights.
4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
5) With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

4. Adjust flow-measuring devices installed in mains and branches to design water flows.

a. Measure flow in main and branch pipes.
b. Adjust main and branch balance valves for design flow.
c. Re-measure each main and branch after all have been adjusted.

5. Adjust flow-measuring devices installed at terminals for each space to design water flows.

a. Measure flow at terminals.
b. Adjust each terminal to design flow.
c. Re-measure each terminal after it is adjusted.
d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
e. Perform temperature tests after flows have been balanced.

6. For systems with pressure-independent valves at terminals:

a. Measure differential pressure, and verify that it is within manufacturer's specified range.
b. Perform temperature tests after flows have been verified.

7. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.
b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system pressure-differential set point(s).
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.

11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:

    a. Re-measure and confirm that total water flow is within design.
    b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
    c. Mark final settings.

3.12 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first.

B. Balance the secondary circuits after the primary circuits are complete.

C. Adjust pumps to deliver total design flow.

1. Measure total water flow.

    a. Position valves for full flow through coils.
    b. Measure flow by main flow meter, if installed.
    c. If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.

2. Measure pump TDH as follows:

    a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
    b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
    c. Convert pressure to head and correct for differences in gauge heights.
    d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
    e. With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

3. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.

D. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

E. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.

2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

F. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

G. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

H. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
3. Mark final settings.

I. Verify that memory stops have been set.

3.13 PROCEDURES FOR STEAM AND CONDENSATE SYSTEMS

A. Measure and record upstream and downstream pressure of each piece of equipment.

B. Measure and record upstream and downstream steam pressure of pressure-reducing valves.

C. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.

D. Check settings and operation of each safety valve. Record settings.

E. Verify the operation of each steam trap.

3.14 PROCEDURES FOR STEAM-TO-WATER HEAT EXCHANGERS

A. Adjust and record water flow to within specified tolerances.

B. Measure and record inlet and outlet water temperatures.

C. Measure and record inlet steam pressure and condensate outlet pressure.

D. Check and record settings and operation of safety and relief valves.

3.15 PROCEDURES FOR WATER-TO-WATER HEAT EXCHANGERS

A. Adjust and record water flow to within specified tolerances.

B. Measure and record inlet and outlet water temperatures.

C. Measure and record pressure drop.

D. Check and record settings and operation of safety and relief valves.

3.16 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.17 PROCEDURES FOR WATER CHILLERS

A. Air-Cooled Chillers: Balance water flow through each evaporator to within specified tolerances of indicated flow, with all pumps operating. With only one chiller operating in a multiple-chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:

1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
2. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
3. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.
4. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
5. Capacity: Calculate in tons of cooling.
6. Efficiency: Calculate operating efficiency for comparison to submitted equipment.
7. Verify condenser-fan rotation and record fan and motor data, including number of fans and entering- and leaving-air temperatures.

B. Water-Cooled Chillers: Balance water flow through each evaporator and condenser to within specified tolerances of indicated flow, with all pumps operating. With only one chiller operating in a multiple-chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:

1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
2. Condenser-water entering and leaving temperatures, pressure drop, and water flow.
3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
4. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.
5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
6. Capacity: Calculate in tons of cooling.
7. Efficiency: Calculate operating efficiency for comparison to submitted equipment.

3.18 PROCEDURES FOR AIR-COOLED CONDENSING UNITS

A. Verify proper rotation of fan(s).

B. Measure and record entering- and leaving-air temperatures.

C. Measure and record entering and leaving refrigerant pressures.

D. Measure and record operating data of compressor(s), fan(s), and motors.

3.19 PROCEDURES FOR AIR-COOLED CONDENSERS

A. Verify proper rotation of fan(s).

B. Measure and record entering- and leaving-air temperatures.

C. Measure and record entering and leaving refrigerant pressures.

D. Measure and record operating data of fan(s) and motor(s).

3.20 PROCEDURES FOR BOILERS

A. Hydronic Boilers:

1. Measure and record entering- and leaving-water temperatures.
2. Measure and record water flow.
3. Measure and record pressure drop.
4. Measure and Record relief valve(s) pressure setting.
5. Capacity: Calculate in Btu/h of heating output.
6. Fuel Consumption: If boiler fuel supply is equipped with flow meter, measure and record consumption.
7. Efficiency: Calculate operating efficiency for comparison to submitted equipment.
8. Fan, motor, and motor controller operating data.

B. Steam Boilers:

1. Measure and record entering-water temperature.
2. Measure and record feedwater flow.
3. Measure and record leaving-steam pressure and temperature.
4. Measure and Record relief valve(s) pressure setting.
5. Capacity: Calculate in Btu/h of heating output.
6. Efficiency: Calculate operating efficiency for comparison to submitted equipment.
7. Fan, motor, and motor controller operating data.

C. Boilers with Flue Gas Economizers:

1. Measure and record entering- and leaving-water temperature.
2. Measure and record water flow rate.
3. Measure and record water pressure drop.
4. Heat Recovered: Calculate in Btu/h of waste heat recovered.

3.21 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each hydronic coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Air pressure drop.
5. Voltage and amperage input of each phase at full load.
6. Calculated kilowatt at full load.
7. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Inlet steam pressure.

D. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.

5. Entering and leaving refrigerant pressure and temperatures.

E. AHJ Tests: Conduct additional tests required by authorities having jurisdiction.

3.22 SOUND TESTS

A. After systems are balanced and Substantial Completion, measure and record sound levels at locations as designated by the Architect.

B. Instrumentation:

1. The sound-testing meter shall be a portable, general-purpose testing meter consisting of a microphone, processing unit, and readout.
2. The sound-testing meter shall be capable of showing fluctuations at minimum and maximum levels, and measuring the equivalent continuous sound pressure level (L_{eq}).
3. The sound-testing meter must be capable of using one-third octave band filters to measure mid-frequencies from 31.5 Hz to 8000 Hz.
4. The accuracy of the sound-testing meter shall be plus or minus one decibel.

C. Test Procedures:

1. Perform test at quietest background noise period. Note cause of unpreventable sound that affects test outcome.
2. Equipment should be operating at design values.
3. Calibrate the sound-testing meter prior to taking measurements.
4. Use a microphone suitable for the type of noise levels measured that is compatible with meter. Provide a windshield for outside or in-duct measurements.
5. Record a set of background measurements in dBA and sound pressure levels in the eight unweighted octave bands 63 Hz to 8000 Hz (NC) or 31.5 Hz to 4000 Hz (RC) with the equipment off.
6. Take sound readings in dBA and sound pressure levels in the eight unweighted octave bands 63 Hz to 8000 Hz (NC) or 31.5 Hz to 4000 Hz (RC) with the equipment operating.
7. Take readings no closer than 36 inches from a wall or from the operating equipment and approximately 60 inches from the floor, with the meter held or mounted on a tripod.
8. For outdoor measurements, move sound-testing meter slowly and scan area that has the most exposure to noise source being tested. Use A-weighted scale for this type of reading.

D. Reporting:

1. Report shall record the following:

   a. Location.
   b. System tested.
   c. dBA reading.
   d. Sound pressure level in each octave band with equipment on and off.

2. Plot sound pressure levels on Noise Criteria (NC) or Room Criteria (RC) worksheet with equipment on and off.

3.23 DUCT LEAKAGE TESTS

A. Witness the duct leakage testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.24 PIPE LEAKAGE TESTS

A. Witness the pipe pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.25 HVAC CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify HVAC control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.26 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record the operating speed, airflow, and static pressure of each fan and equipment with fan(s).
2. Measure and record flows, temperatures, and pressures of each piece of equipment in each hydronic system. Compare the values to design or nameplate information, where information is available.
3. Measure motor voltage and amperage. Compare the values to motor nameplate information.
4. Check the refrigerant charge.

5. Check the condition of filters.
6. Check the condition of coils.
7. Check the operation of the drain pan and condensate-drain trap.
8. Check bearings and other lubricated parts for proper lubrication.
9. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. TAB After Construction: Before performing testing and balancing of renovated existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished in accordance with renovation scope indicated by Contract Documents. Verify the following:

1. New filters are installed.
2. Coils are clean and fins combed.
3. Drain pans are clean.
4. Fans are clean.
5. Bearings and other parts are properly lubricated.
6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.

1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the airflow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
4. Balance each air outlet.

3.27 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent . If design value is less than 100 cfm, within 10 cfm.
2. Air Outlets and Inlets: Plus or minus 10 percent. If design value is less than 100 cfm, within 10 cfm.
3. Heating-Water Flow Rate: Plus or minus 10 percent. If design value is less than 10 gpm, within 10 percent.
4. Chilled-Water Flow Rate: Plus or minus 10 percent. If design value is less than 10 gpm, within 10 percent.
5. Condenser-Water Flow Rate: Plus or minus 10 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.28 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents, including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans performance forms, including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Heating coil, dry-bulb conditions.
    e. Face and bypass damper settings at coils.
    f. Fan drive settings, including settings and percentage of maximum pitch diameter.

g. Variable-frequency controller or Inlet vane settings for variable-air-volume systems.
h. Settings for pressure controller(s).
i. Other system operating conditions that affect performance.

16. Test conditions for pump performance forms, including the following:

a. Variable-frequency controller settings for variable-flow hydronic systems.
b. Settings for pressure controller(s).
c. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units, include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Unit arrangement and class.
g. Discharge arrangement.
h. Sheave make, size in inches, and bore.
i. Center-to-center dimensions of sheave and amount of adjustments in inches.
j. Number, make, and size of belts.
k. Number, type, and size of filters.

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and speed.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.

b. Total system static pressure in inches wg.
c. Fan speed.
d. Inlet and discharge static pressure in inches wg.
e. For each filter bank, filter static-pressure differential in inches wg.
f. Preheat-coil static-pressure differential in inches wg.
g. Cooling-coil static-pressure differential in inches wg.
h. Heating-coil static-pressure differential in inches wg.
i. List for each internal component with pressure-drop, static-pressure differential in inches wg.
j. Outdoor airflow in cfm.
k. Return airflow in cfm.
l. Outdoor-air damper position.
m. Return-air damper position.
n. Vortex damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch o.c.
f. Make and model number.
g. Face area in sq. ft.
h. Tube size in NPS.
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.
d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig.
n. Refrigerant suction temperature in deg F.
o. Inlet steam pressure in psig.

G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

    a. System identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Fuel type in input data.
    g. Output capacity in Btu/h.
    h. Ignition type.
    i. Burner-control types.
    j. Motor horsepower and speed.
    k. Motor volts, phase, and hertz.
    l. Motor full-load amperage and service factor.
    m. Sheave make, size in inches, and bore.
    n. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Test Data (Indicated and Actual Values):

    a. Total airflow rate in cfm.
    b. Entering-air temperature in deg F.
    c. Leaving-air temperature in deg F.
    d. Air temperature differential in deg F.
    e. Entering-air static pressure in inches wg.
    f. Leaving-air static pressure in inches wg.
    g. Air static-pressure differential in inches wg.
    h. Low-fire fuel input in Btu/h.
    i. High-fire fuel input in Btu/h.
    j. Manifold pressure in psig.
    k. High-temperature-limit setting in deg F.
    l. Operating set point in Btu/h.
    m. Motor voltage at each connection.
    n. Motor amperage for each phase.
    o. Heating value of fuel in Btu/h.

H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:

    a. System identification.
    b. Location.
    c. Coil identification.
    d. Capacity in Btu/h.
    e. Number of stages.
    f. Connected volts, phase, and hertz.
    g. Rated amperage.
    h. Airflow rate in cfm.
    i. Face area in sq. ft.
    j. Minimum face velocity in fpm.

2. Test Data (Indicated and Actual Values):

   a. Heat output in Btu/h.
   b. Airflow rate in cfm.
   c. Air velocity in fpm.
   d. Entering-air temperature in deg F.
   e. Leaving-air temperature in deg F.
   f. Voltage at each connection.
   g. Amperage for each phase.

I. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

   a. System identification.
   b. Location.
   c. Make and type.
   d. Model number and size.
   e. Manufacturer's serial number.
   f. Arrangement and class.
   g. Sheave make, size in inches, and bore.
   h. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Motor Data:

   a. Motor make, and frame type and size.
   b. Horsepower and speed.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches, and bore.
   f. Center-to-center dimensions of sheave and amount of adjustments in inches.
   g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

   a. Total airflow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan speed.
   d. Discharge static pressure in inches wg.
   e. Suction static pressure in inches wg.

J. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

   a. System fan and air-handling-unit number.
   b. Location and zone.
   c. Traverse air temperature in deg F.
   d. Duct static pressure in inches wg.

e. Duct size in inches.
f. Duct area in sq. ft.
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

K. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq. ft.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Air velocity in fpm.
c. Preliminary airflow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final airflow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

L. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

M. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves, and include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model number and serial number.
f. Water flow rate in gpm.
g. Water pressure differential in feet of head or psig.
h. Required net positive suction head in feet of head or psig.
i. Pump speed.
j. Impeller diameter in inches.
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.
n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig.
b. Pump shutoff pressure in feet of head or psig.
c. Actual impeller size in inches.
d. Full-open flow rate in gpm.
e. Full-open pressure in feet of head or psig.
f. Final discharge pressure in feet of head or psig.
g. Final suction pressure in feet of head or psig.
h. Final total pressure in feet of head or psig.
i. Final water flow rate in gpm.
j. Voltage at each connection.
k. Amperage for each phase.

N. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.29 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection.

B. Randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to the lesser of either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 20 percent of the total measurements checked during the final inspection, the TAB shall be considered incomplete and shall be rejected.

E. If recheck measurements find the number of failed measurements noncompliant with requirements indicated, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection. All changes shall be tracked to show changes made to previous report.
2. If the second final inspection also fails, Owner may pursue others Contract options to complete TAB work.

F. Prepare test and inspection reports.

3.30 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
7. Outdoor, concealed supply and return.
8. Outdoor, exposed supply and return.

B. Related Sections:

1. Section 230716 "HVAC Equipment Insulation."
2. Section 230719 "HVAC Piping Insulation."
3. Section 233113 "Metal Ducts" for duct liners.

1.2 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 insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.

1.3 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.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program, certified by the Department of Labor, Bureau of Apprenticeship and Training.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers are to be marked with the manufacturer's name, appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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 installation and testing of heat tracing.

1.7 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.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.

1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. All Insulation Installed Indoors; Outdoors-Installed Insulation in Contact with Airstream: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

3. All Insulation Installed Indoors and Outdoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials are to be applied.

B. Products do not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.

E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric: Closed-cell or expanded-rubber materials; suitable for maximum use temperature between minus 70 deg F and 220 deg F. Comply with ASTM C534, Type II for sheet materials.

G. Glass-Fiber Blanket: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 450 deg F in accordance with ASTM C411. Comply with ASTM C553, Type II, and ASTM C1290, Type I, unfaced, 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.

H. Glass-Fiber Board Insulation: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature between 35 deg F and 250 deg F for jacketed and between 35 deg F and 450 deg F for unfaced in accordance with ASTM C411. Comply with ASTM C612, Type IA or Type IB. For duct and plenum applications, provide insulation unfaced, with factory-applied ASJ or with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

I. Glass-Fiber, Pipe and Tank: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature between 35 deg F and 850 deg F, in accordance with ASTM C411. Comply with ASTM C1393.

1. Semirigid board material with factory-applied ASJ or FSK jacket.
2. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

J. Polyolefin: Polyethylene thermal plastic insulation. Comply with ASTM C1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

2.3 ADHESIVES

A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

C. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

D. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

E. PVC Jacket Adhesive: Compatible with PVC jacket.

2.4 MASTICS AND COATINGS

A. Materials are compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below ambient services.

1. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.
4. Color: White.

C. Vapor-Retarder Mastic, Solvent Based, Interior Use: Suitable for indoor use on below ambient services.

1. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
2. Service Temperature Range: 0 to 180 deg F.
3. Color: White.

D. Vapor-Retarder Mastic, Solvent Based, Exterior Use: Suitable for outdoor use on below ambient services.

1. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
2. Service Temperature Range: Minus 50 to plus 220 deg F.
3. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Water-Vapor Permeance: ASTM E96, greater than 1.0 perm at manufacturer's recommended dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and are compatible with insulation materials, jackets, and substrates.

1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
2. Service Temperature Range: 0 to plus 180 deg F.
3. Color: White.

2.6 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Materials are compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

1. Materials are compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.

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 C1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested in accordance with ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.
6. ASJ+: All-service jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136, Types I, II, III, IV, and VII.
7. PSK Jacket: Aluminum foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets comply with ASTM C921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, 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. Adhesive: As recommended by jacket material manufacturer.
2. Color: White or Color-code jackets based on system. Color as selected by Architect.

D. Metal Jacket:

1. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

   a. Sheet and roll stock ready for shop or field sizing Factory cut and rolled to size.
   b. Finish and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier for Indoor Applications: 1-mil thick, heat-bonded polyethylene and kraft paper, 3-mil thick, heat-bonded polyethylene and kraft paper or 3-mil thick polysurlyn.
   d. Moisture Barrier for Outdoor Applications: 3-mil thick, heat-bonded polyethylene and kraft paper 3-mil thick polysurlyn.

2. Stainless-Steel Jacket: ASTM A167 or ASTM A240/A240M.

   a. Sheet and roll stock ready for shop or field sizing or Factory cut and rolled to size.
   b. Material, finish, and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier for Indoor Applications: 1-mil thick, heat-bonded polyethylene and kraft paper, 3-mil thick, heat-bonded polyethylene and kraft paper or 3-mil thick polysurlyn.
   d. Moisture Barrier for Outdoor Applications: 3-mil thick, heat-bonded polyethylene and kraft paper or 3-mil thick polysurlyn.

E. Self-Adhesive Outdoor Jacket (Asphaltic): 60-mil thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors;

consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white stucco-embossed aluminum-foil facing.

F. Self-Adhesive Indoor/Outdoor Jacket (Non-Asphaltic): Vapor barrier and waterproofing jacket for installation over insulation located aboveground outdoors or indoors. Specialized jacket has five layers of laminated aluminum and polyester film with low-temperature acrylic pressure-sensitive adhesive. Outer aluminum surface is coated with UV-resistant coating for protection from environmental contaminants.

1. Permeance: 0.00 perm as tested in accordance with ASTM F1249.
2. Flamespread/Smoke Developed: 25/50 as tested in accordance with ASTM E84.
3. Aluminum Finish: Embossed or Smooth.

2.9 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Mesh: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering ducts.

B. Woven Polyester Mesh: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for ducts.

2.10 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Cloth: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

2.11 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1. Width: 3 inches.
2. Thickness: 11.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. 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 C1136.

1. Width: 3 inches.
2. Thickness: 6.5 mils.
3. Adhesion: 90 ounces force/inch in width.

4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. 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. Width: 2 inches.
2. Thickness: 6 mils.
3. Adhesion: 64 ounces force/inch in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Width: 2 inches.
2. Thickness: 3.7 mils.
3. Adhesion: 100 ounces force/inch in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch in width.

2.12 SECUREMENTS

A. Bands:
1. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch or 3/4 inch wide with wing seal or closed seal.
2. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch or 3/4 inch wide with wing seal or closed seal.
3. 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.

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.

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
b. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum or Stainless steel, fully annealed, 0.106-inch diameter shank, length to suit depth of insulation indicated.
c. 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, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
b. Spindle: Nylon, 0.106-inch diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
c. 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, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
b. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum or Stainless steel, fully annealed, 0.106-inch diameter shank, length to suit depth of insulation indicated.
c. Adhesive-backed base with a peel-off protective cover.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick, galvanized-steel, aluminum or stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

a. 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 as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch wide, stainless steel or Monel.

D. Wire: 0.080-inch nickel-copper alloy, 0.062-inch soft-annealed, stainless steel or 0.062-inch soft-annealed, galvanized steel.

2.13 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC in accordance with ASTM D1784, 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 in accordance with ASTM B209, 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 in accordance with ASTM A167 or ASTM A240/A240M, 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 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. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

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

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct 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, compress, or otherwise damage insulation or jacket .

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. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with Contract Documents, unless otherwise approved by the engineer-of-record.

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.

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.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
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 o.c.
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 2 inches o.c.

   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 duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. 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.

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 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.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. 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 Section 078413 "Penetration Firestopping."

E. 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 Section 078413 "Penetration Firestopping."

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC AND POLYOLEFIN INSULATION

A. Comply with manufacturer's written installation instructions and ASTM C1710.

B. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Square and Rectangular Ducts and Plenums:

1. Provide 1/4 inch more per side for a tight, compression fit.
2. Cut sheet insulation with the following dimensions:

a. Width of duct plus 1/4 inch, one piece.
b. Height of duct plus 1/4 inch, plus thickness of insulation, two pieces.
c. Width of duct plus 1/4 inch, plus 2 times the thickness of insulation, one piece.

3. Insulate the bottom of the duct with the sheet from (a) above, then the sides with the two sheets from (b) above, and finally the top of the duct with the sheet from (c) above.
4. Insulation without self-adhering backing:

   a. Apply 100 percent coverage of manufacturer adhesive on the metal surface, then the insulation, except for the last 1/4 inch where sheets will butt together.
   b. Roll sheet down into position.
   c. Press two sheets together under compression and apply adhesive at the butt joint to seal the two sheets together.

5. Insulation with self-adhering backing:

   a. Peel back release paper in 6- to 8-inch increments and line up sheet.
   b. Press firmly to activate adhesive.
   c. Align material and continue to line up correctly, pressing firmly while slowly removing release paper.
   d. Allow 1/4-inch overlap for compression at butt joints.
   e. Apply adhesive at the butt joint to seal the two sheets together.

6. Insulate duct brackets following manufacturer's written installation instructions.

D. Circular Ducts:

1. Determine the circumference of the duct, using a strip of insulation the same thickness as to be used.
2. Cut the sheet to the required size.
3. Apply 100 percent coverage of manufacturer adhesive on the metal surface then the insulation.
4. Apply manufacturer adhesive to the cut surfaces along 100 percent of the longitudinal seam. Press together the seam at the ends and then the middle. Close the entire seam starting from the middle.

3.6 INSTALLATION OF GLASS-FIBER AND MINERAL-WOOL INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

B. Comply with manufacturer's written installation instructions.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 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 o.c.
b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. 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 overcompress insulation during installation.
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 o.c. 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 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 o.c.
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 o.c.

C. 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, for 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 o.c.

b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. 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 overcompress 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 o.c. 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 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 o.c.

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 overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's 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 o.c. and at end joints.

3.8 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "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.

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.

3.9 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 is limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

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

3.10 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
7. Outdoor, concealed supply and return.
8. Outdoor, exposed supply and return.

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

3.11 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, supply-air plenum insulation is one of the following:

1. Flexible Elastomeric: 1 inch thick.
2. Glass-Fiber Blanket: 2 inches thick and installed R-value of R-6.
3. Glass-Fiber Board: 2 inches thick and installed R-value of R-6/.
4. Mineral Wool Blanket: 2 inches thick and installed R-value of R-6.
5. Mineral Wool Board: 2 inches thick and installed R-value of R-6.
6. Polyolefin: 1 inch thick.
7. Insulation R-values to be in accordance with IECC.

B. Concealed, return-air plenum insulation is one of the following:

1. Flexible Elastomeric: 1 inch thick.
2. Glass-Fiber Blanket: 2 inches thick and installed R-value of R-6.
3. Glass-Fiber Board: 2 inches thick and insulation R-value of R-6.
4. Mineral Wool Blanket: 2 inches thick and insulation R-value of R-6.
5. Mineral Wool Board: 2 inches thick and insulation R-value of R-6.
6. Polyolefin: 1 inch thick.
7. Insulation R-values to be in accordance with IECC.

C. Concealed, outdoor-air plenum insulation is one of the following:

1. Glass-Fiber Blanket: 1-1/2 inches thick and 0.75 lb/cu. ft. nominal density.

2. Glass-Fiber Board: 1-1/2 inches thick and 2 lb/cu. ft. nominal density.
3. Mineral Wool Blanket: 1-1/2 inches thick and 4 lb/cu. ft. nominal density.
4. Mineral Wool Board: 1-1/2 inches thick and 4 lb/cu. ft. nominal density.
5. Insulation R-values to be in accordance with IECC.

D. Concealed, exhaust-air plenum insulation is one of the following:

1. Glass-Fiber Blanket: 1-1/2 inches thick and 0.75 lb/cu. ft. nominal density.
2. Glass-Fiber Board: 1-1/2 inches thick and 2 lb/cu. ft. nominal density.
3. Mineral Wool Blanket: 1-1/2 inches thick and 4 lb/cu. ft. nominal density.
4. Mineral Wool Board: 1-1/2 inches thick and 4 lb/cu. ft. nominal density.
5. Insulation R-values to be in accordance with IECC.

E. Exposed, supply-air plenum insulation is one of the following:

1. Flexible Elastomeric: 1 inch thick and R-value of R-6.
2. Glass-Fiber Blanket: 2 inches thick and installed R-value of R-6.
3. Glass-Fiber Board: 2 inches thick and installed R-value of R-6.
4. Mineral Wool Blanket: 2 inches thick and installed R-value of R-6.
5. Mineral Wool Board: 2 inches thick and installed R-value of R-6.
6. Polyolefin: 1 inch thick and installed R-value of R-6.
7. Insulation R-values to be in accordance with IECC.

F. Exposed, return-air plenum insulation is one of the following:

1. Flexible Elastomeric: 1 inch thick and installed R-value of R-6.
2. Glass-Fiber Blanket: 2 inches thick and installed R-value of R-6.
3. Glass-Fiber Board: 2 inches thick and installed R-value of R-6.
4. Mineral Wool Blanket: 2 inches thick and installed R-value of R-6.
5. Mineral Wool Board: 2 inches thick and installed R-value of R-6.
6. Polyolefin: 1 inch thick and installed R-value of R-6.
7. Insulation R-values to be in accordance with IECC.

G. Exposed, outdoor-air plenum insulation is one of the following:

1. Glass-Fiber Blanket: 1-1/2 inches thick and 0.75 lb/cu. ft. nominal density.
2. Glass-Fiber Board: 1-1/2 inches thick and 2 lb/cu. ft. nominal density.
3. Mineral Wool Blanket: 1-1/2 inches thick and 4 lb/cu. ft. nominal density.
4. Mineral Wool Board: 1-1/2 inches thick and 4 lb/cu. ft. nominal density.
5. Insulation R-values to be in accordance with IECC.

H. Exposed, exhaust-air plenum insulation is one of the following:

1. Glass-Fiber Blanket: 1-1/2 inches thick and 0.75 lb/cu. ft. nominal density.
2. Glass-Fiber Board: 1-1/2 inches thick and 2 lb/cu. ft. nominal density.
3. Mineral Wool Blanket: 1-1/2 inches thick and 4 lb/cu. ft. nominal density.
4. Mineral Wool Board: 1-1/2 inches thick and 4 lb/cu. ft. nominal density.
5. Insulation R-values to be in accordance with IECC.

3.12 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.

B. Concealed, supply-air plenum insulation is one of the following:

1. Glass-Fiber Blanket: 3 inches and installed R-value of R-12.
2. Glass-Fiber Board: 3 inches thick and installed R-value of R-12.
3. Mineral Wool Blanket: 2 inches thick and installed R-value of R-12.
4. Mineral Wool Board: 2 inches thick and installed R-value of R-12.
5. Insulation R-values to be in accordance with IECC.

C. Concealed, return-air plenum insulation is one of the following:

1. Glass-Fiber Blanket: 3 inches and installed R-value of R-12.
2. Glass-Fiber Board: 3 inches thick and installed R-value of R-12.
3. Mineral Wool Blanket: 2 inches thick and installed R-value of R-12.
4. Mineral Wool Board: 2 inches thick and installed R-value of R-12.
5. Insulation R-values to be in accordance with IECC.

D. Exposed supply-air duct insulation is one of the following:

1. Glass-Fiber Blanket: 3 inches and installed R-value of R-12.
2. Glass-Fiber Board: 3 inches thick and installed R-value of R-12.
3. Mineral Wool Blanket: 3 inches thick and installed R-value of R-12.
4. Mineral Wool Board: 3 inches thick and installed R-value of R-12.
5. Insulation R-values to be in accordance with IECC.

E. Exposed return-air duct insulation is one of the following:

1. Glass-Fiber Blanket: 3 inches and installed R-value of R-12.
2. Glass-Fiber Board: 3 inches thick and installed R-value of R-12.
3. Mineral Wool Blanket: 3 inches thick and installed R-value of R-12.
4. Mineral Wool Board: 3 inches thick and installed R-value of R-12.
5. Insulation R-values to be in accordance with IECC.

F. Exposed, supply-air plenum insulation is one of the following:

1. Glass-Fiber Blanket: 3 inches and installed R-value of R-12.
2. Glass-Fiber Board: 3 inches thick and installed R-value of R-12.
3. Mineral Wool Blanket: 3 inches thick and installed R-value of R-12.
4. Mineral Wool Board: 3 inches thick and installed insulation of R-12.
5. Insulation R-values to be in accordance with IECC.

G. Exposed, return-air plenum insulation is one of the following:

1. Glass-Fiber Blanket: 3 inches and installed R-value of R-12.
2. Glass-Fiber Board: 3 inches thick and installed R-value of R-12.
3. Mineral Wool Blanket: 3 inches thick and installed R-value of R-12.

4. Mineral Wool Board: 3 inches thick and installed R-value of R-12.
5. Insulation R-values to be in accordance with IECC.

3.13 INDOOR, 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. Ducts and Plenums, Concealed:

1. PVC or PVC, Color-Coded by System: 30 mils thick.
2. Aluminum, Smooth Corrugated Stucco Embossed: 0.024 inch or 0.032 inch.
3. Painted Aluminum, Smooth, Corrugated or Stucco Embossed: 0.024 inch or 0.032 inch thick.

D. Ducts and Plenums, Exposed:

1. PVC or PVC, Color-Coded by System: 30 mils thick.
2. Aluminum, Smooth, Corrugated or Stucco Embossed: 0.024 inch or 0.032 inch thick.
3. Painted Aluminum, Smooth, Corrugated or Stucco Embossed: 0.024 inch or 0.032 inch thick.

3.14 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. Ducts and Plenums, Concealed:

1. PVC or PVC, Color-Coded by System: 30 mils thick.
2. Aluminum, Smooth, Corrugated or Stucco Embossed: 0.024 inch, 0.032 inch or 0.040 inch thick.
3. Painted Aluminum, Smooth, Corrugated Stucco Embossed: 0.024 inch or 0.032 inch thick.

D. Ducts and Plenums, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:

1. Aluminum, Smooth, Corrugated or Stucco Embossed: 0.024 inch, 0.032 inch or 0.040 inch thick.
2. Painted Aluminum, Smooth Corrugated Stucco Embossed: 0.024 inch or 0.032 inch thick.

E. Ducts and Plenums, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:

1. Painted Aluminum, Smooth or Stucco Embossed with 1-1/4-Inch Deep Corrugations: 0.040 inch thick.

END OF SECTION 230713

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulation for HVAC piping systems.

B. Related Requirements:

1. Section 230713 "Duct Insulation" for duct insulation.
2. Section 230716 "HVAC Equipment Insulation" for equipment insulation.

1.2 ACTION SUBMITTALS

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

1. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
2. Sheet Form Insulation Materials: 12 inches square.
3. Jacket Materials for Pipe: 12 inches long by NPS 2.
4. Sheet Jacket Materials: 12 inches square.
5. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.3 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.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program, certified by the Department of Labor, Bureau of Apprenticeship and Training.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation system materials are to be delivered to the Project site in unopened containers. The packaging is to include name of manufacturer, fabricator, type, description, and size, as well as ASTM standard designation, and maximum use temperature.

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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.

1.7 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.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84 by a testing agency acceptable to authority having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.

1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. All Insulation Installed Indoors; Outdoors-Installed Insulation in Contact with Airstream: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
3. All Insulation Installed Indoors and Outdoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 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 are applied.

B. Products do not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come into contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.

E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.

F. Calcium Silicate: Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C533, Type I.

1. Prefabricated Fitting Covers: Comply with ASTM C450 and ASTM C585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Comply with ASTM C552.
1. Preformed Pipe Insulation without Jacket: Type II, Class 1, unfaced.
2. Preformed Pipe Insulation with Jacket: Type II, Class 2, with factory-applied ASJ, ASJ-SSL, ASJ+ or PSK jacket.
3. Fabricated shapes in accordance with ASTM C450, ASTM C585, and ASTM C1639.
4. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

H. Flexible Elastomeric: Closed-cell, or expanded-rubber materials; suitable for maximum use temperature between minus 70 deg F and 220 deg F. Comply with ASTM C534/C534M, Type I, for tubular materials, Type II for sheet materials.

I. Glass-Fiber, Preformed Pipe: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 850 deg F in accordance with ASTM C411. Comply with ASTM C547.

1. Preformed Pipe Insulation: Type I, Grade A, unfaced with factory-applied ASJ, with factory-applied ASJ-SSL, with factory-applied ASJ+ jacket or with factory-applied PSK jacket.
2. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
3. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

J. Mineral Wool, Preformed Pipe: Mandrel-wound mineral wool fibers bonded with a thermosetting resin, unfaced; suitable for maximum use temperature up to 1200 deg F in accordance with ASTM C447. Comply with ASTM C547.

1. Preformed Pipe Insulation: Type II, Grade A, unfaced, with factory-applied ASJ with factory-applied ASJ-SSL, with factory-applied ASJ+ jacket or with factory-applied PSK jacket.
2. Fabricated shapes in accordance with ASTM C450 and ASTM C585.

K. Glass-Fiber, Pipe and Tank: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature between 35 deg F and 850 deg F, in accordance with ASTM C411. Comply with ASTM C1393.

1. Semirigid board material with factory-applied ASJ, FSK, ASJ+ or PSK jacket.
2. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

L. Mineral Wool, Pipe and Tank: Mineral wool fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 1000 deg F, in accordance with ASTM C411. Comply with ASTM C1393.

1.
2. Semirigid board material with factory-applied ASJ FSK ASJ+ PSK jacket.
3. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

M. Phenolic: Prefabricated pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C1126, Type III.

1.
2. Prefabricated Pipe Insulation: Type III, unfaced , with factory-applied ASJ with factory-applied ASJ+ jacket with factory-applied PSK jacket.
3. Prefabricated shapes in accordance with ASTM C450 and ASTM C585.
4. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

N. Polyisocyanurate: Prefabricated, rigid cellular polyisocyanurate material intended for use as thermal insulation. Comply with ASTM C591.

1.
2. Prefabricated insulation, unfaced , with factory-applied ASJ , with factory-applied ASJ-SSL , with field-applied PVDC jacket , with field-applied PVDC-SSL.
3. Type IV, except thermal conductivity (k-value) do not exceed 0.19 Btu x in./h x sq. ft. x deg F at 75 deg F after 180 days of aging.

4. Flame-spread index is 25 or less, and smoke-developed index is 50 or less for thicknesses of up to 1.5 inch as tested in accordance with ASTM E84.
5. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
6. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

O. Polyolefin: Polyethylene thermal plastic insulation. Comply with ASTM C1427, Type I, Grade 1, for tubular materials and with Type II, Grade 1, for sheet materials, self-seal.

1.

P. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C578, Type I-XII for board or Type XIII for pipe insulation, except thermal conductivity (k-value) do not exceed 0.26 Btu x in./h x sq. ft. x deg F after 180 days of aging. Fabricate shapes in accordance with ASTM C450 and ASTM C585.

1.

2.3 INSULATING CEMENTS

A. Glass-Fiber and Mineral Wool Insulating Cement: Comply with ASTM C195.

1.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C196.

1.

C. Glass-Fiber and Mineral Wool Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

1.

2.4 ADHESIVES

A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.

1.

C. 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.

D. Phenolic and Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

1.

E. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.

1.
2. Flame-spread index is 25 or less and smoke-developed index is 50 or less as tested in accordance with ASTM E84.
3. Wet Flash Point: Below 0 deg F.
4. Service Temperature Range: 40 to 200 deg F.
5. Color: Black .

F. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1.

G. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F.

1.

H. ASJ Adhesive and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.

1.

I. PVC Jacket Adhesive: Compatible with PVC jacket.

1.

2.5 MASTICS AND COATINGS

A. Materials are compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.

1.
2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
3. Service Temperature Range: 0 to plus 180 deg F.
4. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.
5. Color: White .

C. Vapor-Retarder Mastic, Solvent Based, Indoor Use: Suitable for indoor use on below-ambient services.

1.
2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
3. Service Temperature Range: 0 to 180 deg F.
4. Color: White .

D. Vapor-Retarder Mastic, Solvent Based, Outdoor Use: Suitable for outdoor use on below-ambient services.

1.
2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Color: White .

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1.
2. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
3. Service Temperature Range: 0 to plus 180 deg F.
4. Color: White .

2.6 LAGGING ADHESIVES

A. Adhesives comply with MIL-A-3316C, Class I, Grade A, and are compatible with insulation materials, jackets, and substrates.

1.
2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
3. Service Temperature Range: 0 to plus 180 deg F.
4. Color: White.

2.7 SEALANTS

A. Materials are as recommended by the insulation manufacturer and are compatible with insulation materials, jackets, and substrates.

B. Joint Sealants:

1.
2. Permanently flexible, elastomeric sealant.

   a. Service Temperature Range: Minus 150 to plus 250 deg F.
   b. Color: White or gray.

C. FSK and Metal Jacket Flashing Sealants:

1.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.

D. ASJ Flashing Sealants and PVDC and PVC Jacket Flashing Sealants:

1.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.

2.8 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 C1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
4. ASJ+: Aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136, Types I, II, III, IV, and VII.
5. PSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

2.9 FIELD-APPLIED JACKETS

A. Field-applied jackets comply with ASTM C1136, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, 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.
2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White, Color-code jackets based on system.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

   a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

D. Metal Jacket:

1.
2. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.

   a. Sheet and roll stock ready for shop or field sizing or Factory cut and rolled to size.

b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper.
d. Moisture Barrier for Outdoor Applications: 53-mil- thick, heat-bonded polyethylene and kraft paper or 53-mil- thick polysurlyn.
e. 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.

3. Stainless Steel Jacket: ASTM A240/A240M.

a. Sheet and roll stock ready for shop or field sizing Factory cut and rolled to size.
b. Material, finish, and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper.
d. Moisture Barrier for Outdoor Applications: 53-mil- thick, heat-bonded polyethylene and kraft paper or 53-mil- thick polysurlyn.
e. 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.

E. Underground Direct-Buried Jacket: 125-mil- 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.

F. Self-Adhesive Outdoor Jacket (Asphaltic): 60-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with white stucco-embossed aluminum-foil facing.

1.

G. Self-Adhesive Indoor/Outdoor Jacket (Non-Asphaltic): Vapor barrier and waterproofing jacket for installation over insulation located aboveground outdoors or indoors. Specialized jacket has five layers of laminated aluminum and polyester film with low-temperature acrylic pressure-sensitive adhesive. Outer aluminum surface is coated with UV-resistant coating for protection from environmental contaminants.

1.
2. Permeance: 0.00 perm as tested in accordance with ASTM F1249.
3. Flamespread/Smoke Developed: 25/50 as tested in accordance with ASTM E84.
4. Aluminum Finish: Embossed or Smooth.

H. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested in accordance with ASTM E96/E96M and with a flame-spread index of 10 and a smoke-developed index of 20 when tested in accordance with ASTM E84.

1.

I. PVDC Jacket for Outdoor Applications: 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested in accordance with ASTM E96/E96M and with a flame-spread index of 25 and a smoke-developed index of 50 when tested in accordance with ASTM E84.

1.

J. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

1.

2.10 FIELD-APPLIED FABRIC REINFORCING MESH

A. Woven Glass-Fiber Mesh: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.

1.

B. Woven Polyester Mesh: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.

1.

2.11 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Cloth: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

1.

2.12 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1.
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 C1136.

1.
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.
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.
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.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1.
2. Width: 3 inches .

3. Film Thickness: 2 mils .
4. Adhesive Thickness: 1.5 mils .
5. Elongation at Break: 120 percent.
6. Tensile Strength: 20 psi in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

1.
2. Width: 3 inches .
3. Film Thickness: 6 mils .
4. Adhesive Thickness: 1.5 mils .
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 psi in width.

2.13 SECUREMENTS

A. Bands:

1.
2. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.
3. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.
4. Springs: Twin spring set constructed of stainless steel, with ends flat and slotted to accept metal bands. Spring size is determined by manufacturer for application.

B. Staples: Outward-clinching insulation staples, nominal 3/4 inch wide, stainless steel or Monel.

C. Wire: 0.080-inch nickel-copper alloy, 0.062-inch soft-annealed, stainless steel or 0.062-inch soft-annealed, galvanized steel.

1.

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 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. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. 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 of 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 tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. 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. 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 of 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, compress, or otherwise damage insulation or jacket.

D. Install insulation with longitudinal seams at top and bottom (12 o'clock and 6 o'clock positions) 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 storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with the Contract Documents, unless otherwise approved by the engineer of record.

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 attached to structure with vapor-barrier mastic.
3. Install insert materials and 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, but not to the extent of creating wrinkles or areas of compression in the insulation.
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 o.c.
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 o.c.
4. For below-ambient services, apply vapor-barrier mastic over staples.
5. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
6. 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.

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 in similar fashion 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.

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. 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 Section 078413 "Penetration Firestopping" 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 Section 078413 "Penetration Firestopping."

3.5 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 below.

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

1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using prefabricated fitting insulation or mitered or routed fittings made from same material and density as that of adjacent pipe insulation. Each piece is 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 prefabricated fitting insulation or sectional pipe insulation of same material and thickness as that 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 prefabricated fitting insulation or sectional pipe insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 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 prefabricated fitting insulation or sectional pipe insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 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, mechanical couplings, and unions using a section of oversized preformed pipe insulation to fit. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
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 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.

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 conforms 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 that of adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 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.

3.6 INSTALLATION OF CALCIUM SILICATE INSULATION

A. 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.

B. Insulation Installation on Pipe Flanges:

1. Install prefabricated 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 that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.
4. Finish flange insulation same as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When prefabricated 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.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install pipe insulation, quads, hex sections, or beveled lag segments, adhered together, 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.

3.7 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 jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with 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 prefabricated 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 that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.
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 prefabricated sections of same material as that of 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 or routed sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install prefabricated 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 manufacturer's 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 that of pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's 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 sections of pipe insulation and miter if required in accordance with manufacturer's written instructions.
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 prefabricated valve covers manufactured of same material as that of pipe insulation when available.
2. When prefabricated 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 GLASS-FIBER AND MINERAL WOOL 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 jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with 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 prefabricated 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 glass-fiber or mineral-wool 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 prefabricated sections of same material as that of 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 prefabricated sections of same material as that of straight segments of pipe insulation when available.
2. When prefabricated sections are not available, install fabricated 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 PHENOLIC INSULATION

A. General Installation Requirements:

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 0.062-inch wire spaced at 12-inch intervals. Secure outer layer with stainless steel bands at 12-inch intervals.

B. 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 jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with jackets with vapor retarder 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.

C. Insulation Installation on Pipe Flanges:

1. Install prefabricated 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 that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install prefabricated insulation sections, or mitered or routed fittings, of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install prefabricated insulation sections of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.
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.

3.11 INSTALLATION OF POLYISOCYANURATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3- and 9-o'clock positions on the pipe.
2. For insulation with jackets with vapor barriers, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive or tape, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic.
3. All insulation is tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:

1. Install prefabricated pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, and same thickness as that of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.

C. Insulation Installation on Fittings and Elbows:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install prefabricated sections of polyisocyanurate 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.

3.12 INSTALLATION OF POLYOLEFIN INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive ,or via self-seal mechanism 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 that of pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's 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.

3.13 INSTALLATION OF POLYSTYRENE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3- and 9-o'clock positions on the pipe.
2. For insulation with jackets with vapor barriers, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive or tape, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic.
3. All insulation is tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:

1. Install prefabricated pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, and make thickness same as that of adjacent pipe insulation, not to exceed 1-1/2 inches.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness that of as pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install prefabricated insulation sections of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install prefabricated section of polystyrene 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.

3.14 INSTALLATION OF FIELD-APPLIED JACKETS

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 and for horizontal applications, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's 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 o.c. and at end joints.

E. Where PVDC jackets are indicated, install as follows:

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap presized jackets around individual pipe insulation sections, with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
3. Continuous jacket can be spiral-wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch- circumference limit allows for 2-inch- overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.15 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "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.

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.

3.16 FIELD QUALITY CONTROL

A. Owner will engage a qualified testing agency to perform tests and inspections.

B. Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative.

E. Tests and Inspections: 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 is 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.

F. All insulation applications will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

3.17 PIPING INSULATION SCHEDULE, GENERAL

A. Insulation conductivity and thickness per pipe size comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.

B. 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.

C. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Underground piping.
2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.18 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:

1. All Pipe Sizes: Insulation is one of the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Flexible Elastomeric: 1 inch thick.
c. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
d. Mineral Wool, Preformed Pipe Insulation, Type II: 1 inch thick.
e. Phenolic: 1 inch thick.
f. Polyisocyanurate: 1 inch thick.
g. Polyolefin: 1 inch thick.
h. Thermal conductivity shall be IECC compliant.

B. Chilled Water and Brine, 40 Deg F and below:

1. NPS 6 and Smaller: Insulation is one of the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Flexible Elastomeric: 1 inch thick.
c. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
d. Mineral Wool, Preformed Pipe Insulation, Type II: 1 inch thick.
e. Phenolic: 1 inch thick.
f. Polyisocyanurate: 1 inch thick.
g. Polyolefin: 1 inch thick.
h. Thermal conductivity shall be IECC compliant.

2. NPS 8 and Larger: Insulation is one of the following:

a. Cellular Glass: 2 inches thick.
b. Glass-Fiber, Preformed Pipe Insulation, Type I, or Pipe and Tank Insulation: 2 inches thick.
c. Mineral Wool, Preformed Pipe Insulation, Type II, or Pipe and Tank Insulation: 2 inches thick.
d. Phenolic: 2 inches thick.
e. Thermal conductivity shall be IECC compliant.

C. Chilled Water and Brine, Above 40 Deg F:

1. Insulation is one of the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Flexible Elastomeric: 1 inch thick.

c. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
d. Mineral Wool, Preformed Pipe Insulation, Type II: 1 inch thick.
e. Phenolic: 1 inch thick.
f. Polyisocyanurate: 1 inch thick.
g. Polyolefin: 1 inch thick.
h. Thermal conductivity shall be IECC compliant.

D. Condenser-Water Supply and Return:

1. Insulation is one of the following:

a. Cellular Glass: 2 inches thick.
b. Flexible Elastomeric: 1 inch thick.
c. Glass-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inchesthick.
d. Mineral Wool, Preformed Pipe Insulation, Type II: 1-1/2 inches thick.
e. Phenolic: 1 inch 1-1/2 inches thick.
f. Polyisocyanurate: 1 inch thick.
g. Polyolefin: 1 inch thick.
h. Thermal conductivity shall be IECC compliant.

E. Heating-Hot-Water Supply and Return, 200 Deg F and Below:

1. Insulation is one of the following:

a. Cellular Glass: 2 inches thick.
b. Glass-Fiber, Preformed Pipe, Type I: 2 inches thick.
c. Mineral Wool, Preformed Pipe, Type II: 2 inches thick.
d. Phenolic: 2 inches thick.
e. Polyisocyanurate: 1 inch thick.
f. Thermal conductivity shall be IECC compliant.

F. Heating-Hot-Water Supply and Return, Above 200 Deg F:

1. NPS 8 and Smaller: Insulation is one of the following:

a. Calcium Silicate: 2 inches thick.
b. Cellular Glass: 2 inches thick.
c. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
d. Mineral Wool, Preformed Pipe Insulation, Type II: 2 inches thick.
e. Thermal conductivity shall be IECC compliant.

2. NPS 10 and Larger: Insulation is one of the following:

a. Calcium Silicate: 3 inches thick.
b. Cellular Glass: 4 inches thick.
c. Glass-Fiber, Preformed Pipe, Type I: 3 inches thick.
d. Mineral Wool, Preformed Pipe, Type II: 3 inches thick.
e. Thermal conductivity shall be IECC compliant.

G. Steam and Steam Condensate, Boiler Blowdown, Vents, Drains, and Safety Relief Vents 350 Deg F and Below:

1. Insulation is one of the following:

   a. Calcium Silicate: 4.5 inches thick.
   b. Cellular Glass: 4.5 inches thick.
   c. Glass-Fiber, Preformed Pipe Insulation, Type I: 4.5 inches thick.
   d. Mineral Wool, Preformed Pipe Insulation, Type II: 4.5 inches thick.
   e. Thermal conductivity shall be IECC compliant.

H. Steam and Steam Condensate, Boiler Blowdown, Vents, Drains, and Safety Relief Vents Above 350 Deg F:

1. Insulation is one of the following:

   a. Calcium Silicate: 5 inches thick.
   b. Cellular Glass: 5 inches thick.
   c. Glass-Fiber, Preformed Pipe Insulation, Type I: 5 inches thick.
   d. Mineral Wool, Preformed Pipe Insulation, Type II: 5 inches thick.
   e. Thermal conductivity shall be IECC compliant.

I. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation is one of the following:

   a. Cellular Glass: 1-1/2 inches thick.
   b. Flexible Elastomeric: 1 inch thick.
   c. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
   d. Mineral Wool, Preformed Pipe Insulation, Type II: 1 inch thick.
   e. Polyisocyanurate: 1 inch thick.
   f. Polyolefin: 1 inch thick.
   g. Thermal conductivity shall be IECC compliant.

J. Refrigerant Suction and Hot-Gas Flexible Tubing:

1. All Pipe Sizes: Insulation is one of the following:

   a. Flexible Elastomeric: 2 inches thick.
   b. Polyolefin: 2 inches thick.
   c. Thermal conductivity shall be IECC compliant.

K. Refrigerant Liquid Piping:

1. All Pipe Sizes: Insulation is one of the following:

   a. Cellular Glass: 1-1/2 inches thick.
   b. Flexible Elastomeric: 1 inch thick.
   c. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
   d. Mineral Wool, Preformed Pipe Insulation, Type II: 1 inch thick.

e. Polyisocyanurate: 1 inch thick.
f. Polyolefin: 1 inch thick.
g. Thermal conductivity shall be IECC compliant.

L. Dual-Service Heating and Cooling, 40 to 200 Deg F:

1. Insulation is one of the following:

a. Cellular Glass: 2 inches thick.
b. Flexible Elastomeric: 2 inches thick.
c. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
d. Mineral Wool, Preformed Pipe Insulation, Type I: 2 inches thick.
e. Thermal conductivity shall be IECC compliant.

M. Heat-Recovery Piping:

1. All Pipe Sizes: Insulation is one of the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Flexible Elastomeric: 1 inch thick.
c. Glass-Fiber, Preformed Pipe Insulation, Type I or Pipe and Tank Insulation: 1 inch thick.
d. Mineral Wool, Preformed Pipe Insulation, Type II or Pipe and Tank Insulation: 1 inch thick.
e. Phenolic: 1 inch thick.
f. Polyisocyanurate: 1 inch thick.
g. Polyolefin: 1 inch thick.
h. Thermal conductivity shall be IECC compliant.

3.19 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Chilled Water and Brine:

1. All Pipe Sizes: Insulation is one of the following:

a. Cellular Glass: 3 inches thick.
b. Flexible Elastomeric: 3 inches thick.
c. Glass-Fiber, Preformed Pipe Insulation, Type I: 3 inches thick.
d. Mineral Wool, Preformed Pipe Insulation, Type II: 3 inches thick.
e. Phenolic: 2 inches thick.
f. Polyisocyanurate: 2 inches thick.
g. Polystyrene: 2 inches thick.
h. Thermal conductivity shall be IECC compliant.

B. Condenser-Water Supply and Return:

1. All Pipe Sizes: Insulation is one of the following:

a. Cellular Glass: 2 inches thick.

b. Flexible Elastomeric: 2 inches thick.
c. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
d. Mineral Wool, Preformed Pipe Insulation, Type II: 2 inches thick.
e. Phenolic: 2 inches thick.
f. Polyisocyanurate: 2 inches thick.
g. Polystyrene: 2 inches thick.
h. Thermal conductivity shall be IECC compliant.

C. Heating-Hot-Water Supply and Return, 200 Deg F and Below:

1. All Pipe Sizes: Insulation is one of the following:

a. Cellular Glass: 3 inches thick.
b. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
c. Mineral Wool, Preformed Pipe Insulation, Type II: 2 inches thick.
d. Phenolic: 2 inches thick.
e. Polyisocyanurate: 2 inches thick.
f. Thermal conductivity shall be IECC compliant.

D. Heating-Hot-Water Supply and Return, Above 200 Deg F:

1. All Pipe Sizes: Insulation is one of the following:

a. Calcium Silicate: 3 inches thick.
b. Cellular Glass: 3 inches thick.
c. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
d. Mineral Wool, Preformed Pipe Insulation, Type II: 2 inches thick.
e. Thermal conductivity shall be IECC compliant.

E. Steam and Steam Condensate, and Safety Relief Vents, 350 Deg F and Below:

1. All Pipe Sizes: Insulation is one of the following:

a. Calcium Silicate: 4 inches thick.
b. Cellular Glass: 4 inches thick.
c. Glass-Fiber, Preformed Pipe Insulation, Type I: 3 inches thick.
d. Mineral Wool, Preformed Pipe Insulation, Type II: 3 inches thick.
e. Thermal conductivity shall be IECC compliant.

F. Steam and Steam Condensate, and Safety Relief Vents, Above 350 Deg F:

1. All Pipe Sizes: Insulation is one of the following:

a. Calcium Silicate: 5 inches thick.
b. Cellular Glass: 5 inches thick.
c. Glass-Fiber, Preformed Pipe Insulation, Type I: 4 inches thick.
d. Mineral Wool, Preformed Pipe Insulation, Type II: 4 inches thick.
e. Thermal conductivity shall be IECC compliant.

G. Refrigerant Suction and Hot-Gas Piping:

1. All Pipe Sizes: Insulation is one of the following:

    a. Cellular Glass: 2 inches thick.
    b. Flexible Elastomeric: 2 inches thick.
    c. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
    d. Mineral Wool, Preformed Pipe Insulation, Type II: 2 inches thick.
    e. Phenolic: 2 inches thick.
    f. Polyisocyanurate: 2 inches thick.
    g. Polystyrene: 2 inches thick.
    h. Thermal conductivity shall be IECC compliant.

H. Refrigerant Suction and Hot-Gas Flexible Tubing:

1. All Pipe Sizes: Insulation is the following:

    a. Flexible Elastomeric: 2 inches thick, Thermal conductivity shall be IECC compliant.

I. Refrigerant Liquid Piping:

1. All Pipe Sizes: Insulation is one of the following:

    a. Flexible Elastomeric: 1 inch 2 inches thick.
    b. Polyolefin: 1 inch thick.
    c. Thermal conductivity shall be IECC compliant.

J. Heat-Recovery Piping:

1. All Pipe Sizes: Insulation is one of the following:

    a. Cellular Glass: 2 inches thick.
    b. Flexible Elastomeric: 2 inches thick.
    c. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
    d. Mineral Wool, Preformed Pipe Insulation, Type II: 2 inches thick.
    e. Phenolic: 2 inches thick.
    f. Polyisocyanurate: 2 inches thick.
    g. Polystyrene: 2 inches thick.
    h. Thermal conductivity shall be IECC compliant.

K. Dual-Service Heating and Cooling:

1. All Pipe Sizes: Insulation is one of the following:

    a. Cellular Glass: 3 inches thick.
    b. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
    c. Mineral Wool, Preformed Pipe Insulation, Type II: 2 inches thick.
    d. Phenolic: 2 inches thick.
    e. Polyisocyanurate: 2 inches thick.
    f. Thermal conductivity shall be IECC compliant.

L. Fuel Oil Piping, Heated:

1. All Pipe Sizes: Insulation is one of the following:

a. Cellular Glass: 2 inches thick.
b. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
c. Mineral Wool, Preformed Pipe Insulation, Type II: 2 inches thick.
d. Thermal conductivity shall be IECC compliant.

3.20 OUTDOOR, UNDERGROUND, PIPING INSULATION SCHEDULE

A. Insulation for belowground piping is specified in Section 232113.13 "Underground Hydronic Piping" and Section 232213.13 "Underground Steam and Condensate Heating Piping."

B. Chilled Water, All Sizes: Cellular glass, 2 inches thick and Thermal conductivity shall be IECC compliant.

C. Condenser-Water Supply and Return, All Sizes: Cellular glass, 2 inches thick and Thermal conductivity shall be IECC compliant.

D. Heating-Hot-Water Supply and Return, All Sizes, 200 Deg F and Below: Cellular glass, 3 inches thick and Thermal conductivity shall be IECC compliant.

E. Heating-Hot-Water Supply and Return, All Sizes, Above 200 Deg F:

1. Calcium Silicate: 3 inches thick and Thermal conductivity shall be IECC compliant.
2. Cellular Glass: 3 inches thick and Thermal conductivity shall be IECC compliant.

F. Steam and Steam Condensate, All Sizes, 350 Deg F and Below:

1. Calcium Silicate: 4 inches thick and Thermal conductivity shall be IECC compliant.
2. Cellular Glass: 4 inches thick and Thermal conductivity shall be IECC compliant.

G. Steam and Steam Condensate, All Sizes, Above 350 Deg F:

1. Calcium Silicate: 5 inches thick and Thermal conductivity shall be IECC compliant.
2. Cellular Glass: 5 inches thick and Thermal conductivity shall be IECC compliant.

H. Dual-Service Heating and Cooling, All Sizes, 40 to 200 Deg F: Cellular glass, 3 inches thick and Thermal conductivity shall be IECC compliant.

I. Fuel Oil Piping, All Sizes, Heated: Cellular glass, 2 inches thick and Thermal conductivity shall be IECC compliant.

3.21 INDOOR, 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. PVC or PVC, Color-Coded by System: 30 mils thick.
2. Aluminum, Smooth, Corrugated or Stucco Embossed: 0.020 inch thick.
3. Painted Aluminum, Smooth Corrugated Stucco Embossed: 0.020 inch thick.

D. Piping, Exposed:
1. PVC PVC, Color-Coded by System: 30 mils thick.
2. Aluminum, Smooth Corrugated Stucco Embossed: 0.020 inch thick.
3. Painted Aluminum, Smooth Corrugated Stucco Embossed: 0.020 inch thick.

3.22 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 or PVC, Color-Coded by System: 30 mils thick.
3. Aluminum, Smooth Corrugated Stucco Embossed: 0.024 inch, 0.032 inch or 0.040 inch thick.
4. Painted Aluminum, Smooth, Corrugated or Stucco Embossed: 0.024 inch or 0.032 inch thick.

D. Piping, Exposed:

1. PVC: 30 mils 40 mils thick.
2. Painted Aluminum, Smooth, Corrugated or Stucco Embossed with Z-Shaped Locking Seam: 0.024 inch, 0.032 inch or 0.040 inch thick.

3.23 UNDERGROUND, FIELD-APPLIED INSULATION JACKET

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

END OF SECTION 230719

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

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Direct digital control (DDC) system equipment and components for monitoring and controlling of HVAC, exclusive of instrumentation and control devices.

1.2 DEFINITIONS

A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. BACnet Specific Definitions:

1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data and services over a network.
2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.

D. Binary: Two-state signal where a high signal level represents "ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

E. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: network controllers, programmable application controllers, and application-specific controllers.

F. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.

G. COV: Changes of value.

H. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.

I. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems to be capable of operating in a standalone mode using the last best available data.

J. E/P: Voltage to pneumatic.

K. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

L. HLC: Heavy load conditions.

M. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI) and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

N. I/P: Current to pneumatic.

O. LAN: Local area network.

P. LNS: LonWorks Network Services.

Q. LON Specific Definitions:

1. FTT-10: Echelon Transmitter-Free Topology Transceiver.
2. LonMark International: Association comprising suppliers and installers of LonTalk products. Association provides guidelines for implementing LonTalk protocol to ensure interoperability through a standard or consistent implementation.
3. LonTalk: An open standard protocol developed by Echelon Corporation that uses a "Neuron Chip" for communication. LonTalk is a register trademark of Echelon.
4. LonWorks: Network technology developed by Echelon.
5. Node: Device that communicates using CTA-709.1-D protocol and that is connected to a CTA-709.1-D network.
6. Node Address: The logical address of a node on the network, consisting of a Domain number, Subnet number, and Node number. "Node number" portion of an address is a number assigned to device during installation, is unique within a subnet, and is not a factory-set unique Node ID.
7. Node ID: A unique 48-bit identifier assigned at factory to each CTA-709.1-D device. Sometimes called a "Neuron ID."
8. Program ID: An identifier (number) stored in a device (usually, EEPROM) that identifies node manufacturer, functionality of device (application and sequence), transceiver used, and intended device usage.
9. Standard Configuration Property Type (SCPT): Pronounced "skip-it." A standard format type maintained by LonMark for configuration properties.
10. Standard Network Variable Type (SNVT): Pronounced "snivet." A standard format type maintained by LonMark used to define data information transmitted and received by individual nodes. "SNVT" is used in two ways. It is an acronym for "Standard Network

Variable Type" and is often used to indicate a network variable itself (i.e., it can mean "a network variable of a standard network variable type").

11. Subnet: Consists of a logical grouping of up to 127 nodes, where logical grouping is defined by node addressing. Each subnet is assigned a number, which is unique within a Domain. See "Node Address."
12. TP/FT-10: Free Topology Twisted Pair network defined by CTA-709.3 and is most common media type for a CTA-709.1-D control network.
13. TP/XF-1250: High-speed, 1.25 Mbps, twisted-pair, doubly terminated bus network defined by "LonMark Interoperability Guidelines" and typically used only to connect multiple TP/FT-10 networks.
14. User-Defined Configuration Property Type (UCPT): Pronounced "u-keep-it." A Configuration Property format type that is defined by device manufacturer.
15. User-Defined Network Variable Type (UNVT): Network variable format defined by device manufacturer. UNVTs create non-standard communications that other vendors' devices may not correctly interpret and may negatively impact system operation. UNVTs are not allowed.

R. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

S. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.

T. Modbus TCP/IP: An open protocol for exchange of process data.

U. MS/TP: Master-slave/token-passing, ISO/IEC/IEEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

V. MTBF: Mean time between failures.

W. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.

X. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

Y. Peer to Peer: Networking architecture that treats all network stations as equal partners.

Z. POT: Portable operator's terminal.

AA. RAM: Random access memory.

BB. RF: Radio frequency.

CC. Router: Device connecting two or more networks at network layer.

DD. Server: Computer used to maintain system configuration, historical and programming database.

EE. TCP/IP: Transport control protocol/Internet protocol.

FF. UPS: Uninterruptible power supply.

GG. USB: Universal Serial Bus.

HH. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.

II. VAV: Variable air volume.

JJ. WLED: White light emitting diode.

1.3 PREINSTALLATION MEETINGS

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

1.4 ACTION SUBMITTALS

A. Multiple Submissions:

1. If multiple submissions are required to execute work within schedule, first submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission.
2. Clearly identify each submittal requirement indicated and in which submission the information will be provided.
3. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.

B. Product Data:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation, and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.

   a. Workstations.
   b. Servers.
   c. Gateways.
   d. Routers.

e. Protocol analyzers.
f. DDC controllers.
g. Enclosures.
h. Electrical power devices.
i. UPS units.
j. Accessories.
k. Instruments.
l. Control dampers and actuators.
m. Control valves and actuators.

6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
7. Each submitted piece of product literature to clearly cross reference specification and drawings that submittal is to cover.

C. Software Submittal:

1. Cross-referenced listing of software to be loaded on each operator workstation, server, gateway, and DDC controller.
2. Description and technical data of all software provided and cross-referenced to products in which software will be installed.
3. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
4. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
5. Listing and description of each engineering equation used with reference source.
6. Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.
7. Description of operator interface to alphanumeric and graphic programming.
8. Description of each network communication protocol.
9. Description of system database, including all data included in database, database capacity, and limitations to expand database.
10. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden, and system throughout.
11. 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.

D. Shop Drawings:

1. General Requirements:

a. Include cover drawing with Project name, location, Owner, Architect, Contractor, and issue date with each Shop Drawings submission.
b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.

2. Include plans, elevations, sections, and mounting details where applicable.

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

c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.

9. DDC system electrical power riser diagram indicating the following:

   a. Each point of connection to field power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
   b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
   c. Each product requiring power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
   d. Power wiring type and size, race type, and size for each.

10. Monitoring and control signal diagrams indicating the following:

   a. Control signal cable and wiring between controllers and I/O.
   b. Point-to-point schematic wiring diagrams for each product.
   c. Control signal tubing to sensors, switches, and transmitters.
   d. Process signal tubing to sensors, switches, and transmitters.
   e. Pneumatic main air and control signal tubing to pneumatic damper and valve actuators, pilot-positioners if applicable, and associated transducers.

11. Color graphics indicating the following:

   a. Itemized list of color graphic displays to be provided.
   b. For each display screen to be provided, a true color copy showing layout of pictures, graphics, and data displayed.
   c. Intended operator access between related hierarchical display screens.

E. System Description:

1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
2. Complete listing and description of each report, log and trend for format and timing, and events that initiate generation.
3. System and product operation under each potential failure condition including, but not limited to, the following:

   a. Loss of power.
   b. Loss of network communication signal.
   c. Loss of controller signals to inputs and outpoints.
   d. Operator workstation failure.
   e. Server failure.
   f. Gateway failure.
   g. Network failure.

h. Controller failure.
i. Instrument failure.
j. Control damper and valve actuator failure.

4. Complete bibliography of documentation and media to be delivered to Owner.
5. Description of testing plans and procedures.
6. Description of Owner training.

F. Samples:

1. For each of the following exposed product(s), installed in finished space for approval of selection of aesthetic characteristics:

a. Gas instruments specified in Section 230923.16 "Gas Instruments."
b. Moisture instruments specified in Section 230923.19 "Moisture Instruments."
c. Motion instruments specified in Section 230923.21 "Motion Instruments."
d. Pressure instruments specified in Section 230923.23 "Pressure Instruments."
e. Temperature instruments specified in Section 230923.27 "Temperature Instruments."

G. Delegated Design Submittals: For DDC system products and installation indicated as being delegated.

1. Supporting documentation showing DDC system design complies with performance requirements indicated, including calculations and other documentation necessary to prove compliance.
2. Schedule and design calculations for control dampers and actuators.

a. Flow at Project design and minimum flow conditions.
b. Face velocity at Project design and minimum airflow conditions.
c. Pressure drop across damper at Project design and minimum airflow conditions.
d. AMCA 500-D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
e. Maximum close-off pressure.
f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
g. Torque required at worst case condition for sizing actuator.
h. Actuator selection indicating torque provided.
i. Actuator signal to control damper (on, close, or modulate).
j. Actuator position on loss of power.
k. Actuator position on loss of control signal.

3. Schedule and design calculations for control valves and actuators.

a. Flow at Project design and minimum flow conditions.
b. Pressure-differential drop across valve at Project design flow condition.
c. Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.
d. Design and minimum control valve coefficient with corresponding valve position.
e. Maximum close-off pressure.
f. Leakage flow at maximum system pressure differential.

g. Torque required at worst case condition for sizing actuator.
h. Actuator selection indicating torque provided.
i. Actuator signal to control damper (on, close or modulate).
j. Actuator position on loss of power.
k. Actuator position on loss of control signal.

4. Schedule and design calculations for selecting flow instruments.

a. Instrument flow range.
b. Project design and minimum flow conditions with corresponding accuracy, control signal to transmitter, and output signal for remote control.
c. Extreme points of extended flow range with corresponding accuracy, control signal to transmitter, and output signal for remote control.
d. Pressure-differential loss across instrument at Project design flow conditions.
e. Where flow sensors are mated with pressure transmitters, provide information for each instrument separately and as an operating pair.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved.
2. Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved.

B. Qualification Statements:

1. Systems Provider's Qualification Data:

a. Resume of project manager assigned to Project.
b. Resumes of application engineering staff assigned to Project.
c. Resumes of installation and programming technicians assigned to Project.
d. Resumes of service technicians assigned to Project.
e. Brief description of past project including physical address, floor area, number of floors, building system cooling and heating capacity, and building's primary function.
f. Description of past project DDC system, noting similarities to Project scope and complexity indicated.
g. Names of staff assigned to past project that will also be assigned to execute work of this Project.
h. Owner contact information for past project including name, phone number, and email address.
i. Contractor contact information for past project including name, phone number, and email address.
j. Architect and Engineer contact information for past project including name, phone number, and email address.

2. Manufacturer's qualification data.
3. Testing agency's qualification data.

C. Product Certificates-one of the following:

1. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with ASHRAE 135.
2. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with LonWorks.

D. Test and Evaluation Reports:

1. Product Test Reports: For each product, for tests performed by manufacturer and witnessed by a qualified testing agency.
2. Preconstruction Test Reports: For each separate test performed.

E. Source Quality-Control Submittals:

1. Source quality-control reports.

F. Field Quality-Control Submittals:

1. Field quality-control reports.

G. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
c. As-built versions of submittal Product Data.
d. Names, addresses, email addresses, and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
g. Engineering, installation, and maintenance manuals that explain how to do the following:

1) Design and install new points, panels, and other hardware.
2) Perform preventive maintenance and calibration.
3) Debug hardware problems.
4) Repair or replace hardware.

h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
i. Backup copy of graphic files, programs, and databases on electronic media.
j. List of recommended spare parts with part numbers and suppliers.
k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
m. Licenses, guarantees, and warranty documents.
n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
o. Owner training materials.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Extra Stock Material: Furnish extra materials and parts to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Include product manufacturers' recommended parts lists for proper product operation over four-year period following warranty period. Parts list to be indicated for each year.

C. Furnish parts, as indicated by manufacturer's recommended parts list, for product operation during two-year period following warranty period.

D. Furnish quantity indicated of matching product(s) in Project inventory for each unique size and type of following:

1. Network Controller: One.
2. Programmable Application Controller: One.
3. Application-Specific Controller: One.
4. General-Purpose Relay: One.
5. Multifunction Time-Delay Relay: One.
6. Latching Relay: One.
7. Current-Sensing Relay: One.
8. Combination On-Off Status Sensor and On-Off Relay: One.
9. Transformer: One.
10. DC Power Supply: One.

1.8 QUALITY ASSURANCE

A. DDC System Manufacturer Qualifications:

1. Nationally recognized manufacturer of DDC systems and products.
2. DDC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
3. DDC systems and products that have been successfully tested and in use on at least three past projects.
4. Having complete published catalog literature, installation, operation, and maintenance manuals for all products intended for use.
5. Having full-time in-house employees for the following:

   a. Product research and development.
   b. Product and application engineering.
   c. Product manufacturing, testing, and quality control.
   d. Technical support for DDC system installation training, commissioning, and troubleshooting of installations.
   e. Owner operator training.

B. DDC System Provider Qualifications:

1. Authorized representative of, and trained by, DDC system manufacturer.
2. Demonstrate past experience with installation of DDC system products being installed for period within three consecutive years before time of bid.
3. Demonstrate past experience on five projects of similar complexity, scope, and value.
4. Demonstrate past experience of each person assigned to Project.
5. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
6. Service and maintenance staff assigned to support Project during warranty period.
7. Product parts inventory to support ongoing DDC system operation for a period of not less than five years after Substantial Completion.
8. DDC system manufacturer's backing to take over execution of the Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

C. Testing Agency Qualifications: Member company of NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

D. Welding Qualifications: Qualify procedures and personnel in accordance with the following welding codes:

1. AWS D1.1/D1.1M.
2. AWS D1.2/D1.2M.
3. AWS D1.3/D1.3M.
4. AWS D1.4/D1.4M.

E. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators in accordance with ASME Boiler and Pressure Vessel Code.

1.9 MOCKUPS

A. Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, to set quality standards for materials and execution, and to set quality standards for fabrication and installation.

1. Build mockups of completed installation for areas as indicated on Drawings.
2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Owner specifically approves such deviations by Change Order.
3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.10 WARRANTY

A. Special Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Adjust, repair, or replace failures at no additional cost or reduction in service to Owner.
2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.

    a. Install updates only after receiving Owner's written authorization.

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

    a. For Gateway: Two-year parts and labor warranty for each.

PART 2 - PRODUCTS

2.1 DDC SYSTEM MANUFACTURERS

A. Alerton

2.2 DDC SYSTEM DESCRIPTION

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

1. DDC system consisting of high-speed, peer-to-peer network of distributed DDC controllers, other network devices, operator interfaces, and software.

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

2.3 WEB ACCESS

A. DDC system to be web based or web compatible.

1. Web-Based Access to DDC System:

a. DDC system software based on server thin-client architecture, designed around open standards of web technology. DDC system server accessed using a web browser over DDC system network, using Owner's LAN, and remotely over Internet or through Owner's LAN.
b. Intent of thin-client architecture is to provide operators complete access to DDC system via a web browser. No special software other than a web browser is required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
c. Password-protected web access.

2. Web-Compatible Access to DDC System:

a. Workstation and or server to perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.
b. DDC system to support web browser access to building data. Operator using a standard web browser is able to access control graphics and change adjustable set points.
c. Password-protected web access.

2.4 PERFORMANCE REQUIREMENTS

A. ASME Compliance:

1. DDC system for monitoring and controlling of HVAC systems.

B. Delivery of selected control devices to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.

C. Delegated Design, Qualified Professional: Engage a qualified professional to design DDC system to satisfy requirements indicated.

1. System Performance Objectives:

a. DDC system manages HVAC systems.
b. DDC system operates HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
c. DDC system responds to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.

d. DDC system operates while unattended by an operator and through operator interaction.
e. DDC system records trends and transactions of events and produces report information such as performance, energy, occupancies, and equipment operation.

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

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

E. DDC System Speed:

1. Response Time of Connected I/O:

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

2. Display of Connected I/O:

a. Update and display analog point COV connected to DDC system at least every 10 seconds for use by operator.
b. Update and display binary point COV connected to DDC system at least every 10 seconds for use by operator.
c. Update and display alarms of analog and digital points connected to DDC system within 30 seconds of activation or change of state.
d. Update graphic display refresh within eight seconds.
e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations to not exceed graphic refresh rate indicated.

F. Network Bandwidth: Design each network of DDC system to include spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions. Minimum spare bandwidth as follows:

1. Level 1 Networks: 20.
2. Level 2 Networks: 20.
3. Level 3 Networks: 10.

G. DDC System Data Storage:

1. Include capability to archive not less than 24 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends, and other information indicated.
2. Local Storage:

   a. Provide server with data storage indicated. Server(s) to use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.

3. Cloud Storage:

   a. Provide application-based and web browser interfaces to configure, upload, download, and manage data and to service plan with storage adequate to store all data for term indicated. Cloud storage uses IT industry standard database platforms and is capable of functions described in "DDC Data Access" Paragraph.

H. DDC Data Access:

1. When logged into the system, operator able to also interact with any DDC controllers connected to DDC system as required for functional operation of DDC system.
2. Use for application configuration; for archiving, reporting, and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.

I. Future Expandability:

1. DDC system size is expandable to an ultimate capacity of at least 1.5 times total I/O points indicated.
2. Design and install system networks to achieve ultimate capacity with only addition of DDC controllers, I/O, and associated wiring and cable. Design and install initial network infrastructure to support ultimate capacity without having to remove and replace portions of network installation.
3. Operator interfaces installed initially do not require hardware and software additions and revisions for system when operating at ultimate capacity.

J. Input Point Values Displayed Accuracy: Meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.

1. Energy:

   a. Thermal: Within 2 percent of reading.
   b. Electric Power: Within 1 percent of reading.
   c. Requirements indicated on Drawings for meters not supplied by utility.

2. Flow:

   a. Air: Within 5 percent of design flow rate.
   b. Air (Terminal Units): Within 10 percent of design flow rate.

c. Fuel Oil: Within 2 percent of design flow rate.
d. Natural Gas: Within 2 percent of design flow rate.
e. Water: Within 2 percent of design flow rate.
f. Steam: Within 5 percent of design flow rate.

3. Gas:

a. Carbon Dioxide: Within 50 ppm.
b. Carbon Monoxide: Within 5 percent of reading.
c. Oxygen: Within 5 percent of reading.
d. Refrigerant: Within 5 percent of reading.
e. VOCs: Within 5 percent of reading.

4. Moisture (Relative Humidity):

a. Air: Within 5 percent RH.
b. Space: Within 5 percent RH.
c. Outdoor: Within 5 percent RH.

5. Level: Within 5 percent of reading.
6. Pressure:

a. Air, Ducts and Equipment: 1 percent of instrument range.
b. Space: Within 1 percent of instrument range.
c. Water: Within 1 percent of instrument range.
d. Steam: Within 1 percent of instrument range.

7. Speed: Within 10 percent of reading.
8. Temperature, Dew Point:

a. Air: Within 1 deg F.
b. Space: Within 1 deg F.
c. Outdoor: Within 2 deg F.

9. Temperature, Dry Bulb:

a. Air: Within 1 deg F.
b. Space: Within 1 deg F.
c. Outdoor: Within 2 deg F.
d. Chilled Water: Within 1 deg F.
e. Condenser Water: Within 1 deg F.
f. Heating Hot Water: Within 1 deg F.
g. Energy Recovery Runaround Liquid: Within 1 deg F.
h. Steam: Within 2 deg F.
i. Temperature Difference: Within 0.25 deg F.
j. Other Temperatures Not Indicated: Within 1 deg F.

10. Temperature, Wet Bulb:

a. Air: Within 1 deg F.

b. Space: Within 1 deg F.
c. Outdoor: Within 2 deg F.

11. Vibration: Within 5 percent of reading.

K. Precision of I/O Reported Values: Values reported in database and displayed to have following precision:

1. Current:

a. Milliamperes: Nearest 1/100th of a milliampere.
b. Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.

2. Energy:

a. Electric Power:

1) Rate (Watts): Nearest 1/10th of a watt through 1000 W.
2) Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
3) Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.

b. Fuel Oil (Usage): For gallons, nearest 1/10th of a gallon up to 100 gal.; nearest gallon for above 100 gal..
c. Natural Gas (Usage): Nearest 1/10th of a unit (cubic feet, MCF, therm) up to 100 units; nearest unit for above 100 units.
d. Thermal, Rate:

1) Heating: For British thermal units per hour, nearest British thermal unit per hour up to 1000 Btu/h; nearest 10 Btu/h between 1000 and 10,000 Btu/h; nearest 100 Btu/h for above 10,000 Btu/h. For MBh, round to nearest MBh up to 1000 MBh; nearest 10 MBh between 1000 and 10,000 MBh; nearest 100 MBh above 10,000 MBh.
2) Cooling: For tons, nearest ton up to 1000 tons; nearest 10 tons between 1000 and 10,000 tons; nearest 100 tons above 10,000 tons.

e. Thermal, Usage:

1) Heating: For British thermal unit, nearest British thermal unit up to 1000 Btu; nearest 10 Btu between 1000 and 10,000 Btu; nearest 100 Btu for above 10,000 Btu. For MBtu, round to nearest MBtu up to 1000 MBtu; nearest 10 MBtu between 1000 and 10,000 MBtu; nearest 100 MBtu above 10,000 MBtu.
2) Cooling: For ton-hours, nearest ton-hours up to 1000 ton-hours; nearest 10 ton-hours between 1000 and 10,000 ton-hours; nearest 100 tons above 10,000 tons.

3. Flow:

   a. Air: Nearest 1/10th of a cubic feet per minute through 100 cfm; nearest cubic feet per minute between 100 and 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm; nearest 100 cfm above 10,000 cfm.
   b. Fuel Oil: Nearest 1/10th of a gallon per minute through 100 gpm; nearest gallon per minute between 100 and 1000 gpm
   c. Natural Gas:Nearest 1/10th of a cubic feet per hour through 100 cfh; nearest cubic feet per hour between 100 and 1000 cfh; nearest 10 cfh between 1000 and 10,000 cfh; nearest 100 cfh above 10,000 cfh.
   d. Water: Nearest 1/10th of a gallon per minute through 100 gpm; nearest gallon per minute between 100 and 1000 gpm; nearest 10 gpm between 1000 and 10,000 gpm; nearest 100 gpm above 10,000 gpm.
   e. Steam: Nearest 1/10th of a pound per hour through 100 lb/h; nearest pound per hour between 100 and 1000 lb/h; nearest 10 lb/h above 1000 lb/h.

4. Gas:

   a. Carbon Dioxide (ppm): Nearest ppm.
   b. Carbon Monoxide (ppm): Nearest ppm.
   c. Oxygen (Percentage): Nearest 1/10th of 1 percent.
   d. Refrigerant (ppm): Nearest ppm.
   e. Volatile Organic Compounds (ppm): Nearest ppm

5. Moisture (Relative Humidity):

   a. Relative Humidity (Percentage): Nearest 1 percent.

6. Level: Nearest 1/100th of an inch through 10 inches; nearest 1/10 of an inch between 10 and 100 inches; nearest inch above 100 inches.
7. Speed:

   a. Rotation (rpm): Nearest 1 rpm.
   b. Velocity: Nearest 1/10th of feet per minute through 100 fpm; nearest feet per minute between 100 and 1000 fpm; nearest 10 fpm above 1000 fpm.

8. Position, Dampers and Valves (Percentage Open): Nearest 1 percent.
9. Pressure:

   a. Air, Ducts and Equipment: Nearest 1/10th of an inch water closet.
   b. Space: Nearest 1/100th of an inch water closet.
   c. Steam: Nearest 1/10th of pounds per square inch gauge through 100 psig; nearest pounds per square inch gauge above 100 psig.
   d. Water: Nearest 1/10 of a pound per square inch gauge through 100 psig; nearest pound per square inch gauge above 100 psig.

10. Temperature:

   a. Air, Ducts and Equipment: Nearest 1/10th of a degree.
   b. Outdoor: Nearest degree.

c. Space: Nearest 1/10th of a degree.
d. Chilled Water: Nearest 1/10th of a degree.
e. Condenser Water: Nearest 1/10th of a degree.
f. Heating Hot Water: Nearest degree.
g. Heat Recovery Runaround: Nearest 1/10th of a degree.
h. Steam: Nearest degree.

11. Vibration: Nearest 1/10th of an inch per second.
12. Voltage: Nearest 1/10 V up to 100 V; nearest volt above 100 V.

L. Control Stability: Control variables indicated within the following limits:

1. Flow:

   a. Air, Ducts and Equipment, except Terminal Units: Within 5 percent of design flow rate.
   b. Air, Terminal Units: Within 5 percent of design flow rate.
   c. Water: Within 5 percent of design flow rate.
   d. Steam: Within 5 percent of design flow rate.

2. Gas:

   a. Carbon Dioxide: Within 50 ppm.
   b. Carbon Monoxide: Within 5 percent of reading.
   c. Oxygen: Within 5 percent of reading.

3. Moisture (Relative Humidity):

   a. Air: Within 5 percent RH.
   b. Space: Within 5 percent RH.
   c. Outdoor: Within 5 percent RH.

4. Level: Within 5 percent of reading.
5. Pressure:

   a. Air, Ducts and Equipment: 1 percent of instrument range.
   b. Space: Within 1 percent of instrument range.
   c. Water: Within 1 percent of instrument range.
   d. Steam: Within 1 percent of instrument range span.

6. Temperature, Dew Point:

   a. Air: Within 1 deg F.
   b. Space: Within 1 deg F.

7. Temperature, Dry Bulb:

   a. Air: Within 1 deg F.
   b. Space: Within 1 deg F.
   c. Chilled Water: Within 1 deg F.

d. Condenser Water: Within 1 deg F.
e. Heating Hot Water: Within 1 deg F.
f. Energy Recovery Runaround Liquid: Within 1 deg F.

8. Temperature, Wet Bulb:

a. Air: Within 1 deg F.
b. Space: Within 1 deg F.

M. Environmental Conditions for Controllers, Gateways, and Routers:

1. Products to operate without performance degradation under ambient environmental temperature, pressure, and humidity conditions encountered for installed location.

a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure to be internally insulated, electrically heated, cooled, and ventilated as required by product and application.

2. Protect products with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. House products not available with integral enclosures complying with requirements indicated in protective secondary enclosures. Installed location dictates the following NEMA 250 enclosure requirements:

a. Outdoors, Protected: Type 3.
b. Outdoors, Unprotected: Type 4.
c. Indoors, Heated with Filtered Ventilation: Type 2.
d. Indoors, Heated with Non-Filtered Ventilation: Type 12.
e. Indoors, Heated and Air-Conditioned: Type 1.
f. Mechanical Equipment Rooms:

1) Chiller and Boiler Rooms: Type 4.
2) Air-Moving Equipment Rooms: Type 12.

g. Localized Areas Exposed to Washdown: Type 4.
h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 3.
i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.
j. Hazardous Locations: Explosion-proof rating for condition.
k. Corrosive Environments: Type 4X.

N. Environmental Conditions for Instruments and Actuators:

1. Instruments and actuators to operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

a. If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure is internally insulated, electrically heated, cooled, and ventilated as required by instrument and application.

2. Protect instruments, actuators, and accessories with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. House instruments and actuators not available with integral enclosures complying with requirements indicated in protective secondary enclosures. Installed location is to dictate the following NEMA 250 enclosure requirements:

   a. Outdoors, Protected: Type 3.
   b. Outdoors, Unprotected: Type 4.
   c. Indoors, Heated with Filtered Ventilation: Type 2.
   d. Indoors, Heated with Non-Filtered Ventilation: Type 12.
   e. Indoors, Heated and Air-conditioned: Type 1.
   f. Mechanical Equipment Rooms:

      1) Chiller and Boiler Rooms: Type 4.
      2) Air-Moving Equipment Rooms: Type 12.

   g. Localized Areas Exposed to Washdown: Type 4.
   h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 3.
   i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4X.
   j. Hazardous Locations: Explosion-proof rating for condition.
   k. Corrosive Environments: Type 4X.

O. DDC System Reliability:

1. Design, install, and configure DDC controllers, gateways, routers, to yield a MTBF of at least 40,000 hours, based on a confidence level of at least 90 percent. MTBF value includes any failure for any reason to any part of products indicated.
2. If required to comply with MTBF indicated, include DDC system and product redundancy to maintain DCC system, and associated systems and equipment being controlled, operational, and under automatic control.
3. See Drawings for critical systems and equipment that require a higher degree of DDC system redundancy than MTBF indicated.

P. Electric Power Quality:

1. Power-Line Surges:

   a. Protect susceptible DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.1 and IEEE C62.41.2.
   b. Do not use fuses for surge protection.
   c. Test protection in the normal mode and in the common mode, using the following two waveforms:

1) 10-by-1000-microsecond waveform with a peak voltage of 1500 V and a peak current of 60 A.
2) 8-by-20-microssecond waveform with a peak voltage of 1000 V and a peak current of 500 A.

2. Power Conditioning:

a. Protect susceptible DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner are as follows:

1) At 85 percent load, output voltage to not deviate by more than plus or minus 1 percent of nominal when input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.
2) During load changes from zero to full load, output voltage to not deviate by more than 3 percent of nominal.
3) Accomplish full correction of load switching disturbances within five cycles, and 95 percent correction within two cycles of onset of disturbance.
4) Total harmonic distortion to not exceed 2 percent at full load.

3. Ground Fault: Protect products from ground fault by providing suitable grounding. Products to not fail due to ground fault condition.

Q. Backup Power Source:

1. Serve DDC system products that control HVAC systems and equipment served by a backup power source also from a backup power source.

R. UPS:

1. DDC system products powered by UPS units are to include the following:

a. Servers.
b. Gateways.
c. DDC controllers, except application-specific controllers.
d. Desktop workstations.

2. DDC system instruments and actuators powered by UPS units are to include the following:

a. Instruments: Where indicated on Drawings;

b. Damper Actuators: Where indicated on Drawings;

c. Valve Actuators: Where indicated on Drawings;

S. Continuity of Operation after Electric Power Interruption:

1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems

are to automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.5 PANEL-MOUNTED, MANUAL OVERRIDE SWITCHES

A. Manual Override of Control Dampers:

1. Include panel-mounted, two-position, selector switch for each automatic control damper being controlled by DDC controller.
2. Label each switch with damper designation served by switch.
3. Label switch positions to indicate either "Manual" or "Auto" control signal to damper.
4. With switch in "Auto" position, control signal to damper actuator with control loop output signal from DDC controller.
5. With switch in "Manual" position, control signal to damper actuator at panel with either an integral or a separate switch to include local control.

    a. For Binary Control Dampers: Manual two-position switch with "Close" and "Open" switch positions indicated. With switch in "Close" position, close damper. With switch in "Open" position, open damper.
    b. For Analog Control Dampers: A gradual switch with "Close" and "Open" switch limits indicated. Operator switches knob to adjust damper to any position from close to open.

6. DDC controller to monitor and report position of each manual override selector switch. With switch placed in "manual" position, DDC controller to signal an override condition to alert operator that damper is under manual, not automatic, control.
7. Configure manual override switches to allow operator to manually operate damper while at panel without DDC controller installed and operational.
8. Terminal equipment including VAV units, fan-coil units, and unit heaters do not require manual override unless otherwise indicated by sequence of operation.

B. Manual Override of Control Valves:

1. Include panel-mounted, two-position, selector switch for each automatic control valve being controlled by DDC controller.
2. Label each switch with valve designation served by switch.
3. Label switch positions to indicate either "Manual" or "Auto" control signal to valve.
4. With switch in "Auto" position, control signal to valve actuator with a control loop output signal from DDC controller.
5. With switch in "Manual" position, control signal to valve actuator at panel with either an integral or a separate switch to include local control.

    a. For Binary Control Valves: Manual two-position switch with "Close" and "Open" switch positions indicated. With switch in "Close" position, close valve. With switch in "Open" position, open valve.

b. For Analog Control Valves: A gradual switch with "Open" and "Close" switch limits indicated. Operator rotates switch knob to adjust valve to any position from close to open.

6. DDC controller to monitor and report position of each manual override selector switch. With switch placed in "manual" position, DDC controller to signal an override condition to alert operator that valve is under manual, not automatic, control.
7. Configure manual override switches to allow operator to manually operate valve while at panel without DDC controller installed and operational.
8. Terminal equipment including VAV units, fan-coil units, and unit heaters do not require manual override unless otherwise indicated by sequence of operation.

2.6 SYSTEM ARCHITECTURE

A. System architecture consisting of no more than two or three levels of LANs.

1. Level 2 LAN: Connect network controllers and operator workstations.
2. Level 1 or Level 2 LAN: Connect programmable application controllers to other programmable application controllers and to network controllers.
3. Level 2 or Level 3 LAN: Connect application-specific controllers to programmable application controllers and to network controllers application-specific controllers.

B. Provide dedicated and separated DDC system LANs that are not shared with other building systems and tenant data and communication networks.

C. Provide modular system architecture with inherent ability to expand to not less than 1.5 times system size indicated with no impact to performance indicated.

D. Configure architecture to eliminate or minimize need to remove and replace existing network equipment for system expansion.

E. Make number of LANs and associated communication transparent to operator. Configure all I/O points residing on any LAN to be capable of global sharing between all system LANs.

F. Design system to eliminate dependence on any single device for system alarm reporting and control execution. Design each controller to operate independently by performing own control, alarm management, and historical data collection.

G. Special Network Architecture Requirements:

1. Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and VAV terminal units, include a dedicated LAN of application-specific controllers serving VAV terminal units connected directly to controller that is controlling air-handling-system air-handling unit(s). Basically, create DDC system LAN that aligns with air-handling system being controlled.

2.7 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator able to access entire DDC system through any of multiple means including, but not limited to, the following:

1. Desktop and portable workstation with hardwired connection through LAN port.
2. Portable operator terminal with hardwired connection through LAN port.
3. Portable operator workstation with wireless connection through LAN router.
4. Mobile device and application with secured wireless connection through LAN router or cellular data service.
5. Remote connection through web access.

B. Make access to system, regardless of operator means used, transparent to operator.

C. Network Ports: For hardwired connection of desktop or portable workstation. Network port easily accessible, properly protected, clearly labeled, and installed at the following locations as applicable:

1. Each mechanical equipment room.
2. Each boiler room.
3. Each chiller room.
4. Each outdoor on-grade yard and elevated platform with equipment connected to DDC system.
5. Each different roof level with roof-mounted equipment connected to DDC system.
6. Security system command center.
7. Fire-alarm system command center.

D. Desktop Workstations:

1. Connect desktop workstation(s) to DDC system Level 1 LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Able to communicate with any device located on any DDC system LAN.

E. Portable Workstations:

1. Connect portable workstation(s) to DDC system Level 1 LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Able to communicate with any device located on any DDC system LAN.
3. Connect to DDC system Level 2 or Level 3 LAN through a communications port on an application-specific controller, or a room temperature sensor connected to an application-specific controller.
4. Connect to system through a wireless router connected to Level 1 LAN.
5. Connect to system through a cellular broadband data service.
6. Portable workstation able to communicate with any device connected to any system LAN regardless of point of physical connection to system.
7. Monitor, program, schedule, adjust set points, and report capabilities of I/O connected anywhere in system.
8. Have dynamic graphic displays that are identical to desktop workstations.

F. POT:

1. Connect DDC controller through a communications port local to controller.
2. Able to communicate with any DDC system controller that is directly connected or with LAN or connected to DDC system.

G. Mobile Device (Tablet and Smart Phone):

1. Connect Owner-furnished mobile devices to system through a wireless router connected to LAN and cellular data service.
2. Able to communicate with any DDC controller connected to DDC system using dedicated application and secure web access.

H. Critical Alarm Reporting:

1. Send operator-selected critical alarms to notify operator of critical alarms that require immediate attention.
2. Send alarm notification to multiple recipients that are assigned for each alarm.
3. Notify recipients by any or all means, including email, text message, and prerecorded phone message to mobile and landline phone numbers.

I. Simultaneous Operator Use: Capable of accommodating up to 10 simultaneous operators that are accessing DDC system through any of operator interfaces indicated.

2.8 NETWORKS

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

1. ATA 878.1, ARCNET.
2. CTA-709.1-D.
3. IP.
4. ISO/IEC/IEEE 8802-3, Ethernet.

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

1. ATA 878.1, ARCNET.
2. CTA-709.1-D.
3. IP.
4. ISO/IEC/IEEE 8802-3, Ethernet.

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

1. ATA 878.1, ARCNET.
2. CTA-709.1-D.
3. TIA 485-A.
4. IP.
5. ISO/IEC/IEEE 8802-3, Ethernet.

2.9 NETWORK COMMUNICATION PROTOCOL

A. Use network communication protocol(s) that are open to Owner and available to other companies for use in making future modifications to DDC system.

B. Industry Standard Protocols:

1. Use any one or a combination of the following industry standard protocols for network communication while complying with other DDC system requirements indicated:

a. ASHRAE 135.
b. CTA-709.1-D.
c. Modbus Application Protocol Specification V1.1b3.

2. Operator workstations and network controllers are to communicate through ASHRAE 135 or CTA-709.1-D protocol.
3. Provide portions of DDC system networks using ASHRAE 135 communication protocol as an open implementation of network devices complying with ASHRAE 135. Use network devices that are tested and listed by BTL.
4. Provide portions of DDC system networks using CTA-709.1-D communication protocol as an open implementation of LonWorks technology using CTA-709.1-D communication protocol and using LonMark SNVTs as defined in LonMark SNVT list exclusively for DDC system.
5. Provide portions of DDC system networks using Modbus Application Protocol Specification V1.1b3 communication protocol as an open implementation of network devices and technology complying with Modbus Application Protocol Specification V1.1b3.
6. Use gateways to connect networks and network devices with different protocols.

2.10 DDC SYSTEM WIRELESS NETWORKS

A. Use Zigbee or an open industry standard and technology used by multiple DDC system manufacturers technology to create a wireless mesh network to provide wireless connectivity for network devices at multiple system levels including communications from programmable application controllers and application-specific controllers to temperature sensors and from network controllers to programmable application controllers and application-specific controllers.

B. Design and install wireless networks to comply with DDC system performance requirements indicated using wireless network devices that can co-exist on same network with hardwired devices.

C. Provide hardwired controllers capable of retrofitting to wireless devices with no special software.

D. Provide a wireless coordinator for wireless interface between programmable application controllers, application-specific controllers, and network controllers.

E. Wireless Coordinators:

1. Use for initiation and formation of each wireless mesh network.
2. Use direct-sequence spread spectrum RF technology.
3. Operate on 2.4 GHz ISM Band.
4. Comply with IEEE 802.15.4 for low-power, low duty-cycle RF transmitting systems.
5. FCC compliant to 47 CFR 15, Subpart B, Class A.
6. Operate as a bidirectional transceiver with sensors and routers to confirm and synchronize data transmission.
7. Capable of communication with sensors and routers up to a maximum distance of 250 ft. in line of sight.
8. Include visual indicators to provide diagnostic information required for operator verification of operation.

F. Wireless Routers:

1. Use wireless routers with any controller to provide a wireless interface to a network controller, through a wireless coordinator.
2. Use direct-sequence spread spectrum RF technology.
3. Operate on 2.4 GHz ISM Band.
4. Comply with IEEE 802.15.4 for low-power, low duty-cycle RF transmitting systems.
5. FCC compliant to 47 CFR 15, Subpart B, Class A.
6. Operate as a bidirectional transceiver with other mesh network devices to ensure network integrity.
7. Capable of communication with other mesh network devices at a maximum distance of 250 ft. in line of sight.
8. Include indication for use in commissioning and troubleshooting.

G. Wireless Temperature Sensors:

1. Wireless temperature sensors to sense and transmit room temperatures, temperature set point, room occupancy notification, and low battery condition to an associated router.
2. Use direct-sequence spread spectrum RF technology.
3. Operate on 2.4 GHz ISM Band.
4. Comply with IEEE 802.15.4 for low-power, low duty-cycle RF transmitting systems.
5. FCC compliant to 47 CFR 15, Subpart B, Class A.
6. Include set-point adjustment between 55 to 85 deg F.
7. Configure so multiple sensors can report to a router connected to DDC controller for averaging or high and low selection.

H. One-to-One Wireless Network Receivers:

1. One-to-one wireless receivers receive wireless RF signals containing temperature data from multiple wireless room temperature sensors and communicate information to programmable application controllers or application-specific controllers.

   a. Use direct-sequence spread spectrum RF technology.
   b. Operate on 2.4 GHz ISM Band.
   c. Comply with IEEE 802.15.4 for low-power, low duty-cycle RF transmitting systems.
   d. FCC compliant to 47 CFR 15, Subpart B, Class A.

e. Operate as a bidirectional transceiver with sensors to confirm and synchronize data transmission.
f. Capable of communication up to a distance of 200 ft..
g. Include visual indication of the following:

1) Power.
2) Receiver activity.
3) Wireless RF transmission from wireless sensors.
4) No transmission, weak signal, adequate signal, or excellent signal.

I. One-to-One Wireless Network Sensors:

1. One-to-one wireless sensors sense and report room temperatures to one-to-one receiver.

a. Use direct-sequence spread spectrum RF technology.
b. Operate on 2.4 GHz ISM Band.
c. Comply with IEEE 802.15.4 for low-power, low duty-cycle RF transmitting systems.
d. FCC compliant to 47 CFR 15, Subpart B, Class A.
e. Include set-point adjustment between 55 to 85 deg F.

2.11 DESKTOP WORKSTATIONS

A. Description: A tower or all-in-one computer designed for normal use at a single, semipermanent location.

B. Performance Requirements:

1. May dictate equipment exceeding minimum requirements indicated.
2. ENERGY STAR compliant.

C. Personal Computer:

1. At least four expansion slots of 32 64 bit.
2. Video Card:

a. Resolution: 1920 by 1200 pixels.

3. Sound Card:

a. At least 128 voice wavetable synthesis.
b. Capable of delivering three-dimensional sound effects.
c. High-resolution, 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.

4. Network Interface Card: Include card with connection, as applicable.

a. 10-100-1000 base TX Ethernet with RJ-45 connector port.
b. 100 base FX Ethernet with SC or ST port.

D. Wireless Ethernet, 802.11 ac:

1. Optical Modem: Full duplex link for connection to optical fiber cable provided.
2. I/O Ports:

    a. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
    b. One serial port.
    c. One parallel port.
    d. Two PS/2 ports.
    e. One RJ-45.
    f. One stereo line-in and headphone/line-out on back panel.
    g. One microphone and headphone connector on front panel.
    h. One IEEE 1394 on front and back panel with PCI-e card.
    i. One ESATA port on back panel.

3. Battery: Life of at least three years to maintain system clock/calendar and ROM, at a minimum.

E. Keyboard:

1. 101 enhanced keyboard.
2. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.
3. Wireless operation within up to 72 inches in front of workstation.

F. Pointing Device:

1. Two- or three-button mouse.
2. Wireless operation within up to 72 inches in front of workstation.

G. Flat Panel Display Monitor:

1. Display:

    a. Digital or analog input signal.
    b. Aspect Ratio: 16 to 9.
    c. Antiglare display.
    d. Dynamic Contrast Ratio: 50000 to 1.
    e. Brightness: 250 cd/sq. m.
    f. Tilt adjustable base.
    g. ENERGY STAR compliant.
    h. Resolution: 1920 by 1080 pixels at 60 Hz with pixel size of 0.277 mm or smaller.
    i. Number of Displays: Two.

H. Speakers:

1. Two, with individual controls for volume, bass and treble.
2. Signal to Noise Ratio: At least 65 dB.

3. Power: At least 4 W per speaker/channel.
4. Magnetic shielding to prevent distortion on the video monitor.

I. I/O Cabling: Include applicable cabling to connect I/O devices.

2.12 PORTABLE WORKSTATIONS

A. Description: A self-contained computer designed to allow for normal use in different locations and conditions.

B. Performance Requirements:

1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
2. ENERGY STAR compliant.
3. Hardware and software to support local down-loading to DDC controllers.
4. Data transfer rate to DDC controller is to be at network speed.

C. I/O Ports:

1. Serial port.
2. Shared port for external keyboard or mouse.
3. Four USB 3.0 ports.
4. Ethernet port.
5. HDMI port.
6. IEEE 1394 port.

D. Battery:

1. Capable of supporting operation of portable workstation for a minimum of 8 hours.
2. Battery life of at least three years.
3. Battery charge time of less than three hours.

E. Keyboard:

1. 85-key backlit keyboard.
2. Full upper- and lowercase ASCII keyset.

F. Integral Pointing Device: Touchpad with two buttons. Gesture enabled.

G. Display:

1. High-definition WLED color display.
2. Antiglare screen.
3. 1920 by 1080 pixel resolution.
4. Brightness: 300 nits.

H. Network Interfaces:

1. Network Interface Card: Include card with connection, as application.

   a. 10-100-1000 base TX Ethernet with RJ-45 connector port.
   b. 100 base FX Ethernet with SC or ST port.

2. Wireless:

   a. Internal with integrated antenna, capable of supporting WiFi standards 802.11 a/b/g/n.

I. Digital Video Disc Rewrite Recorder (DVD+/-RW):

1. Compatible with DVD discs and data, audio, recordable, and rewritable compact discs.

2. 160-ms access time.

J. Accessories:

1. Nylon carrying case.
2. Docking station.
3. Mobile broadband card.
4. Wireless optical mouse.
5. Light-sensitive web cam and noise-cancelling digital array microphone.
6. Category 6a patch cable.
7. HDMI cable.

2.13 PORTABLE OPERATOR TERMINALS

A. Description: Handheld device with integral keypad or touch screen operator interface.

B. Display: Multiple lines of text display for use in operator interaction with DDC system.

C. Cable: Flexible coiling cable, at least 36 inches long, with a plug-in jack for connection to DDC controllers, network ports, or instruments with an integral LAN port. As an alternative to hardwired connection, POTs may be accessible to DDC controllers through a wireless network connection.

D. Power POTs through network connection.

E. Connection of POTs to DDC system to not interrupt or interfere with normal network operation in any way, prevent alarms from being transmitted, or preclude central initiated commands and system modification.

F. POTs to give operator ability to do the following:

1. Display and monitor BI point status.
2. Change BO point set point (on or off, open or closed).
3. Display and monitor analog point values.
4. Change analog control set points.

5. Command a setting of AO point.
6. Display and monitor I/O point in alarm.
7. Add a new or delete an existing I/O point.
8. Enable and disable I/O points, initiators, and programs.
9. Display and change time and date.
10. Display and change time schedules.
11. Display and change run-time counters and run-time limits.
12. Display and change time and event initiation.
13. Display and change control application and DDC parameters.
14. Display and change programmable offset values.
15. Access DDC controller initialization routines and diagnostics.

2.14 SYSTEM SOFTWARE

A. System Software Minimum Requirements:

1. Real-time multitasking and multiuser operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
2. Operating system capable of operating DOS and Microsoft Windows applications.
3. Database management software to manage all data on an integrated and non-redundant basis. Additions and deletions to database are to be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
4. Network communications software to manage and control multiple network communications to provide exchange of global information and execution of global programs.
5. Operator interface software to include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
6. Scheduling software to schedule centrally based time and event, temporary, and exception day programs.

B. Operator Interface Software:

1. Minimize operator training through use of English language prorating and English language point identification.
2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.
3. Make operator sign-off a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
4. Make automatic sign-off period programmable from one to 60 minutes in one-minute increments on a per operator basis.
5. Record operator sign-on and sign-off activity and send to printer.
6. Security Access:

   a. Use password control for operator access to DDC system.
   b. Assign an alphanumeric password (field assignable) to each operator.
   c. Grant operators access to DDC system by entry of proper password.

d. Use same operator password regardless of which computer or other operator interface means are used.
e. Automatically update additions or changes made to passwords.
f. Assign each operator an access level to restrict access to data and functions the operator is cable of performing.
g. Provide software with at least five access levels.
h. Assign each menu item an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
i. Display menu items to operator with those capable of access highlighted. Make menu and operator access level assignments online programmable and under password control.

7. Data Segregation:

a. Include data segregation for control of specific data routed to a workstation, to an operator or to a specific output device, such as a printer.
b. Include at least 32 segregation groups.
c. Make segregation groups selectable such as "fire points," "fire points on second floor," "space temperature points," "HVAC points," and so on.
d. Make points assignable to multiple segregation groups. Display and output of data to printer or monitor is to occur where there is a match of operator or peripheral segregation group assignment and point segregations.
e. Make alarms displayed and printed at each peripheral to which segregation allows, but only those operators assigned to peripheral and having proper authorization level will be allowed to acknowledge alarms.
f. Assign operators and peripherals to multiple segregation groups and make all assignments online programmable and under password control.

8. Operators able to perform commands including, but not limited to, the following:

a. Start or stop selected equipment.
b. Adjust set points.
c. Add, modify, and delete time programming.
d. Enable and disable process execution.
e. Lock and unlock alarm reporting for each point.
f. Enable and disable totalization for each point.
g. Enable and disable trending for each point.
h. Override control loop set points.
i. Enter temporary override schedules.
j. Define holiday schedules.
k. Change time and date.
l. Enter and modify analog alarm limits.
m. Enter and modify analog warning limits.
n. View limits.
o. Enable and disable demand limiting.
p. Enable and disable duty cycle.
q. Display logic programming for each control sequence.

9. Reporting:

a. Generated automatically and manually.
b. Sent to displays, printers and disc files.
c. Types of Reporting:

1) General listing of points.
2) List points currently in alarm.
3) List of off-line points.
4) List points currently in override status.
5) List of disabled points.
6) List points currently locked out.
7) List of items defined in a "Follow-Up" file.
8) List weekly schedules.
9) List holiday programming.
10) List of limits and deadbands.

10. Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.

C. Graphic Interface Software:

1. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.
2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface is to use a pointing device with pull-down or penetrating menus, color, and animation to facilitate operator understanding of system.
3. Include at least 10 levels of graphic penetration with the hierarchy operator assignable.
4. Make descriptors for graphics, points, alarms, and such modifiable through operator's workstation under password control.
5. Make graphic displays online user definable and modifiable using the hardware and software provided.
6. Make data displayed within a graphic assignable regardless of physical hardware address, communication, or point type.
7. Make graphics online programmable and under password control.
8. Make points assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
9. Graphics to also contain software points.
10. Penetration within a graphic hierarchy is to display each graphic name as graphics are selected to facilitate operator understanding.
11. Provide a back-trace feature to permit operator to move upward in the hierarchy using a pointing device. Back trace to show all previous penetration levels. Include operator with option of showing each graphic full-screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
12. Display operator accessed data on the monitor.
13. Provide operator with ability to select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Display defined and linked graphic below that selection.

14. Include operator with means to directly access graphics without going through penetration path.
15. Make dynamic data assignable to graphics.
16. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
17. Use color, rotation, or other highly visible means, to denote status and alarm states. Make colors variable for each class of points, as chosen by operator.
18. Provide dynamic points with operator adjustable update rates on a per point basis from one second to over a minute.
19. For operators with appropriate privilege, command points directly from display using pointing device.

    a. For an analog command point such as set point, display current conditions and limits so operator can position new set point using pointing device.
    b. For a digital command point such as valve position, show valve in current state such as open or closed so operator could select alternative position using pointing device.
    c. Include a keyboard equivalent for those operators with that preference.

20. Give operator ability to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot, and other information on other quadrants on screen. This feature allows real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.
21. Help Features:

    a. Online context-sensitive help utility to facilitate operator training and understanding.
    b. Bridge to further explanation of selected keywords and contain text and graphics to clarify system operation.

        1) If help feature does not have ability to bridge on keywords for more information, provide a complete set of user manuals in an indexed word-processing program, which runs concurrently with operating system software.

    c. Available for Every Menu Item:

        1) Index items for each system menu item.

22. Provide graphic generation software to allow operator ability to add, modify, or delete system graphic displays.

    a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols similar to those indicated.
    b. Use a pointing device in conjunction with a drawing program to allow operator to perform the following:

        1) Define background screens.
        2) Define connecting lines and curves.

3) Locate, orient, and size descriptive text.
4) Define and display colors for all elements.
5) Establish correlation between symbols or text and associated system points or other displays.

D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.
2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:

   a. Room layouts with room identification and name.
   b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
   c. Location and identification of each hardware point being controlled or monitored by DDC system.

3. Control schematic for each of following, including a graphic system schematic representation, similar to that indicated on Drawings, with point identification, set point and dynamic value indication, sequence of operation and control logic diagram.
4. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.
5. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, gateways, operator workstations and other network devices.

E. Customizing Software:

1. Software to modify and tailor DDC system to specific and unique requirements of equipment installed, to programs implemented and to staffing and operational practices planned.
2. Online modification of DDC system configuration, program parameters, and database using menu selection and keyboard entry of data into preformatted display templates.
3. At a minimum, include the following modification capability:

   a. Operator Assignment: Designation of operator passwords, access levels, point segregation, and auto sign-off.
   b. Peripheral Assignment: Assignment of segregation groups and operators to consoles and printers, designation of backup workstations and printers, designation of workstation header points, and enabling and disabling of print-out of operator changes.
   c. System Configuration and Diagnostics; Communications and peripheral port assignments, DDC controller assignments to network, DDC controller enable and disable, assignment of command trace to points, and application programs and initiation of diagnostics.
   d. System Text Addition and Change: English or native language descriptors for points, segregation groups and access levels and action messages for alarms, run time, and trouble condition.

e. Time and Schedule Change: Time and date set, time and occupancy schedules, exception and holiday schedules, and daylight-savings time schedules.
f. Point related change capability is to include the following:

1) System and point enable and disable.
2) Run-time enable and disable.
3) Assignment of points to segregation groups, calibration tables, lockout, and run time and to a fixed I/O value.
4) Assignment of alarm and warning limits.

g. Application program change capability is to include the following:

1) Enable and disable of software programs.
2) Programming changes.
3) Assignment of comfort limits, global points, time and event initiators, time and event schedules and enable and disable time and event programs.

4. Provide software to allow operator ability to add points, or groups of points, to DDC system and to link them to energy optimization and management programs. Make additions and modifications online programmable using operator workstations, downloaded to other network devices and entered into their databases. After verification of point additions and associated program operation, upload and record database on hard drive and disc for archived record.
5. Include high-level language programming software capability for implementation of custom DDC programs. Include a compiler, linker, and up- and down-load capability.
6. Include a library of DDC algorithms, intrinsic control operators, arithmetic, logic, and relational operators for implementation of control sequences. Also include, at a minimum, the following:

a. Proportional control (P).
b. Proportional plus integral (PI).
c. Proportional plus integral plus derivative (PID).
d. Adaptive and intelligent self-learning control.

1) Algorithm monitors loop response to output corrections and adjust loop response characteristics in accordance with time constant changes imposed.
2) Algorithm operates in a continuous self-learning manner and retains in memory a stored record of system dynamics so that on system shut down and restart, learning process starts from where it left off.

7. Fully implemented intrinsic control operators including sequence, reversing, ratio, time delay, time of day, highest select AO, lowest select AO, analog controlled digital output, analog control AO, and digitally controlled AO.
8. Logic operators such as "And," "Or," "Not," and others that are part of a standard set available with a high-level language.
9. Arithmetic operators such as "Add," "Subtract," "Multiply," "Divide," and others that are part of a standard set available with a high-level language.
10. Relational operators such as "Equal to," "Not Equal to," "Less Than," "Greater Than," and others that are part of a standard set available with a high-level language.

F. Alarm Handling Software:

1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers, gateways and other network devices.
2. Include first in, first out handling of alarms in accordance with alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.
3. Make alarm handling active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.
4. Alarms display is to include the following:

   a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
   b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."
   c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."
   d. Include extended message capability to allow assignment and printing of extended action messages. Capability is to be operator programmable and assignable on a per point basis.

5. Direct alarms to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.
6. Send email alarm messages to designated operators.
7. Send email, page, text, and voice messages to designated operators for critical alarms.
8. Categorize and process alarms by class.

   a. Class 1:

      1) Associated with fire, security, and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.
      2) Unacknowledged alarms to be placed in unacknowledged alarm buffer.
      3) All conditions make an audible alarm sound and require individual acknowledgment to silence audible sound.

   b. Class 2:

      1) Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
      2) Acknowledgement may be through a multiple alarm acknowledgment.

   c. Class 3:

      1) General alarms; printed, displayed, and placed in unacknowledged alarm buffer queues.
      2) Configure so each new alarm received makes an audible alarm sound that are silenced by "acknowledging" alarm or by pressing a "silence" key.

3) Make acknowledgement of queued alarms either on an individual basis or through a multiple alarm acknowledgement.
4) Print alarms returning to normal condition without an audible alarm sound or require acknowledgment.

d. Class 4:

1) Routine maintenance or other types of warning alarms.
2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.

9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.
10. To ensure that no alarm records are lost, make it possible to assign a backup printer to accept alarms in case of failure of primary printer.

G. Reports and Logs:

1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
2. Setup each report so data content, format, interval, and date are operator definable.
3. Sample and store report data on DDC controller, within storage limits of DDC controller, and then uploaded to archive on workstation or server for historical reporting.
4. Make it possible for operators to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
5. Store reports and logs on workstations and servers hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
6. Make reports and logs readily printable and set to be print either on operator command or at a specific time each day.

H. Standard Reports: Provide standard DDC system reports with operator ability to customize reports later.

1. All I/O: With current status and values.
2. Alarm: All current alarms, except those in alarm lockout.
3. Disabled I/O: All I/O points that are disabled.
4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
6. Logs:

a. Alarm history.
b. System messages.
c. System events.
d. Trends.

I. Custom Reports: Operator able to easily define and prepare any system data into a daily, weekly, monthly, annual, or other historical report. Reports to include a title with time and date stamp.

J. Standard Trends:

1. Trend all I/O point present values, set points, and other parameters indicated for trending.
2. Associate trends into groups, and setup a trend report for each group.
3. Store trends within DDC controller and uploaded to hard drives automatically on reaching 75 percent of DDC controller buffer limit, or by operator request, or by archiving time schedule.
4. Preset trend intervals for each I/O point after review with Owner.
5. Make trend intervals operator selectable from 10 seconds up to 60 minutes. Make minimum number of consecutive trend values stored at one time 100 per variable.
6. When drive storage memory is full, overwrite oldest data with most recent data.
7. Make archived and real-time trend data available for viewing numerically and graphically by operators.

K. Custom Trends: Operator-definable custom trend log for any I/O point in DDC system.

1. Include each trend with interval, start time, and stop time.
2. Sample and store data on DDC controller, within reaching 75 percent storage limits of DDC controller, and then uploaded to archive on workstation or server hard drives.
3. Make data retrievable for use in spreadsheets and standard database programs.

L. Programming Software:

1. Include programming software to execute sequences of operation indicated.
2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
3. Programming software is to be any of the following:

   a. Graphic Based: Use a library of function blocks made from preprogrammed code designed for DDC control systems.

      1) Assemble function blocks with interconnection lines that represent to control sequence in a flowchart.
      2) Make programming tools viewable in real time to show present values and logical results of each function block.

   b. Menu Based: Done by entering parameters, definitions, conditions, requirements, and constraints.
   c. Line by Line and Text Based: Programming is to declare variable types such as local, global, real, integer, and so on, at the beginning of the program. Use descriptive comments frequently to describe programming code.

4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

2.15 OFFICE APPLICATION SOFTWARE

A. Include current version of office application software at time of Substantial Completion.

B. Office application software package to include multiple separate applications and use a common platform for all applications.

1. Database.
2. Email.
3. Presentation.
4. Publishing.
5. Spreadsheet.
6. Word processing.

2.16 ASHRAE 135 GATEWAYS

A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, chillers, and variable-speed drives.

B. Include gateways to connect BACnet to legacy systems where indicated, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment.

C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.

D. Gateway Minimum Requirements:

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

2.17 CTA-709.1-D NETWORK HARDWARE

A. Routers:

1. Network routers, including routers configured as repeaters, are to comply with requirements of CTA-709.1-D and include connection between two or more CTA-709.3 TP/FT-10 channels or between two or more CTA-709.3 TP/FT-10 channels and a TP/XF-1250 channel.
2. IP Routers:

   a. Perform layer three routing of CTA-709.1-D packets over an IP network in accordance with CTA-852-C.
   b. Include appropriate connection to IP network and connections to CTA-709.3 TP/FT-10 or TP/XF-1250 network.
   c. Support the Dynamic Host Configuration Protocol for IP configuration and use of an CTA-852-C Configuration Server (for CTA-852-C configuration), but do not rely on these services for configuration.
   d. Capable of manual configuration via a console RS-232 port.

B. Gateways:

1. Perform bidirectional protocol translation from one non-CTA-709.1-D protocol to CTA-709.1-D.
2. Incorporate a network connection to TP/FT-10 network in accordance with CTA-709.3 and a connection for non-CTA-709.1-D network.

2.18 DDC CONTROLLERS

A. DDC system consisting of a combination of network controllers, programmable application controllers, and application-specific controllers to satisfy performance requirements indicated.

B. DDC controllers to perform monitoring, control, energy optimization, and other requirements indicated.

C. DDC controllers are to use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.

D. Each DDC controller is capable of full and complete operation as a completely independent unit and as a part of DDC system wide distributed network.

E. Environment Requirements:

1. Controller hardware suitable for anticipated ambient conditions.
2. Controllers located in conditioned space rated for operation at 32 to 120 deg F.
3. Controllers located outdoors rated for operation at 40 to 150 deg F.

F. Power and Noise Immunity:

1. Operate controller at 90 to 110 percent of nominal voltage rating and perform an orderly shutdown below 80 percent of nominal voltage.
2. Protect against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.

G. Maintenance and Support: Include the following features to facilitate maintenance and support:

1. Mount microprocessor components on circuit cards for ease of removal and replacement.
2. Means to quickly and easily disconnect controller from network.
3. Means to quickly and easily access connect to field test equipment.
4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

H. General Requirements for CTA-709.1-D DDC Controllers:

1. LonMark certified.
2. Distinguishable and accessible switch, button, or pin, when pressed is to broadcast its 48-bit Node ID and Program ID over network.
3. TP/FT-10 transceiver in accordance with CTA-709.3 and connections for TP/FT-10 control network wiring.
4. TP/XF-1250 transceiver in accordance with CTA-709.3 and connections for TP/XF-1250 control network wiring.
5. Communicate using CTA-709.1-D protocol.
6. Controllers configured into subnets, as required, to comply with performance requirements indicated.
7. Network communication through LNS network management and database standard for CTA-709.1-D network devices.
8. Locally powered, not powered through network connection.
9. Functionality required to support applications indicated including, but not limited to, the following:

    a. I/Os indicated and as required to support sequence of operation and application in which it is used. SNVTs to have meaningful names identifying the value represented by SNVT. Unless SNVT of an appropriate engineering type is unavailable, all network variables to be of SNVT with engineering units appropriate to value the variable represents.
    b. Configurable through SCPTs defined in LonMark SCPT List, operator-defined UCPTs, network configuration inputs (NCIs) of SNVT type defined in LonMark SNVT List, NCIs of an operator-defined network variable type, or hardware settings on controller itself for all settings and parameters used by application in which it is used.

10. Programmable controllers comply with "LonMark Interoperability Guidelines" and have LonMark certification.

I. I/O Point Interface:

1. Connect hardwired I/O points to network, programmable application, and application-specific controllers.
2. Protect I/O points so shorting of point to itself, to another point, or to ground will not damage controller.
3. Protect I/O points from voltage up to 24 V of any duration so that contact will not damage controller.
4. AIs:

a. Include monitoring of low-voltage (0 to 10 V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
b. Compatible with, and field configurable to, sensor and transmitters installed.
c. Perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
d. Signal conditioning including transient rejection for each AI.
e. Capable of being individually calibrated for zero and span.
f. Incorporate common-mode noise rejection of at least 50 dB from 0 to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.
g. External conversion resistors are not permitted.

5. AOs:

a. Perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 12 bits or better to comply with accuracy requirements indicated.
b. Output signals range of 4 to 20 mA dc or 0 to 10 V dc as required to include proper control of output device.
c. Capable of being individually calibrated for zero and span.
d. Drift is to be not greater than 0.4 percent of range per year.
e. External conversion resistors are not permitted.

6. BIs:

a. Accept contact closures and ignore transients of less than 5 ms duration.
b. Isolate and protect against an applied steady-state voltage of up to 180 V ac peak.
c. Include a wetting current of at least 12 mA to be compatible with commonly available control devices and protected against effects of contact bounce and noise.
d. Sense "dry contact" closure without external power (other than that provided by controller) being applied.
e. Pulse accumulation input points complying with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Include buffer to totalize pulses. Pulse accumulator is to accept rates of at least 20 pulses per second. Reset the totalized value to zero on operator's command.

7. BOs:

a. Include relay contact closures or triac outputs for momentary and maintained operation of output devices.

1) Relay contact closures to have a minimum duration of 0.1 second and at least 180 V of isolation.
2) Include electromagnetic interference suppression on all output lines to limit transients to non-damaging levels.
3) Minimum contact rating to be 1 A at 24 V ac.
4) Triac outputs to have at least 180 V of isolation and minimum contact rating of 1 A at 24 V ac.

b. Include BOs with two-state operation or a pulsed low-voltage signal for pulse-width modulation control.

c. BOs to be selectable for either normally open or normally closed operation.
d. Include tristate outputs (two coordinated BOs) for control of three-point, floating-type electronic actuators without feedback.
e. Limit use of three-point floating devices to VAV terminal unit control applications, and other applications indicated on Drawings,. Control algorithms to operate actuator to one end of its stroke once every 24 hours for verification of operator tracking.

2.19 NETWORK CONTROLLERS

A. General:

1. Include adequate number of controllers to achieve performance indicated.
2. Provide one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
3. Include enough memory to support its operating system, database, and programming requirements with spare memory indicated.
4. Share data between networked controllers and other network devices.
5. Operating system of controller to manage I/O communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
6. Include network controllers with a real-time clock.
7. Controller to continually check status of its processor and memory circuits. If an abnormal operation is detected, controller is to assume a predetermined failure mode and generate an alarm notification.
8. Make controllers fully programmable.

B. Communication:

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

C. Operator Interface:

1. Equip controllers with a service communications port for connection to desktop operator's workstation, portable operator's workstation, POT or mobile device.

D. Serviceability:

1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Maintain Basic Input Output System (BIOS) and programming information in event of power loss for at least 72 hours.

2.20 PROGRAMMABLE APPLICATION CONTROLLERS

A. General:

1. Include adequate number of controllers to achieve performance indicated.
2. Provide enough memory to support its operating system, database, and programming requirements with spare memory indicated.
3. Share data between networked controllers and other network devices.
4. Include controller with operating system to manage I/O communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Include controllers that perform scheduling with a real-time clock.
6. Controller is to continually check status of its processor and memory circuits. If an abnormal operation is detected, controller assumes a predetermined failure mode and generates an alarm notification.
7. Fully programmable.

B. Communication:

1. Programmable application controllers are to communicate with other devices on network.

C. Operator Interface:

1. Equip controllers with a service communications port for connection to desktop operator's workstation, portable operator's workstation, POT or mobile device.

D. Serviceability:

1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Maintain BIOS and programming information in event of power loss for at least 72 hours.

2.21 APPLICATION-SPECIFIC CONTROLLERS

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

1. Capable of standalone operation and continued control functions without being connected to network.
2. Share data between networked controllers and other network devices.

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

C. Operator Interface: Equip controllers with a service communications port for connection to desktop workstation, portable operator's workstation, POT or mobile device. Connection is to extend to port on space temperature sensor that is connected to controller.

D. Serviceability:

1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.22 CONTROLLER SOFTWARE

A. General:

1. Software applications are to reside and operate in controllers. Edit applications through operator workstations or mobile devices.
2. Identify I/O points by up to 30-character point name and up to 16-character point descriptor. Use same names throughout, including at operator workstations.
3. Execute control functions within controllers using DDC algorithms.
4. Configure controllers to use stored default values to ensure fail-safe operation. Use default values when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Security:

1. Secure operator access using individual security passwords and user names.
2. Passwords restrict operator to points, applications, and system functions as assigned by system manager.
3. Record operator log-on and log-off attempts.
4. Protect from unauthorized use by automatically logging off after last keystroke. Make the delay time operator-definable.

C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule is to consist of the following:

1. Weekly Schedule:

a. Include separate schedules for each day of week.
b. Each schedule should include capability for start, stop, optimal start, optimal stop, and night economizer.
c. Each schedule may consist of up to 10 events.
d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.

2. Exception Schedules:

a. Include ability for operator to designate any day of the year as an exception schedule.
b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.

3. Holiday Schedules:

a. Include capability for operator to define up to 99 special or holiday schedules.
b. Place schedules on scheduling calendar with ability to repeated each year.
c. Operator able to define length of each holiday period.

D. System Coordination:

1. Include standard application for proper coordination of equipment.
2. Include operator with a method of grouping together equipment based on function and location.
3. Include groups that may be for use in scheduling and other applications.

E. Binary Alarms:

1. Set each binary point to alarm based on operator-specified state.
2. Include capability to automatically and manually disable alarming.

F. Analog Alarms:

1. Provide each analog object with both high and low alarm limits.
2. Include capability to automatically and manually disable alarming.

G. Alarm Reporting:

1. Include ability for operators to determine action to be taken in event of an alarm.
2. Route alarms to appropriate operator workstations based on time and other conditions.
3. Include ability for alarms to start programs, print, be logged in event logs, generate custom messages, and display graphics.

H. Remote Communication:

1. Include ability for system to notify operators by phone message, text message, and email in event of an alarm.

I. Electric Power Demand Limiting:

1. Monitor building or other operator-defined electric power consumption from signals connected to electric power meter or from a watt transducer or current transformer.
2. Predict probable power demand such that action can be taken to prevent exceeding demand limit. When demand prediction exceeds demand limit, action will be taken to reduce loads in a predetermined manner. When demand prediction indicates demand limit will not be exceeded, action will be taken to restore loads in a predetermined manner.
3. Accomplish demand reduction by the following means:

a. Reset air-handling-unit supply temperature set points.
b. Reset space temperature set points.
c. De-energize equipment based on priority.

4. Base demand-limiting parameters, frequency of calculations, time intervals, and other relevant variables on the means by which electric power service provider computes demand charges.
5. Include demand-limiting prediction and control for any individual meter monitored by system or for total of any combination of meters.
6. Include means operator to make the following changes online:

a. Addition and deletion of loads controlled.
b. Changes in demand intervals.
c. Changes in demand limit for meter(s).
d. Maximum shutoff time for equipment.
e. Minimum shutoff time for equipment.
f. Select rotational or sequential shedding and restoring.
g. Shed and restore priority.

7. Include the following information and reports, to be available on an hourly, daily, weekly, monthly, and annual basis:

a. Total electric consumption.
b. Peak demand.
c. Date and time of peak demand.
d. Daily peak demand.

J. Maintenance Management: Monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.

K. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.

L. Control Loops:

1. Support any of the following control loops, as applicable to control required:

a. Two-position (on/off, open/close, slow/fast) control.
b. Proportional control.
c. Proportional plus integral (PI) control.
d. Proportional plus integral plus derivative (PID) control.

1) Include PID algorithms with direct or reverse action and anti-windup.
2) Algorithm to calculate a time-varying analog value used to position an output or stage a series of outputs.
3) Make controlled variable, set point, and PID gains operator-selectable.

e. Adaptive (automatic tuning).

M. Staggered Start: Prevent all controlled equipment from simultaneously restarting after a power outage. Make the order which equipment (or groups of equipment) is started, along with the time delay between starts, operator-selectable.

N. Energy Calculations:

1. Include software to allow instantaneous power or flow rates to be accumulated and converted to energy usage data.
2. Include algorithm that calculates a sliding-window average (rolling average). Make algorithm flexible to allow window intervals to be operator specified (such as 15, 30, or 60 minutes).
3. Include algorithm that calculates a fixed-window average. Use a digital input signal to define start of window period (such as signal from utility meter) to synchronize fixed-window average with that used by utility.

O. Anti-Short Cycling:

1. Protect BO points from short cycling.
2. Feature to allow minimum on-time and off-time to be selected.

P. On and Off Control with Differential:

1. Include algorithm that allows BO to be cycled based on a controlled variable and set point.
2. Use direct- or reverse-acting algorithm and incorporate an adjustable differential.

Q. Run-Time Totalization:

1. Include software to totalize run-times for all BI and BO points.
2. Assign a high run-time alarm, if required, by operator.

2.23 ENCLOSURES

A. General:

1. House each controller and associated control accessories in single enclosure. Enclosure is to serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies, and transformers.
2. Do not house more than one controller in single enclosure.
3. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
4. Freestanding enclosures maximum of 48 inches wide and 72 inches high.
5. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.
6. Supply each enclosure with complete set of as-built schematics, tubing, and wiring diagrams and product literature located in pocket on inside of door. For enclosures with windows, include pocket on bottom of enclosure.

B. Internal Arrangement:

1. Arrange internal layout of enclosure to group and protect pneumatic, electric, and electronic components associated with controller, but not an integral part of controller.
2. Arrange layout to group similar products together.
3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
4. Factory or shop install products, tubing, cabling, and wiring complying with requirements and standards indicated.
5. Terminate field cable and wire using heavy-duty terminal blocks.
6. Include spare terminals, equal to not less than 10 percent of used terminals.
7. Include spade lugs for stranded cable and wire.
8. Install maximum of two wires on each side of terminal.
9. Include enclosure field electric power supply with toggle-type switch located at entrance inside enclosure to disconnect power.
10. Include enclosure with line-voltage nominal 20 A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with 5 A circuit breaker.
11. Mount products within enclosure on removable internal panel(s).
12. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). Nameplates are to have at least 1/4-inch- high lettering.
13. Route tubing cable and wire located inside enclosure within a raceway with continuous removable cover.
14. Label each end of cable, wire, and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
15. Size enclosure internal panel to include at least 15 percent spare area on face of panel.

C. Environmental Requirements:

1. Evaluate temperature and humidity requirements of each product to be installed within each enclosure.
2. Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction, and wind) on enclosure.
3. Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.
4. Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.
5. Include temperature-controlled cooling within the enclosure for applications where ventilation fans cannot maintain inside temperature of enclosure below maximum operating temperature of product with most stringent requirement.
6. Where required by application, include humidity-controlled electric dehumidifier or cooling to maintain inside of enclosure below maximum relative humidity of product with most stringent requirement and to prevent surface condensation within enclosure.

D. Wall-Mounted, NEMA 250, Type 1:
1. NRTL listed in accordance with UL 50 or UL 50E.
2. Construct enclosure of steel, not less than the following:

a. Enclosure Size Less Than 24 Inches: 0.053 inch or 0.067 inch thick.
b. Enclosure Size 24 Inches and Larger: 0.067 inch or 0.093 inch thick.

3. Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

   a. Exterior Color: Manufacturer's standard.
   b. Interior Color: Manufacturer's standard.

4. Hinged door full size of front face of enclosure and supported using the following:

   a. Enclosures Sizes Less Than 36 Inches Tall: Multiple butt hinges.
   b. Enclosures Sizes 36 Inches Tall and Larger: Continuous piano hinges.

5. Removable internal panel with white or gray polyester powder coating that is electrostatically applied and then baked to bond to substrate.

   a. Size Less Than 24 Inches: Solid or perforated steel, 0.053 inch thick.
   b. Size 24 Inches and Larger: Solid aluminum, 0.10 inch or steel, 0.093 inch thick.

6. Internal panel mounting hardware, grounding hardware, and sealing washers.
7. Grounding stud on enclosure body.
8. Thermoplastic pocket on inside of door for record Drawings and Product Data.

E. Wall-Mounted, NEMA 250, Types 4 and 12:

1. NRTL listed in accordance with UL 508A.
2. Seam and joints are continuously welded and ground smooth.
3. Where recessed enclosures are indicated, include enclosures with face flange for flush mounting.
4. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
5. Single-door enclosure sizes up to 60 inches tall by 36 inches wide.
6. Double-door enclosure sizes up to 36 inches tall by 60 inches wide.
7. Construct enclosure of steel, not less than the following:

   a. Size Less Than 24 Inches: 0.053 inch or 0.067 inch thick.
   b. Size 24 Inches and Larger: 0.067 inch thick.

8. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

   a. Exterior Color: Manufacturer's standard.
   b. Interior Color: Manufacturer's standard.

9. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.

   a. Sizes through 24 Inches Tall: Two hinges.

b. Sizes between 24 Inches through 48 Inches Tall: Three hinges.
c. Sizes Larger Than 48 Inches Tall: Four hinges.

10. Double-door enclosures with overlapping door design to include unobstructed full-width access.

a. Single-door enclosures 48 inches and taller, and all double-door enclosures, with three-point (top, middle and bottom) latch system.

11. Removable internal panel with white or gray polyester powder coating that is electrostatically applied and then baked to bond to substrate.

a. Size Less Than 24 Inches: Solid or perforated steel, 0.053 inch thick.
b. Size 24 Inches and Larger: Solid aluminum, 0.10 inch or steel, 0.093 inch thick.

12. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
13. Grounding stud on enclosure body.
14. Thermoplastic pocket on inside of door for record Drawings and Product Data.

F. Wall-Mounted, NEMA 250, Type 4X-SS:

1. NRTL listed in accordance with UL 508A.
2. Seams and joints are continuously welded and ground smooth.
3. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
4. Construct enclosure of Type 304 or Type 316L stainless steel, not less than the following:

a. Size Less Than 24 Inches: 0.053 inch thick.
b. Size 24 Inches and Larger: 0.067 inch thick.

5. Outside body and door of enclosure with brushed No. 4 finish.
6. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.

a. Sizes through 24 Inches Tall: Two hinges.
b. Sizes between 24 Inchesthrough 48 Inches Tall: Three hinges.
c. Sizes Larger Than 48 Inches Tall: Four hinges.

7. Removable internal panel of 0.093-inch stainless steel.
8. Internal panel mounting studs and hardware, grounding hardware, and sealing washers.
9. Install corrosion-resistant polyester vent drain in a stainless steel sleeve at bottom of enclosure.
10. Include enclosure with stainless steel mounting brackets.

G. Freestanding, NEMA 250, Type 1:

1. NRTL listed in accordance with UL 508A.
2. Seams and joints are continuously welded and ground smooth.
3. Externally formed body flange around perimeter of enclosure face.

4. Single-door enclosure sizes up to 84 inches tall by 36 inches wide.
5. Double-door enclosure sizes up to 84 inches tall by 72 inches wide.
6. Construct enclosure of steel, not less than 0.067 inch thick.
7. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Exterior Color: Manufacturer's standard.
    b. Interior Color: Manufacturer's standard.

8. Corner-formed flush door, full size of enclosure face, supported using four concealed hinges with easily removable hinge pins.
9. Double-door enclosures with overlapping door design to include unobstructed full-width access.
10. Doors with three-point (top, middle, and bottom) latch system with single heavy-duty handle and integral locking mechanism.
11. Removable back covers.
12. Removable solid steel internal panel, 0.093 inch thick, with white or gray polyester powder coating that is electrostatically applied and then baked to bond to substrate.
13. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
14. Grounding stud on enclosure body.
15. Thermoplastic pocket on inside of door for record Drawings and Product Data.
16. Nominal 4-inch- tall integral lifting base, not less than 0.123 inch thick, with predrilled holes for attachment to mounting surface.
17. Equip each top end of enclosure with lifting tabs, not less than 0.172 inch thick, or not less than two lifting eyes.
18. Internal rack-mount shelves and angles, as required by application.

H. Freestanding, NEMA 250, Types 4 and 12:

1. NRTL listed in accordance with UL 508A.
2. Seams and joints are continuously welded and ground smooth.
3. Externally formed body flange around perimeter of enclosure face.
4. Type 12 Enclosure Sizes:

    a. Single-door enclosure sizes up to 90 inches tall by 36 inches wide.
    b. Double-door enclosure sizes up to 90 inches tall by 72 inches wide.

5. Type 4 Enclosure Sizes:

    a. Single-door enclosure sizes up to 72 inches tall by 36 inches wide.
    b. Double-door enclosure sizes larger than 36 inches wide.

6. Construct enclosure of steel, not less than 0.093 inch thick.
7. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Exterior Color: Manufacturer's standard.
    b. Interior Color: Manufacturer's standard.

8. Corner-formed door with continuous perimeter oil-resistant gasket supported using continuous piano hinge full length of door.
9. Doors fitted with three-point (top, middle, and bottom) latch system with latching rod rollers and single, heavy-duty, oiltight handle with integral locking mechanism.
10. Removable solid steel internal panel, 0.093 inch thick, with white or gray polyester powder coating that is electrostatically applied and then baked to bond to substrate.
11. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
12. Grounding stud on enclosure body.
13. Thermoplastic pocket on inside of door for record Drawings and Product Data.
14. Equip top of enclosure with no fewer than two lifting eyes.
15. Internal rack-mount shelves and angles, as required by application.

I. Freestanding, NEMA 250, Type 4X-SS:

1. NRTL listed in accordance with UL 508A.
2. Seams and joints are continuously welded and ground smooth.
3. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
4. Construct enclosure of Type 304 or Type 316L stainless steel, not less than the following:

   a. Size Less Than 24 Inches: 0.053 inch thick.
   b. Size 24 Inches and Larger: 0.067 inch thick.

5. Outside enclosure and door of enclosure with brushed No. 4 finish.
6. Doors:

   a. Single-door enclosure sizes up to 36 inches wide.
   b. Double-door enclosure sizes larger than 36 inches wide.
   c. Corner-formed door(s) with continuous perimeter oil-resistant gasket, full size of enclosure face, supported using continuous piano hinge full length of door.
   d. Doors fitted with three-point (top, middle, and bottom) latch system with single, heavy-duty, liquidtight, Type 304 or Type 316L stainless steel handle with integral locking mechanism.

7. Removable internal panel of 0.093-inch stainless steel.
8. Internal panel mounting studs and hardware, grounding hardware, and sealing washers.
9. Install corrosion-resistant polyester vent drain in a stainless steel sleeve at bottom of enclosure.
10. Include enclosure with stainless steel mounting brackets.
11. Thermoplastic pocket on inside of door for record Drawings and Product Data.
12. Equip top of enclosure with no fewer than two lifting eyes.
13. Internal rack-mount shelves and angles, as required by application.

J. Accessories:

1. Electric Heater:

   a. Aluminum housing with brushed finish.
   b. Thermostatic control with adjustable set point from 0 to 100 deg F.

c. Capacity: 100, 200, 400, and 800 W, as required by application.
d. Fan draws cool air from bottom of enclosure and passes air across thermostat and heating elements before being released into enclosure cavity. Heated air is discharged through the top of heater.

2. Ventilation Fans, Filtered Intake, and Exhaust Grilles:

a. Number and size of fans, filters, and grilles, as required by application.
b. Compact cooling fans engineered for 50,000 hours of continuous operation without lubrication or service.
c. Fans capable of being installed on any surface and in any position within enclosure for spot cooling or air circulation.
d. Thermostatic control with adjustable set point from 32 to 140 deg F.
e. Airflow Capacity at Zero Pressure:

1) 4-Inch Fan: 100 cfm.
2) 6-Inch Fan: 240 cfm.
3) 10-Inch Fan: 560 cfm.

f. Maximum operating temperature of 158 deg F.
g. 4-inch fan thermally protected and provided with permanently lubricated ball-bearings.
h. 6- and 10-inch fans with ball-bearing construction and split capacitor motors thermally protected to avoid premature failure.
i. Dynamically balanced impellers molded from polycarbonate material.
j. Fan furnished with power cord and polarized plug for power connection.
k. Fan brackets, finger guards, and mounting hardware provided with fans to complete installation.
l. Removable Intake and Exhaust Grilles: ABS plastic or stainless steel, of size to match fan size and suitable for NEMA 250, Types 1 and 12 enclosures.
m. Filters for NEMA 250, Type 1 Enclosures: Washable foam or aluminum, of size to match intake grille.
n. Filters for NEMA 250, Type 12 Enclosures: Disposable, of size to match intake grille.

3. Air Conditioner:

a. Electric-powered, self-contained, air-conditioning unit specially designed for electrical enclosures to maintain temperature inside enclosure below ambient temperature outside enclosure.
b. Thermostatic control with adjustable set point from 60 to 120 deg F.
c. Enclosure side or top mounting with unit capacity, as required by application.
d. Designed for closed-loop cooling with continuous operation in ambient environments up to 125 deg F.
e. HFC refrigerant.
f. Reusable and washable air filter.
g. High-performance, industrial-grade, and high-efficiency fans.
h. Furnished with power cord and polarized plug for power connection.
i. Condensate management system with base pan side drain.

j. Mounting hardware, gaskets, mounting template, and instruction manual furnished with unit.
k. Outdoor units equipped with head pressure control for low ambient operation, compressor heater, coated condenser coil, and thermostat.

4. Thermoelectric Humidifier:

a. ABS plastic enclosure.
b. Capacity of 8 oz. of water per 24 hours.
c. Built-in drain captures moisture and plastic hose directs moisture to outside enclosure through a drain.
d. Controlled to maintain enclosure relative humidity at adjustable set point.
e. Unit power supply is internally wired to enclosure electrical power source.

5. Framed Fixed Window Kit for NEMA 250, Types 4, 4X, and 12 Enclosures:

a. 0.25-inch- thick, scratch-resistant acrylic or polycarbonate window mounted in a metal frame matching adjacent door material.
b. Enclosure types, except NEMA 250 Type 1, to have continuous gasket material around perimeter of window and frame to provide watertight seal.
c. Window kit to be factory or shop installed before shipment to Project.

6. Frameless Fixed Window Kit for NEMA 250, Type 1 Enclosures:

a. 0.125-inch- thick, polycarbonate window mounted in enclosure door material.
b. Window attached to door with screw fasteners and continuous strip of high-strength, double-sided tape around window perimeter.
c. Window kit is factory or shop installed before shipment to Project.

7. Frame Fixed or Hinged Window Kit for NEMA 250, Types 1 and 12 Enclosures:

a. 0.25-inch- thick, scratch-resistant acrylic or polycarbonate window mounted in a metal frame matching adjacent door material.
b. Enclosure types, except NEMA 250 Type 1, to have continuous gasket material around perimeter of window and frame to provide watertight seal.
c. Window kit to be factory or shop installed before shipment to Project.

8. Bar handle with keyed cylinder lock set.

2.24 RELAYS

A. General-Purpose Relays:

1. NRTL listed.
2. Heavy-duty, electromechanical type; rated for at least 10 A at 250 V ac and 60 Hz.
3. SPDT, DPDT, or three-pole double-throw, as required by control application.
4. Plug-in-style relay with 8-pin octal or multiblade plug for DPDT relays and 11-pin octal or multiblade plug for three-pole double-throw relays.

5. Construct contacts of silver, silver alloy, or gold.
6. Enclose relay in a clear transparent polycarbonate dust-tight cover.
7. Include LED indication and push-to-test button to test manual operation of relay without power on coil.
8. Performance:

    a. Mechanical Life: At least 10 million cycles.
    b. Electrical Life: At least 100,000 cycles at rated load.
    c. Pickup Time: 15 ms or less.
    d. Dropout Time: 10 ms or less.
    e. Pull-in Voltage: 85 percent of rated voltage.
    f. Dropout Voltage: 50 percent of nominal rated voltage.
    g. Power Consumption: 2 VA or less.
    h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

9. Equip relays with coil transient suppression to limit transients to non-damaging levels.
10. Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
11. Include relay socket with screw terminals. Mold into socket the coincident screw terminal numbers.

B. Multifunction Time-Delay Relays:

1. NRTL listed.
2. Continuous-duty type, rated for at least 10 A at 240 V ac and 60 Hz.
3. Relay with up to 4 programmable functions to provide on/off delay, interval, and recycle timing functions.
4. Plug-in-style relay with either multi-pin or blade plug.
5. Construct contacts of silver, silver alloy, or gold.
6. Enclose relay in a dust-tight cover.
7. Include knob and dial scale for alternative digital interface for setting delay time.
8. Visual Status Indication: Power "On" and Output "On" status.
9. Performance:

    a. Mechanical Life: At least 10 million cycles.
    b. Electrical Life: At least 100,000 cycles at rated load.
    c. Timing Ranges: Multiple ranges from 0.1 seconds to 100 minutes.
    d. Repeatability: Within 2 percent.
    e. Recycle Time: 45 ms.
    f. Minimum Pulse-Width Control: 50 ms.
    g. Power Consumption: 5 VA or less.
    h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

10. Equip relays with transient suppression to limit transients to non-damaging levels.
11. Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
12. Include relay socket with screw terminals. Mold into socket the coincident screw terminal numbers.

C. Latching Relays:

1. NRTL listed.
2. Continuous-duty type, rated for at least 10 A at 250 V ac and 60 Hz.
3. SPDT, DPDT, or three-pole double-throw, as required by control application.
4. Plug-in-style relay with either multi-pin or blade plug.
5. Construct contacts of silver, silver alloy, or gold.
6. Enclose relay in a clear transparent polycarbonate dust-tight cover.
7. Performance:
    a. Mechanical Life: At least 10 million cycles.
    b. Electrical Life: At least 100,000 cycles at rated load.
    c. Pickup Time: 15 ms or less.
    d. Dropout Time: 10 ms or less.
    e. Pull-in Voltage: 85 percent of rated voltage.
    f. Dropout Voltage: 50 percent of nominal rated voltage.
    g. Power Consumption: 2 VA or less.
    h. Ambient Operating Temperatures: Minus 40 to 115 deg F.
8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
9. Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
10. Relay socket with screw terminals. Mold into socket the coincident screw terminal numbers.

D. Current Sensing Relays:

1. NRTL listed.
2. Monitors ac current.
3. Independent adjustable controls for pickup and dropout current.
4. Energized when supply voltage is present and current is above pickup setting.
5. De-energizes when monitored current is below dropout current.
6. Dropout current is adjustable from 50 to 95 percent of pickup current.
7. Visual indication of contact status.
8. Include current transformer, if required for application.
9. House current sensing relay and current transformer if required in its own enclosure. Use NEMA 250, Type 1 or Type 12 enclosure for indoors applications and NEMA 250, Type 4 or Type 4X for outdoor applications.

E. Combination On-Off Status Sensor and On-Off Control Relays:

1. Description:
    a. On-off control and on-off status indication in a single device.
    b. LED status indication of activated relay and current trigger.
    c. Closed-Open-Auto override switch located on the load side of relay.

2. Performance:

   a. Ambient Temperature: Minus 30 to 140 deg F.
   b. Voltage Rating: Single-phase loads rated for 300 V ac. Three-phase loads rated for 600 V ac.

3. Status Indication:

   a. Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.
   b. Current Sensor Range: As required by application.
   c. Current Set Point: Fixed or adjustable, as required by application.
   d. Current Sensor Output:

      1) Solid-state, SPDT contact rated for 30 V ac and dc and for 0.4 A.
      2) Solid-state, SPDT contact rated for 120 V ac and 1.0 A.
      3) Analog, 0 to 5 or 10 V dc.
      4) Analog, 4 to 20 mA, loop powered.

4. Relay: SPDT, continuous-duty coil; rated for 10-million mechanical cycles.
5. Enclosure: NEMA 250, Type 1 or Type 12 enclosure for indoor applications; NEMA 250, Type 4 or Type 4X enclosure for outdoor applications.

2.25 ELECTRICAL POWER DEVICES

A. Control Transformers:

   1. Sizing Criteria: Size control transformers for total connected load, plus additional 25 percent of connected load for future spare capacity.
   2. Transformer Minimum Capacity: 40 VA.
   3. Protection: Provide transformers with both primary and secondary fuses. Integral circuit breaker is acceptable in lieu of fuses.
   4. Enclosure: House control transformers in NEMA 250 enclosures, type as indicated in "Performance Requirements" Article for application.

B. DC Power Supplies:

   1. Description: Linear or switched, regulated power supplies with ac input to one or multiple dc output(s).

      a. Include both line and load regulation to ensure stable output.
      b. To protect both power supply and load, include power supply with an automatic current limiting circuit.

   2. Features:
      a. Housing: Enclose circuitry in a housing.
      b. Local Adjustment: Include screw adjustment on exterior of housing for dc voltage output.

c. Mounting: DIN rail.
d. Visual status indicator.

3. Performance:

a. Input Voltage: Nominally 120 V ac, 60 Hz.
b. Output Voltage: Nominally 24 V dc with plus or minus 1 V dc adjustment.
c. Output Current: Minimum 100 mA.
d. Load Regulation: Within 0.1 percent.
e. Line Regulation: Within 0.05 percent.
f. Stability: Within 0.1 percent of rated volts after warmup period.
g. Ripple: 1 mV rms.

2.26 UNINTERRUPTABLE POWER SUPPLY (UPS) UNITS

A. Furnish local UPS units, of type indicated, installed with DDC system.

B. DIN Rail Mounted UPS:

1. Provide continuous, regulated output power without using batteries during brown-out, surge, and spike conditions.
2. Performance:

a. Capacity: Load not to exceed 75 percent of rated capacity.
b. Efficiency: Minimum 94 percent.
c. Input Voltage: Single phase, 120 V ac, compatible with field power source.
d. Load Power Factor Range (Crest Factor): 0.65 to 1.0.
e. Output Voltage: 101 to 132 V ac, while input voltage varies between 89 and 152 V ac.
f. On Battery Output Voltage: Sine wave.
g. Inverter Overload Capacity: Minimum 150 percent for 30 seconds.
h. Battery Backup: 10 minutes of operation at full load with battery power.
i. Battery Recharge Time: Maximum of four hours to 90 percent capacity after full discharge.
j. Transfer Time: 6 ms.
k. Surge Voltage Withstand Capacity: IEEE C62.41.1 and IEEE C62.41.2, Categories A and B.

3. Automatic bypass operation during fault or overload conditions.
4. Integral line-interactive, power condition topology to eliminate all power contaminants.
5. Include power switch and visual indication of power, battery, fault, and temperature.
6. Include audible alarm of faults with silence feature.
7. Include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure) and connect points to DDC system.
8. Batteries: Sealed; maintenance free; replacement without dropping load.

C. Tower UPS Models through 1000 VA:

1. Provide continuous, regulated output power without using batteries during brown-out, surge, and spike conditions.
2. Performance:

    a. Capacity: Load not to exceed 75 percent of rated capacity.
    b. Efficiency: Complying with ENERGY STAR requirements; minimum 91 percent.
    c. Input Voltage: Single phase, 120 V ac, compatible with field power source.
    d. Load Power Factor Range (Crest Factor): 0.65 to 1.0.
    e. Output Voltage: 101 to 132 V ac, while input voltage varies between 89 and 152 V ac.
    f. On Battery Output Voltage: Sine wave.
    g. Inverter Overload Capacity: Minimum 150 percent for 30 seconds.
    h. Battery Backup: 10 minutes of operation at full load with battery power.
    i. Battery Recharge Time: Maximum of four hours to 90 percent capacity after full discharge to cutoff.
    j. Transfer Time: 0 ms.
    k. Surge Voltage Withstand Capacity: IEEE C62.41.1 and IEEE C62.41.2, Categories A and B; 6 kV/200 and 500 A; 100 kHz ring wave.

3. Automatic bypass operation during fault or overload conditions.
4. Integral line-interactive, power condition topology to eliminate all power contaminants.
5. Include power switch and visual indication of power, battery, fault, and temperature.
6. Include audible alarm of faults and front panel silence feature.
7. Receptacles: Minimum four, NEMA WD 1, NEMA WD 6 Configuration 5-15R receptacles.
8. Remote Alarms: Include dry contacts (digital output points) or serial communication interface for low battery condition and battery-on (primary utility power failure) and connect points to DDC system.
9. Batteries: Sealed type; maintenance free. Battery replacement is to be front accessible by user without dropping load.
10. Install tower models in enclosures rated for location.

D. Tower and Rack UPS Models through 3000 VA:

1. NRTL Listing: UL 1778.
2. Provide continuous, regulated output power without using batteries during brown-out, surge, and spike conditions.
3. Performance:

    a. Capacity: Load not to exceed 75 percent of UPS rated capacity.
    b. Efficiency: Complying with ENERGY STAR requirements; minimum 91 percent.
    c. Input Voltage: Single phase, 120 V ac, plus 20 to minus 30 percent.
    d. Power Factor: Minimum 0.95 at full load.
    e. Output Voltage: Single phase, 120 V ac, within 2 percent.
    f. Inverter overload capacity to be minimum 150 percent for 30 seconds.
    g. Battery Backup: 10 minutes of operation at full load with battery power.
    h. Battery Recharge Time: Maximum of 6 hours to 90 percent capacity.
    i. Transfer Time: 0 ms.

4. LCD display with operator interface.
5. Receptacles: Minimum 6, NEMA WD 1, NEMA WD 6 Configuration 5-15R or 5-20R receptacles.
6. Automatic bypass operation during fault or overload conditions.
7. Remote Alarms: Include dry contacts (digital output points) or serial communication interface for low battery condition and battery-on (primary utility power failure) and connect points to DDC system.
8. Batteries: Sealed; maintenance free.
9. Enclosures: Install tower models in enclosures rated for location. Install rack models installed on matching racks, as applicable to particular installation location and space availability/configuration.

2.27 PRESSURE INSTRUMENT SIGNAL AIR PIPING AND TUBING

A. Products in this article are intended for use with the following:

1. Main air and signal air to pneumatically controlled instruments, actuators, and other control devices and accessories.
2. Signal air between pressure instruments, such as sensors, switches, transmitters, controllers, and accessories.

B. Copper Tubing:

1. Seamless phosphor deoxidized copper, drawn tempered, or soft annealed, with chemical and physical properties in accordance with ASTM B75/B75M.
2. Performance, dimensions, weight, and tolerance in accordance with ASTM B280.
3. Diameter, as required by application, not less than nominal 1/4 inch.
4. Wall thickness, as required by application, but not less than 0.030 inch.
5. Copper Tubing Connectors and Fittings - Brass, Compression Type:

   a. Single or double ferrule design creating a constant tension between fitting body and fitting nut for leak-free seal.

6. Copper Tubing Connectors and Fittings - Copper, Solder-Joint Type:

   a. Copper Solder-Joint Fittings: Cast, ASME B16.18 or wrought, ASME B16.22.

C. Polyethylene Tubing (for Pneumatic/Pressure Instrument Signal Air):

1. Fire-resistant, black virgin polyethylene in accordance with ASTM D1248, Type 1, Class C, and Grade 5.
2. Complying with stress crack test in accordance with ASTM D1693.
3. Diameter, as required by application, of not less than nominal 1/4 inch.
4. Polyethylene Tubing Connectors and Fittings - Brass, Barb Fittings:

a. Tapered and beaded hose barbs of push-on design; intended for low-pressure applications only.

5. Polyethylene Tubing Connectors and Fittings - Brass, Compression Type:

a. Specially designed for jointing polyethylene tubing to provide leak-free seal without twisting or weakening polyethylene tubing.

2.28 PROCESS TUBING

A. Products in this article are intended for signals to instruments connected to liquid and steam systems.

B. Copper Tubing:

1. Seamless phosphor deoxidized copper, drawn tempered with chemical and physical properties in accordance with ASTM B75/B75M.
2. Performance, dimensions, weight, and tolerance in accordance with ASTM B280.
3. Diameter, as required by application, of not less than nominal 3/8 inch.
4. Wall thickness, as required by application, but not less than 0.030 inch.
5. Copper Tubing Connectors and Fittings (for Process Tubing) - Brass, Compression Type:

a. Single or double ferrule design creating a constant tension between fitting body and fitting nut for leak-free seal.

6. Copper Tubing Connectors and Fittings (for Process Tubing) - Brass, Solder-Joint Type:

a. Copper Solder-Joint Fittings: Cast, ASME B16.18 or wrought, ASME B16.22.

C. Stainless Steel Tubing (for Process Tubing):

1. Seamless Type 316 stainless steel, Grade TP, cold drawn, annealed and pickled, and free from scale.
2. Chemical and physical properties in accordance with ASTM A269/A269M.
3. Diameter, as required by application, of not less than nominal 3/8 inch.
4. Wall thickness, as required by application, but not less than 0.035 inch.
5. Furnish stainless steel tubing in 20 ft. straight random lengths.

D. Stainless Steel Tubing Connectors and Fittings (for Process Tubing) - Stainless Steel, Compression Type:

1. Connectors and fittings constructed from Type 316 stainless steel, with collets, flareless type.
2. Single or double ferrule design creating a constant tension between fitting body and fitting nut for leak-free seal.

3. Connect instruments to tubing with connectors having compression connector on one end and IPS or NPT thread on other end.

2.29 CONTROL WIRE AND CABLE

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

1. Wire Size: Minimum 18 AWG.
2. Conductors: 7/24 soft annealed copper strand with 2- to 2.5-inch lay.
3. Conductor Insulation: 600 V, Type THWN or Type THHN, and 90 deg C in accordance with UL 83.
4. Conductor Insulation Colors: Black (hot), white (neutral), and green (ground).
5. Furnish on spools.

B. Single, Twisted-Shielded, Instrumentation Cable above 24 V:

1. Wire Size: Minimum 18 AWG.
2. Conductors: Twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch lay.
3. Conductor Insulation: Type THHN/THWN or Type TFN rating.
4. Conductor Insulation Colors:

   a. Twisted Pair: Black and white.
   b. Twisted Triad: Black, red, and white.

5. Shielding: 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
6. Outer Jacket Insulation: 600 V, 90 deg C rating, and Type TC cable.
7. Furnish on spools.

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

1. Wire Size: Minimum 18 AWG.
2. Conductors: Twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
3. Conductor Insulation: Nominal 15-mil thickness, constructed from flame-retardant PVC.
4. Conductor Insulation Colors:

   a. Twisted Pair: Black and white.
   b. Twisted Triad: Black, red, and white.

5. Shielding: 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
6. Outer Jacket Insulation: 300 V, 105 deg C rating, and Type PLTC cable.
7. Furnish on spools.

D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

   a. Plenum rated.
   b. Unique color that is different from other cables used on Project.

2.30 ACCESSORIES

A. Pneumatic Pressure Gauges:

1. Face Size: 1.5-inch- diameter face for pressures up through 30 psig and 2.5-inch-diameter face for greater pressures.
2. Face Markings: White dial face with black printing; 1 psig increment for scale ranges through 30 psig and 2 psig increment for larger ranges.
3. Accuracy: Within 1 percent of full-scale range.
4. Applications: Include separate gauges for branch pressure and main pressure tubing.

B. Pressure Electric Switches:

1. Description: Diaphragm-operated, snap-acting switch.
2. Performance:

a. Rating: Resistance loads at 120 V ac.
b. Set Point: Adjustable from 3 to 20 psig.
c. Differential: Adjustable from 2 to 6 psig.

3. Body and Switch Housing: Metal.

C. Control Damper Blade Limit Switches:

1. Application: Sense positive open and/or closed position of damper blades.
2. NEMA 250, Type 13, oiltight construction. Install in instrument enclosure where required for additional environmental protection.
3. Arrange for mounting application, and to prevent "over-center" operation.

D. I/P and E/P Transducers:

1. Commercial Grade:

a. Description: Transducer converting an electronic current (I) or voltage (E) AO signal to a proportional or stepped pneumatic signal. Unless otherwise required by operating sequence, use 3 to 15 psig pneumatic signal for pneumatic actuation.
b. Features:

1) Auto/manual output switch, manual output control, and output pressure gauge.
2) Separate zero and span calibration adjustments.

c. Performance:

1) Accuracy: Within 1.0 percent of output span.
2) Linearity: Within 1.0 percent of output span.
3) Output Capacity: Not less than 550 scim at 15 psig.
4) Maximum Pressure: 30 psig of supply pressure without damage.

5) Vibration: Construct entire assembly so that shock and vibration will not harm transducer or affect accuracy.

d. Applications:

1) Terminal Units: Fan-coil units, VAV units, unit heaters, and.

2. Industrial Grade:

a. Description: Transducer converting an electronic current (I) or voltage (E) AO signal to a proportional pneumatic signal (P). Unless otherwise required by operating sequence, use 3 to 15 psig pneumatic signal for pneumatic actuation. Stepped pneumatic signal is unacceptable.

b. Features:

1) Adjustments: Separate zero and span calibration adjustments.
2) Conduit Connections: Nominal 1/2 inch.
3) Enclosure: NEMA 250, Type 4X.
4) Pressure Gauge: Integral output pressure gauge.

c. Performance:

1) Accuracy: Within 1.0 percent of output span.
2) Hysteresis: Within 0.5 percent of output span.
3) Linearity: Within 0.5 percent of output span.
4) Repeatability: Within 0.5 percent of output span.
5) Output Capacity: Not less than 5 scfm at 15 psig.
6) Air Consumption: Maximum of 5 scfh at 15 psig.
7) Ambient Temperature: Suitable for operation in ambient temperature range of minus 20 to 150 deg F.
8) Pressure: Up to 50 psig without damage.
9) Vibration: Construct entire assembly so shock and vibration will not harm transducer or affect accuracy.

d. Applications:

1) All applications, except for terminal units and other applications with commercial-grade transducers.

E. E/P Switch:

1. Body: Cast aluminum or brass; three pipe body (common, normally open, and normally closed).
2. Internal Components: Brass, copper, steel, or stainless steel.
3. Connections: Barb, or threaded for mating to compression fittings.
4. Rating: 30 psig when installed in systems below 25 psig; 150 psig when installed in systems above 25 psig.
5. Features: Include coil transient suppression.

F. Instrument Enclosures:

1. Application: Include instrument enclosure for secondary protection to comply with requirements indicated in "Performance Requirements" Article.
2. Certification: NRTL listed and labeled to UL 50 or UL 508A as applicable.
3. Subpanel:

   a. Size enclosure with least 25 percent spare area on subpanel.
   b. Mount instrument(s) within enclosure on internal subpanel(s).

4. Identification: Include on face of enclosure an engraved, laminated phenolic nameplate for each instrument installed within enclosure.
5. Pneumatic Pressure Gauges: Include main pressure gauge and a branch pressure gauge for each pneumatic device installed inside enclosure.
6. Raceways: For enclosures housing multiple instruments, route tubing, cable, and wiring within enclosure in a raceway having continuous removable cover.
7. Access: Provide enclosures larger than 12 inches with hinged full-size face cover.

G. Manual Valves:

1. Brass Needle Valves:

   a. Pressure Rating: 150 psig.
   b. Temperature Rating: 250 deg F.
   c. Body: Brass.
   d. Seat: Brass.
   e. Handle: Aluminum, brass, or stainless steel T-bar handle.
   f. Connections: Include tubing connections.
   g. Applications: Copper and polyethylene pneumatic tubing.

2. Stainless Steel Needle Valves:

   a. Pressure Rating: 5000 psig.
   b. Temperature Rating: 450 deg F.
   c. Body: Type 316 stainless steel.
   d. Seat: Type 316 stainless steel.
   e. Packing: PTFE.
   f. Handle: Aluminum or stainless steel T-bar handle.
   g. Connections: Include tubing connections.
   h. Applications: Copper pneumatic tubing; copper and stainless steel process tubing.

3. Bronze Body Ball Valves:

   a. Standard: MSS SP-110.
   b. SWP Rating: 150 psig.
   c. CWP Rating: 600 psig.

d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Handle: Stainless steel with vinyl grip.
k. Port: Full.

2.31 IDENTIFICATION

A. Instrument Air Pipe and Tubing:

1. Engraved tag bearing the following information:

   a. Service (Example): "Instrument Air."
   b. Pressure Range (Example): 0 to 30 psig.

2. Letter size minimum of 0.25 inch high.
3. Engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers color-coded blue with contrasting white center exposed by engraving through outer layer.
4. Include tag with brass grommet, chain, and S-hook.

B. Control Equipment, Instruments, and Control Devices:

1. Self-adhesive label Laminated acrylic or melamine plastic sign bearing unique identification.

   a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.

2. Letter size as follows:

   a. Servers: Minimum of 0.5 inch high.
   b. DDC Controllers: Minimum of 0.5 inch high.
   c. Gateways: Minimum of 0.5 inch high.
   d. Repeaters: Minimum of 0.5 inch high.
   e. Enclosures: Minimum of 0.5 inch high.
   f. Electrical Power Devices: Minimum of 0.25 inch high.
   g. UPS units: Minimum of 0.5 inch high.
   h. Accessories: Minimum of 0.25 inch high.
   i. Instruments: Minimum of 0.25 inch high.
   j. Control Damper and Valve Actuators: Minimum of 0.25 inch high.

3. Engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers color-coded black with contrasting white center exposed by engraving through outer layer.
4. Fastened with drive pins.

5. Instruments, control devices, and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require additional identification.

C. Valve Tags:

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

D. Raceway and Boxes:

1. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
2. Paint cover plates on junction boxes and conduit same color as tape banding for conduits. After painting, label cover plate "HVAC Controls" using engraved phenolic tag.
3. For raceways housing pneumatic tubing, add phenolic tag labeled "HVAC Instrument Air Tubing."
4. For raceways housing air signal tubing, add phenolic tag labeled "HVAC Air Signal Tubing."

E. Equipment Warning Labels:

1. Self-adhesive label with pressure-sensitive adhesive back and peel-off protective jacket.
2. Lettering size at least 14-point type with white lettering on red background.
3. Warning label to read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
4. Lettering to be enclosed in a white line border. Edge of label is to extend at least 0.25 inch beyond white border.

2.32 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate the following in accordance with industry standards for each product, and to verify DDC system reliability specified in performance requirements:

1. DDC controllers.
2. Gateways.
3. Routers.

B. Product(s) and material(s) will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

E. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

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

3.2 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

A. Communication Interface to Equipment with Integral Controls:

1. DDC system has communication interface with equipment having integral controls and having communication interface for remote monitoring or control.

3.3 PREINSTALLATION INTEGRATION TESTING

A. Perform the following pretesting of other systems and equipment integration with DDC system before field installation:

1. Test all communications in a controlled environment to ensure connectivity.
2. Load software and demonstrate functional compliance with each control sequence of operation indicated.
3. Using simulation, demonstrate compliance with sequences of operation and other requirements indicated including, but not limited to, the following:

a. HVAC equipment controlled through DDC system, such as boilers, chillers, pumps, and air-handling units.
b. Equipment faults and system recovery with fault annunciation.
c. Analog and Boolean value alarming and annunciation.

4. Develop a method for testing interfaces before deployment.
5. Submit documentation supporting compliance upon request.

3.4 GENERAL INSTALLATION REQUIREMENTS

A. Install products to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Support products, tubing, piping wiring, and raceways. Brace products to prevent lateral movement and sway or a break in attachment.

D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.

E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

F. Welding Requirements:

1. Restrict welding and burning to supports and bracing.
2. No equipment is cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.
3. Welding, where approved, is to be by inert-gas electric arc process and is to be performed by qualified welders in accordance with applicable welding codes.
4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.

G. Fastening Hardware:

1. Wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

H. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

I. Corrosive Environments:

1. Avoid or limit use of materials in corrosive airstreams and environments including, but not limited to, the following:

   a. Laboratory exhaust-air streams.
   b. Process exhaust-air streams.

2. When conduit is in contact with a corrosive airstream and environment, use Type 316 stainless steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment. Comply with requirements for

installation of raceways and boxes specified in Section 260533 "Raceway and Boxes for Electrical Systems."

3. Where instruments are located in a corrosive airstream and are not already corrosive resistant from instrument manufacturer, field install products in NEMA 250, Type 4X instrument enclosure constructed of Type 316L stainless steel.

3.5 INSTALLATION OF WORKSTATIONS

A. Desktop Workstation Installation:

1. Install workstation(s) at location(s) indicated on Drawings.
2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single, duplex, electrical power receptacle.
3. Install DDC system software on workstation(s) and verify that software functions properly.
4. Develop Project-specific graphics, trends, reports, logs, and historical database.
5. Power each workstation through a UPS unit.

B. Portable Workstation Installation:

1. Install DDC system software on workstation(s) and verify that software functions properly.

C. Color Graphics Application:

1. Use system schematics indicated on Drawings as starting point to create graphics.
2. Develop Project-specific library of symbols for representing system equipment and products.
3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
4. Submit sketch of graphic layout with description of all text for each graphic for Owner's and Architect's review before creating graphic using graphics software.
5. Seek Owner input in graphics development once using graphics software.
6. Make final editing on-site with Owner's and Architect's review and feedback.
7. Refine graphics as necessary for Owner acceptance.
8. On receiving Owner acceptance, print a PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

D. Retractable, Wall-Mounted Cabinet for Portable Operator's Workstation Installation:

1. Install retractable, wall-mounted portable operator's workstation cabinet(s) at location(s) indicated on Drawings.

2. Connect each cabinet to 120 V, single-phase, 60 Hz field power source and install single gang electrical box with NEMA WD 6, Type 20R duplex receptacle and metal cover plate in cabinet.
3. Connect each cabinet to Ethernet network and install an Ethernet network port for connection to portable operator workstation Ethernet cable.

3.6 INSTALLATION OF SERVERS

A. Install server(s) at location(s) indicated on Drawings.

B. Install number of servers required to suit requirements indicated. Review Project requirements and indicate layout of proposed server location in Shop Drawings.

C. Install software indicated on server(s) and verify that software functions properly.

D. Develop Project-specific graphics, trends, reports, logs, and historical database.

E. Power servers through UPS unit. Locate UPS adjacent to server. Install rack-mounted UPS units for powering rack-mounted servers and tower UPS units for tower servers.

3.7 INSTALLATION OF GATEWAYS

A. Install gateways if required for DDC system communication interface requirements indicated.

1. Install gateway(s) required to suit indicated requirements.

B. Test gateways to verify that communication interface functions properly.

3.8 INSTALLATION OF ROUTERS

A. Install routers if required for DDC system communication interface requirements indicated.

1. Install router(s) required to suit indicated requirements.

B. Test routers to verify that communication interface functions properly.

3.9 INSTALLATION OF CONTROLLERS

A. Install controllers in enclosures to comply with indicated requirements.

B. Connect controllers to field power supply and to UPS units where indicated.

C. Install controllers with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation of Network Controllers:

1. DDC system provider and DDC system manufacturer to determine quantity and location of network controllers to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Locate top of controller within 72 inches of finished floor.

F. Installation of Programmable Application Controllers:

1. DDC system provider and DDC system manufacturer to determine quantity and location of programmable application controllers to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Locate top of controller within 72 inches of finished floor, except where dedicated controllers are installed at terminal units.

G. Application-Specific Controllers:

1. DDC system provider and DDC system manufacturer to determine quantity and location of application-specific controllers to satisfy requirements indicated.
2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.10 INSTALLATION OF WIRELESS ROUTERS FOR OPERATOR INTERFACE

A. Install wireless routers to achieve optimum performance and best possible coverage.

B. Mount wireless routers in a protected location that is within 60 inches of floor and easily accessible by operators.

C. Connect wireless routers to field power supply and to UPS units if network controllers are powered through UPS units.

D. Install wireless router with latest version of applicable software and configure wireless router with security and password protection. Create access password with not less than 12 characters consisting of letters and numbers and at least one special character. Document password in operations and maintenance manuals for reference by operators.

E. Test and adjust wireless routers for proper operation with all types (such as, laptops, smartphones, and tablets) of wireless devices intended for use by operators.

3.11 INSTALLATION OF ENCLOSURES

A. Install the following items in enclosures, to comply with indicated requirements:

1. Gateways.
2. Routers.
3. Controllers.
4. Electrical power devices.
5. UPS units.
6. Relays.
7. Accessories.
8. Instruments.
9. Actuators.

B. Attach wall-mounted enclosures to wall using the following types of steel struts:

1. For NEMA 250, Type 1 Enclosures: Use galvanized-steel strut and hardware.
2. For NEMA 250, Type 4 Enclosures and Enclosures Located Outdoors: Use stainless steel strut and hardware.
3. Install plastic caps on exposed cut edges of strut.

C. Align top or bottom of adjacent enclosures of like size.

D. Install floor-mounted enclosures located in mechanical equipment rooms on concrete housekeeping pads. Attach enclosure legs using galvanized-steel or stainless steel anchors.

3.12 ELECTRIC POWER CONNECTIONS

A. Connect electrical power to DDC system products requiring electrical power connections.

B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade to provide a fully functioning DDC system. Work is to comply with NFPA 70 and other requirements indicated.

3.13 INSTALLATION OF IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals.

B. Install self-adhesive labels laminated acrylic or melamine plastic signs with unique identification on face for each of the following:

1. Server.
2. Gateway.
3. Router.
4. Protocol analyzer.
5. DDC controller.
6. Enclosure.
7. Electrical power device.
8. UPS unit.
9. Accessory.

C. Install unique instrument identification for each instrument connected to DDC controller.

D. Install unique identification for each control damper and valve actuator connected to DDC controller.

E. Where product is installed above accessible tile ceiling, also install matching identification on face of ceiling grid located directly below.

F. Where product is installed above an inaccessible ceiling, also install identification on face of access door directly below.

G. Warning Labels and Signs:

1. Permanently attach to equipment that can be automatically started by DDC control system.
2. Locate where highly visible near power service entry points.

3.14 INSTALLATION OF NETWORKS

A. Install balanced twisted pair or optical fiber cable when connecting between the following network devices located in same building:

1. Operator workstations.
2. Operator workstations and network controllers.
3. Network controllers.

B. Install balanced twisted pair or copper cable (as required by equipment) when connecting between the following:

1. Gateways.
2. Gateways and network controllers or programmable application controllers.
3. Routers.
4. Routers and network controllers or programmable application controllers.
5. Network controllers and programmable application controllers.
6. Programmable application controllers.
7. Programmable application controllers and application-specific controllers.
8. Application-specific controllers.

C. Install cable in continuous raceway.

1. Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit.

3.15 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

B. ASHRAE 135 Networks:

1. MAC Address:

   a. Assign and document a MAC address unique to its network for every network device.
   b. Ethernet Networks: Document MAC address assigned at its creation.
   c. MS/TP Networks: Assign from 00 to 64.

2. Network Numbering:

   a. Assign unique numbers to each new network.

b. Provide ability for changing network number through device switches or operator interface.
c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.

3. Device Object Identifier Property Number:

a. Assign unique device object identifier property numbers or device instances for each device network.
b. Provide for future modification of device instance number by device switches or operator interface.
c. LAN is to support up to 4,194,302 unique devices.

4. Device Object Name Property Text:

a. Device object name property field to support 32 minimum printable characters.
b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.

1) Example 1: Device object name for device controlling heating water boiler plant at Building 1000 would be "Heating Water System Bldg. 1000."
2) Example 2: Device object name for VAV terminal unit controller could be "VAV Unit 102."

5. Object Name Property Text for Other Than Device Objects:

a. Object name property field is to support 32 minimum printable characters.
b. Assign object name properties with plain-English names descriptive of application.

1) Example 1: "Zone 1 Temperature."
2) Example 2 "Fan Start and Stop."

6. Object Identifier Property Number for Other Than Device Objects:

a. Assign object identifier property numbers according to Drawings or tables indicated.
b. If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Owner in advance, be documented, and be unique for like object types within device.

3.16 INSTALLATION OF PNEUMATIC AND AIR SIGNAL PIPING AND TUBING

A. Above-Grade Pneumatic and Air Signal Piping and Tubing Installation:

1. Material Application:

a. Install copper tubing, except as follows:

1) Tubing Exposed to View: Polyethylene tubing installed in raceways may be used in lieu of copper tubing.
2) Concealed Tubing: Polyethylene tubing may be used in lieu of copper tubing when concealed behind accessible ceilings and concealed in walls and connecting wall-mounted instruments with recessed connections.

b. Pneumatic Tubing: Install copper tubing, unless other accessible materials are indicated, for pneumatic main and control signals to instruments including, but not limited to, the following:

1) Pneumatic actuators.
2) I/P transducers.
3) Sensors.
4) Switches.
5) Transmitters.

c. Install copper tubing, unless other accessible materials are indicated, for air signals to instruments including, but not limited to, the following:

1) Sensors.
2) Switches.
3) Transmitters.

d. Install drawn-temper copper tubing, except within 36 inches of device terminations tubing is to be annealed-tempered copper tubing.
e. Install compression fittings to connect copper tubing to instruments, control devices, and accessories.
f. Install barbed or compression fittings to connect polyethylene tubing to instruments, control devices, and accessories.

2. Routing:

a. Do not expose tubing in finished spaces, such as spaces with ceilings; occupied spaces, offices, and conference rooms, unless expressly approved in writing by Architect. Tubing may be exposed in areas without ceilings.
b. Where tubing is installed in finished occupied spaces, install the tubing in surface metal raceway with appropriate fittings only where not feasible to conceal in wall, above ceiling, or behind architectural enclosures or covers.
c. Install piping and tubing plumb and parallel to and at right angles with building construction.
d. Install multiple runs of tubing or piping in equally spaced parallel lines.
e. Install piping and tubing not to interfere with access to valves, equipment, duct, and equipment access doors, or obstruct personnel access and passageways of any kind.
f. Coordinate with other trades before installation to prevent proposed piping and tubing from interfering with pipe, duct, terminal equipment, light fixtures, conduit, and cable tray space. If changes to Shop Drawings are necessary due to field coordination, document changes on Record Drawings.
g. Install vibration loops in copper tubing when connecting to instruments and actuators that vibrate.

3. Support:

   a. Space supports in accordance with MSS SP-58, except support spacing not to exceed 60 inches.
   b. Support copper tubing with copper hangers, clips, and tube trays.
   c. Do not use tape for support or dielectric isolation.
   d. Install supports at each change in direction and at each branch take-off.
   e. Attached supports to building structure independent of work of other trades. Support from ducts, pipes, cable trays, and conduits is prohibited.
   f. Attached support from building structure with threaded rods, structural shapes, or channel strut.
   g. Install and brace supports to carry static load plus a safety margin, which will allow tubing to be serviced.
   h. Brace supports to prevent lateral movement.
   i. Paint steel support members that are not galvanized or zinc coated.
   j. Support polyethylene tubing same as copper tubing.

4. Do not attach piping and tubing to equipment that may be removed frequently for maintenance or that may impart vibration and expansion from temperature change.
5. Joining and Makeup:

   a. Where joining and mating dissimilar metals where galvanic action could occur, install dielectric isolation.
   b. Install dirt leg with an isolation valve and threaded plug at each main air, connection to panel, pneumatic pilot positioner, and PRV station.
   c. Make threaded joints for connecting to instrument equipment with connectors with a compression tubing connector on one end and threaded connection on the other end.
   d. Make tubing bends with tube-bending tool. Hard-bends or wrinkled or flattened bends are unacceptable.
   e. Install tube fittings in accordance with manufacturer's written instructions.
   f. Do not make tubing connections to a fitting before completing makeup of the connection.
   g. Align tubing with fitting. Avoid springing tube into position; this may result in excessive stress on both tubing and fitting with possible resulting leaks.
   h. Do not install fittings close to a bend. A length of straight tubing, not deformed by bending, is required for proper connection.
   i. Check tubing for correct diameter and wall thickness.
   j. Cut tube ends square and deburr. Exercise care during cutting to keep tubing round.
   k. Thread pipe on a threading machine. Ream inner edges of pipe ends, and file and grind to remove burrs.
   l. Wrap pipe threads with single wrap of PTFE tape.
   m. Protect piping and tubing from entrance of foreign matter.

6. Do not exceed 50 percent fill capacity where tubing is installed in conduit. Support conduit in accordance with NFPA 70 unless otherwise indicated.

B. Below-Grade Pneumatic and Air Signal Piping and Tubing Installation:

1. Install tubing below-grade in a continuous Schedule 80, PVC conduit.
2. Do not exceed 50 percent fill capacity; minimum size 2 inches.
3. Install top of conduit at depth of at least 24 inches below finished grade.
4. Install tubing in raceways dedicated to only tubing. Do not combine electrical conductors and tubing in raceways.

C. Identify above-grade piping and tubing as follows:

1. Every 50 ft. of straight run.
2. At least once for each branch within 36 inches of main tee.
3. At each change in direction.
4. Within 36 inches of each ceiling, floor, roof, and wall penetration.
5. Where exposed to and where concealed from view, including above ceiling plenums, shafts, and chases.
6. At each valve.
7. Mark each instrument tube connection with a number-coded identification. Each unique tube is to have same unique number at instrument connection and termination at opposite end of tube.

D. Valve Installation for Pneumatic Tubing:

1. Install valves full size of piping and tubing.
2. Install at the following locations:

   a. At each branch.
   b. Before and after each PRV.
   c. Before and after each air dryer.
   d. At each control device.

3. Locate valves to be readily accessible from floor.
4. Install needle valves for isolation and throttling applications. Option to install ball valves in lieu of needle valves for isolation only applications.

3.17 INSTALLATION OF PROCESS TUBING

A. Install process tubing for signal to instruments in liquid and steam systems. Instruments include, but are not limited to, the following:

1. Meters.
2. Sensors.
3. Switches.
4. Transmitters.

B. Support tubing in accordance with MSS SP-58, but at intervals no more than 60 inches apart.

C. Install minimum NPS 1/2 process tubing for industrial-grade sensors, transmitters, and switches. Install bushings where required.

D. Make smooth tubing bends with a bending tool. Flattened or wrinkled bends are unacceptable.

E. Support tubing independent of other trades.

F. Route tubing parallel to and at right angles to building construction.

G. Install tubing concealed in areas with ceilings.

H. Install dirt leg with an isolation valve and threaded plug in drain valve at each connection to a transmitter and switch.

I. Insulate process piping and tubing connected to hot water and steam systems for personnel protection if surface temperature exceeds 120 deg F. Only insulate piping and tubing within maintenance personnel reach from floor, platform, or catwalk.

J. Wrap pipe threads of fitting in process tubing with service temperatures below 350 deg F with single wrap of PTFE tape.

K. Coat pipe threads of fittings on process tubing in services with temperatures exceeding 350 deg F with pipe compound before being made up to reduce possibility of galling.

L. Do not make tubing connections to a fitting before completing makeup of connection.

M. Check tubing for correct diameter and wall thickness. Cut the tube ends square and deburred. Exercise care during cutting to keep tubing round.

N. Do not install fittings close to a bend. Straight length of tubing, not deformed by bending, is required for proper connection.

O. Align tubing with fitting when installed. Avoid springing tube into position.

P. Install tubing with extreme care to keep foreign matter out of system. Plug open tubing ends to keep out dust, dirt, and moisture.

Q. Do not attach tubing to equipment that may be removed frequently for maintenance or may impart vibration and expansion from temperature change.

R. Below-Grade Process Tubing Installation:

1. Install tubing below-grade in a continuous Schedule 80, PVC conduit.
2. Do not exceed 50 percent fill capacity; minimum size 2 inches.
3. Install top of conduit at depth of at least 24 inches below finished grade.
4. Install tubing in raceways dedicated to only process tubing. Do not combine electrical conductors and tubing in raceways.

S. Identify above-grade process tubing as follows:

1. Every 50 ft. of straight run.
2. At least once for each branch within 36 inches of main tee.
3. Near each change in direction.
4. Within 36 inches of each ceiling, floor, roof, and wall penetration.

5. Where exposed to and where concealed from view, including above ceiling plenums, shafts, and chases.
6. Near each isolation valve.
7. Mark each instrument tube connection with a number-coded identification. Each unique tube is to have same unique number at instrument connection and termination at opposite end of tube.

T. Process Tubing Isolation Valves Installation:

1. Install valves full size of piping and tubing.
2. Install isolation valves at the following locations:

    a. Process connection.
    b. Inlet to each instrument including, sensors, transmitters, switches, gauges, and other control devices.

3. Locate valves to be readily accessible from floor.
4. Install needle valves for isolation and throttling applications. Option to install ball valves in lieu of needle valves for isolation only applications.

3.18 INSTALLATION OF CONTROL WIRE, CABLE, AND RACEWAY

A. Comply with NECA 1.

B. Wire and Cable Installation:

1. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.

    a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.

2. Terminate wiring in a junction box.

    a. Clamp cable over jacket in a junction box.
    b. Individual conductors in the stripped section of cable is to be slack between the clamping point and terminal block.

3. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
4. Install signal transmission components in accordance with IEEE C2, REA Form 511a, NFPA 70, and as indicated.
5. Use shielded cable to transmitters.
6. Use shielded cable to temperature sensors.
7. Perform continuity and meager testing on wire and cable after installation.

3.19 FIELD QUALITY CONTROL

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

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and installations, including connections.

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

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

D. Testing of Pneumatic and Air-Signal Tubing:

1. Test for leaks and obstructions.
2. Disconnect each pipe and tubing line before test is performed, and blowout dust, dirt, trash, condensate, and other foreign materials with compressed air. Use commercially pure compressed air or nitrogen as distributed in gas cylinders. Use of compressed air from oil-free compressor with air dryer is an acceptable alternative for test.
3. After foreign matter is expelled and line is free from obstructions, plug far end of tubing run.
4. Connect pressure source to near end of tubing run with needle valve between air supply and tubing run.
5. Connect pressure gauge accurate to within 0.5 percent of test between shutoff needle valve and tubing run under test.
6. For air signal tubing, apply test pressure of 1.5 times instrument operating pressure range. Record pressure in tubing run every 10 minutes for one hour. Allowable drop in pressure in one-hour period to not exceed 0.1 percent of test pressure.
7. For pneumatic system pressures above 30 psig, apply pressure of 1.5 times operating pressure to tubing run. Record pressure in tubing run every 10 minutes for one hour. Allowable drop in pressure in one-hour period to not exceed 1 psig.
8. For pneumatic system pressures 30 psig and below, apply pressure of 1.5 times operating pressure to tubing run. Record pressure in tubing run every five minutes for one hour. Allowable drop in pressure in one-hour period to not exceed 0.5 psig.

E. Optical Fiber Cable Testing:

1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.
2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. At a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.
3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material

furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.

4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Perform testing according to test plan supplied by DDC system manufacturer. Correct defective Work or material and retest. At a minimum, final testing for cable system, including spare cable, to verify compliance of attenuation, length, and bandwidth parameters with performance indicated.
5. Test Equipment: Use optical fiber time-domain reflectometer for testing of length and optical connectivity.
6. Test Results: Record test results and submit copy of test results for Project record.

3.20 DDC SYSTEM I/O CHECKOUT PROCEDURES

A. Check installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

E. For pneumatic products, verify that air supply for each product is properly installed.

F. Control Damper Checkout:

1. For pneumatic control dampers, verify that pressure gauges are provided in each air line connected to the damper actuator and positioner.
2. Verify that control dampers are installed correctly for flow direction.
3. Verify that proper blade alignment, either parallel or opposed, has been provided.
4. Verify that damper frame attachment is properly secured and sealed.
5. Verify that damper actuator and linkage attachment are secure.
6. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
7. Verify that damper blade travel is unobstructed.

G. Control Valve Checkout:

1. For pneumatic control valves, verify that pressure gauges are provided in each air line connected to the valve actuator and positioner.
2. Verify that control valves are installed correctly for flow direction.
3. Verify that valve body attachment is properly secured and sealed.
4. Verify that valve actuator and linkage attachment are secure.
5. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
6. Verify that valve ball, disc, or plug travel is unobstructed.
7. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace valve if leaks persist.

H. Instrument Checkout:

1. Verify that instrument is correctly installed for location, orientation, direction, and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.
4. Verify that wiring is properly labeled with unique identification, correct type, and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8. For temperature instruments, verify the following:

a. Sensing element type and proper material.
b. Length and insertion.

3.21 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION, AND TESTING

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B. Provide written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

C. For each analog instrument, make three-point test of calibration for both linearity and accuracy.

D. Equipment and procedures used for calibration to comply with instrument manufacturer's written instructions.

E. Provide diagnostic and test equipment for calibration and adjustment.

1. Use field testing and diagnostic instruments and equipment with an accuracy at least twice the instrument accuracy of instrument to be calibrated. For example, test and calibrate an installed instrument with accuracy of 1 percent using field testing and diagnostic instrument with accuracy of 0.5 percent or better.

F. Calibrate each instrument in accordance with instruction manual supplied by instrument manufacturer.

G. If after calibration the indicated performance cannot be achieved, replace out-of-tolerance instruments.

H. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Controls Components," in the absence of specific requirements, and to supplement requirements indicated.

I. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

J. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact making or breaking.

K. Control Dampers:

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

L. Control Valves:

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

M. Meters: Check meters at zero, 50, and 100 percent of Project design values.

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

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

P. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.22 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.

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

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

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

3.23 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:

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

    a. Upper quarter of range.
    b. Lower quarter of range.
    c. At midpoint of range.

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

3.24 DDC SYSTEM VALIDATION TESTS

A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.

B. After review of Pretest Checklist and Test Plan, execute all tests and procedures indicated in plan.

C. After testing is complete, submit completed Pretest Checklist.

D. Pretest Checklist: Submit the following list with items checked off once verified:

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

E. Test Plan:

1. Prepare and submit validation Test Plan including test procedures for performance validation tests.
2. Address all specified functions of DDC system and sequences of operation in Test Plan.

3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
5. Include Test Checklist to be used to check and initial that each test has been successfully completed.
6. Submit Test Plan documentation 10 business days before start of tests.

F. Validation Test:

1. Verify operating performance of each I/O point in DDC system.

    a. Verify analog I/O points at operating value.
    b. Make adjustments to out-of-tolerance I/O points.

        1) Identify I/O points for future reference.
        2) Simulate abnormal conditions to demonstrate proper function of safety devices.
        3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.

2. Simulate conditions to demonstrate proper sequence of control.
3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.
4. 24 hours after initial validation test, do as follows:

    a. Re-check I/O points that required corrections during initial test.
    b. Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.

5. 24 Hours after second validation test, do as follows:

    a. Re-check I/O points that required corrections during second test.
    b. Continue validation testing until I/O point is normal on two consecutive tests.

6. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
7. After validation testing is complete, prepare and submit report indicating results of testing. For all I/O points that required correction, indicate how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

3.25 VERIFICATION OF DDC SYSTEM WIRELESS NETWORK

A. DDC system Installer is to design wireless DDC system networks to comply with performance requirements indicated.

B. Verify wireless network performance through field testing and document results in a field test report.

C. Testing and verification of all wireless devices to include, but not be limited to, the following:

1. Speed.
2. Online status.
3. Signal strength.

3.26 FINAL REVIEW

A. Submit written request to Architect Owner, Commissioning Agent and Construction Manager when DDC system is ready for final review. State the following:

1. DDC system has been thoroughly inspected for compliance with Contract Documents and found to be in full compliance.
2. DDC system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.
3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
4. DDC system is complete and ready for final review.

B. Upon receipt of written request for final review, Architect, Owner, Commissioning Agent and Construction Manager to start review within reasonable period and upon completion issue field report(s) documenting observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in reviewer's field report(s) and submit second written request after all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Compensation for Subsequent Reviews: Should more than two reviews be required, DDC system manufacturer and Installer to compensate entity/entities performing reviews for total costs (labor and expenses) associated with subsequent reviews. Estimated cost of each subsequent review to be submitted and approved by DDC system manufacturer and Installer before review.

E. Prepare and submit closeout submittals and begin procedures indicated in "Extended Operation Test" Article when no deficiencies are reported.

F. Part of DDC system final review shall to include demonstration to parties participating in final review.

1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
3. Demonstration to include, but not be limited to, the following applicable items:

    a. Accuracy and calibration of 10 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.

b. HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to 10 I/O points to be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.
c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.
d. Operation of randomly selected dampers and valves in normal-on, normal-off, and failed positions.
e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.
f. Trends, summaries, logs, and reports set up for Project.
g. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.
h. Software's ability to communicate with controllers, operator workstations, and uploading and downloading of control programs.
i. Software's ability to edit control programs offline.
j. Data entry to show Project-specific customizing capability including parameter changes.
k. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
l. Execution of digital and analog commands in graphic mode.
m. Spreadsheet and curve plot software and its integration with database.
n. Online user guide and help functions.
o. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.
p. System speed of response compared to requirements indicated.
q. For Each Network and Programmable Application Controller:

    1) Memory: Programmed data, parameters, trend, and alarm history collected during normal operation are not to be lost during power failure.
    2) Operator Interface: Ability to connect directly to each type of digital controller with portable workstation and mobile device. Show that maintenance personnel interface tools perform as indicated in manufacturer's technical literature.
    3) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.
    4) Electric Power: Ability to disconnect any controller safely from its power source.
    5) Wiring Labels: Match control drawings.
    6) Network Communication: Ability to locate controller's location on network and communication architecture matches Shop Drawings.
    7) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators, and devices.

r. For Each Operator Workstation:

1) I/O points lists agree with naming conventions.
2) Graphics are complete.
3) UPS unit, if applicable, operates.

s. Communications and Interoperability: Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management. Use ASHRAE 135 protocol analyzer to help identify devices, view network traffic, and verify interoperability. Requirements must be met even if only one manufacturer's equipment is installed.

1) Data Presentation: On each operator workstation, demonstrate graphic display capabilities.
2) Reading of Any Property: Demonstrate ability to read and display any used readable object property of any device on network.
3) Set-Point and Parameter Modifications: Show ability to modify set points and tuning parameters indicated. Modifications are made with messages and write services initiated by operator using workstation graphics, or by completing a field in menu with instructional text.
4) Peer-to-Peer Data Exchange: Network devices are installed and configured to perform without need for operator intervention to implement Project sequence of operation and to share global data.
5) Alarm and Event Management: Alarms and events are installed and prioritized according to Owner. Demonstrate that time delays and other logic are set up to avoid nuisance tripping. Show that operators with sufficient privileges are permitted.
6) Schedule Lists: Schedules are configured for start and stop, mode change, occupant overrides, and night setback as defined in sequence of operations.
7) Schedule Display and Modification: Ability to display any schedule with start and stop times for calendar year. Show that all calendar entries and schedules are modifiable from any connected operator workstation by an operator with sufficient privilege.
8) Archival Storage of Data: Data archiving is handled by operator workstation and server and local trend archiving and display is accomplished.
9) Modification of Trend Log Object Parameters: Operator with sufficient privilege can change logged data points, sampling rate, and trend duration.
10) Device and Network Management:

a) Display of network device status.
b) Display of BACnet object information.
c) Silencing devices transmitting erroneous data.
d) Time synchronization.
e) Remote device re-initialization.
f) Backup and restore network device programming and master database(s).
g) Configuration management of routers.

3.27 EXTENDED OPERATION TEST

A. Operate DDC system for operating period of 14 consecutive calendar days following Substantial Completion. Coordinate exact start date of testing with Owner.

B. Provide operator familiar with DDC system installed to man an operator workstation while on-site during eight hours of each normal business day occurring during operating period.

C. During operating period, DDC system to demonstrate correct operation and accuracy of monitored and controlled points as well as operation capabilities of sequences, logs, trends, reports, specialized control algorithms, diagnostics, and other software indicated.

1. Correct defects of hardware and software when they occur.

D. Definition of Failures and Downtime during Operating Period:

1. Failed I/O point constituting downtime is I/O point failing to perform its intended function consistently and a point physically failed due to hardware and software.
2. Downtime is when any I/O point in DDC system is unable to fulfill its required function.
3. Calculate downtime as elapsed time between detected point failure as confirmed by operator, and time point is restored to service.
4. Maximum time interval allowed between DDC system detection of failure occurrence and operator confirmation is to be 0.5 hours.
5. Log downtime in hours to nearest 0.1 hour.
6. Power outages do not count as downtime, but do suspend test hours unless systems are provided with UPS and served through a backup power source.
7. Hardware or software failures caused by power outages do count as downtime.

E. During operating period, log downtime and operational problems are encountered.

1. Identify source of problem.
2. Provide written description of corrective action taken.
3. Record duration of downtime.
4. Maintain log showing the following:

a. Time of occurrence.
b. Description of each occurrence and pertinent written comments for reviewer to understand scope and extent of occurrence.
c. Downtime for each failed I/O point.
d. Running total of downtime and total time of I/O point after each problem has been restored.

5. Make log available to Owner for review at any time.

F. For DDC system to pass extended operation test, total downtime is limited to 1 percent of total point-hours during operating period.

1. If DDC system testing results fail to comply with minimum requirements of passing at end of operating period indicated, extend operating period one consecutive day at a time until DDC system passes requirement.

G. Base evaluation of DDC system passing test on the following calculation:

1. Count downtime on point-hour basis where total number of DDC system point-hours is equal to total number of I/O points in DDC system multiplied by total number of hours during operating period.
2. One point-hour of downtime is one I/O point down for one hour. For example, three I/O points down for five hours is total of 15 point-hours of downtime. Four points down for one-half hour is two point-hours of downtime.
3. Example Calculation: Maximum allowable downtime for 30-day test for DDC system with 1000 total I/O points (combined analog and binary) and passing score of 1 percent downtime is computed by 30 days x 24 h/day x 1000 points x 1 percent equals 7200 point-hours of maximum allowable downtime.

H. Prepare test and inspection reports.

3.28 ADJUSTING

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

3.29 MAINTENANCE SERVICE

A. Beginning at Substantial Completion, verify that maintenance service includes 12 months' full maintenance by DDC system manufacturer's authorized service representative. Include semiannual preventive maintenance, repair or replacement of worn or defective components, cleaning, calibration, and adjusting as required for proper operation. Use only manufacturer's authorized replacement parts and supplies.

3.30 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, verify that service agreement includes software support for two year(s).

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two year(s) from date of Substantial Completion. Verify that upgrading software includes operating system and new or revised licenses for using software.

1. Upgrade Notice: No fewer than 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

3.31 DEMONSTRATION

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.

B. Extent of Training:

1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
3. Minimum Training Requirements:

    a. Provide not less than five days of training total.
    b. Stagger training over multiple training classes to accommodate Owner's requirements. All training to occur before end of warranty period.

C. Training Schedule:

1. Schedule training with Owner 20 business days before expected Substantial Completion.
2. Schedule training to provide Owner with at least 10 business days of notice in advance of training.
3. Training to occur within normal business hours at mutually agreed on time.

D. Training Attendee List and Sign-in Sheet:

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

E. Training Attendee Headcount:

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

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

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

G. Attendee Training Manuals:

1. Provide each attendee with color hard copy of all training materials and visual presentations.
2. Organize hard-copy materials in three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes DVD or flash drive with PDF copy of all hard-copy materials.

H. Instructor Requirements:

1. One or multiple qualified instructors, as required, to provide training.
2. Use instructors who have provided not less than five years of instructional training on not less than five past projects with similar DDC system scope and complexity to DDC system installed.

I. Organization of Training Sessions:

1. Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate the following three levels of operators:

   a. Daily operators.
   b. Advanced operators.
   c. System managers and administrators.

2. Plan and organize training sessions to group training content to protect DDC system security. Some attendees may be restricted to some training sessions to ensure DDC system security.

J. Training Outline:

1. Submit training outline for Owner review at least 10 business day before scheduling training.
2. Include in outline a detailed agenda for each training day that is broken down into each of four training sessions that day, training objectives for each training session, and synopses for each lesson planned.

K. On-Site Training:

1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power, and data connectivity for instructor and each attendee.
2. Provide training materials, projector, and other audiovisual equipment used in training.
3. Provide as much of training located on-site as deemed feasible and practical by Owner.
4. Include on-site training with regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration, and service requirements.
5. Use operator workstation that is to be used with DDC system in the training. If operator workstations are unavailable, provide temporary workstation to convey training content.

L. Off-Site Training:

1. Provide conditioned training rooms and workspace with ample tables desks or tables, chairs, power, and data connectivity for each attendee.
2. Provide capability to remotely access to Project DDC system for use in training.
3. Provide operator workstation for use by each attendee.

M. Training Content for Daily Operators-as required by project:

1. Basic operation of system.
2. Understanding DDC system architecture and configuration.
3. Understanding each unique product type installed including performance and service requirements for each.
4. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm, and each unique optimization routine.
5. Operating operator workstations, printers, and other peripherals.
6. Logging on and off system.
7. Accessing graphics, reports, and alarms.
8. Adjusting and changing set points and time schedules.
9. Recognizing DDC system malfunctions.
10. Understanding content of operation and maintenance manuals including control drawings.
11. Understanding physical location and placement of DDC controllers and I/O hardware.
12. Accessing data from DDC controllers.
13. Operating portable operator workstations.
14. Review of DDC testing results to establish basic understanding of DDC system operating performance and HVAC system limitations as of Substantial Completion.
15. Running each specified report and log.
16. Displaying and demonstrating each data entry to show Project-specific customizing capability. Demonstrating parameter changes.
17. Stepping through graphics penetration tree, displaying all graphics, demonstrating dynamic updating, and direct access to graphics.
18. Executing digital and analog commands in graphic mode.
19. Demonstrating control loop precision and stability via trend logs of I/O for not less than 10 percent of I/O installed.
20. Demonstrating DDC system performance through trend logs and command tracing.
21. Demonstrating scan, update, and alarm responsiveness.
22. Demonstrating spreadsheet and curve plot software, and its integration with database.
23. Demonstrating on-line user guide, and help function and mail facility.

24. Demonstrating multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
25. Demonstrating the following for HVAC systems and equipment controlled by DDC system:

    a. Operation of HVAC equipment in normal-off, normal-on, and failed conditions while observing individual equipment, dampers, and valves for correct position under each condition.
    b. For HVAC equipment with factory-installed software, show that integration into DDC system is able to communicate with DDC controllers or gateways, as applicable.
    c. Using graphed trends, show that sequence of operation is executed in correct manner, and HVAC systems operate properly through complete sequence of operation including seasonal change, occupied and unoccupied modes, warm-up and cool-down cycles, and other modes of operation indicated.
    d. Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.
    e. Reporting of alarm conditions for each alarm, and confirm that alarms are received at assigned locations, including operator workstations.
    f. Each control loop responds to set-point adjustment and stabilizes within time period indicated.
    g. Sharing of previously graphed trends of all control loops to demonstrate that each control loop is stable and set points are being maintained.

N. Training Content for Advanced Operators-as required by project:

1. Making and changing workstation graphics.
2. Creating, deleting, and modifying alarms including annunciation and routing.
3. Creating, deleting, and modifying point trend logs including graphing and printing on an ad-hoc basis and operator-defined time intervals.
4. Creating, deleting, and modifying reports.
5. Creating, deleting, and modifying points.
6. Creating, deleting, and modifying programming including ability to edit control programs offline.
7. Creating, deleting, and modifying system graphics and other types of displays.
8. Adding DDC controllers and other network communication devices such as gateways and routers.
9. Adding operator workstations.
10. Performing DDC system checkout and diagnostic procedures.
11. Performing DDC controllers operation and maintenance procedures.
12. Performing operator workstation operation and maintenance procedures.
13. Configuring DDC system hardware including controllers, workstations, communication devices, and I/O points.
14. Maintaining, calibrating, troubleshooting, diagnosing, and repairing hardware.
15. Adjusting, calibrating, and replacing DDC system components.

O. Training Content for System Managers and Administrators-as required by project:

1. DDC system software maintenance and backups.

2. Uploading, downloading, and offline archiving of all DDC system software and databases.
3. Interface with Project-specific, third-party operator software.
4. Understanding password and security procedures.
5. Adding new operators and making modifications to existing operators.
6. Operator password assignments and modification.
7. Operator authority assignment and modification.
8. Workstation data segregation and modification.

P. Video of Training Sessions:

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

END OF SECTION 230923

SECTION 230923.11 - CONTROL VALVES

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 control valves and actuators for DDC systems.

1.3 DEFINITIONS

A. Cv: Design valve coefficient.

B. DDC: Direct-digital control.

C. NBR: Nitrile butadiene rubber.

D. PTFE: Polytetrafluoroethylene

E. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation, and maintenance instructions, including factors affecting performance.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For control valves to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

D. Backup Power Source: Systems and equipment served by a backup power source shall have associated control valve actuators served from a backup power source.

E. Environmental Conditions:

1. Provide electric control valve actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control valve actuators not available with integral enclosures, complying with requirements indicated, shall be housed in protective secondary enclosures.

    a. Hazardous Locations: Explosion-proof rating for condition.

F. Determine control valve sizes and flow coefficients by ISA 75.01.01.

G. Control valve characteristics and rangeability shall comply with ISA 75.11.01.

H. Selection Criteria:

1. Control valve shutoff classifications shall be FCI 70-2, Class IV or better unless otherwise indicated.
2. Valve pattern, three-way or straight through, shall be as indicated on Drawings.
3. Modulating straight-through pattern control valves shall have equal percentage flow-throttling characteristics unless otherwise indicated.
4. Modulating three-way pattern water valves shall have linear flow-throttling characteristics. The total flow through the valve shall remain constant regardless of the valve's position.
5. Modulating butterfly valves shall have linear or equal percentage flow-throttling characteristics.

6. Globe-type control valves shall pass the design flow required with not more than 95 percent of stem lift unless otherwise indicated.

7. Rotary-type control valves, such as ball and butterfly valves, shall have Cv falling between 65 and 75 degrees of valve full open position and minimum valve Cv between 15 and 25 percent of open position.
8. Selection shall consider viscosity, flashing, and cavitation corrections.
9. Valves shall have stable operation throughout full range of operation, from design to minimum Cv.
10. Minimum Cv shall be calculated at 10 percent of design flow, with a coincident pressure differential equal to the system design pump head.
11. In water systems, select modulating control valves at terminal equipment for a design Cv based on a pressure drop of 5 psig at design flow unless otherwise indicated.

12. Two-position control valves shall be line size unless otherwise indicated.
13. In water systems, use ball- or globe-style control valves for two-position control for valves NPS 2 and smaller and butterfly style for valves larger than NPS 2.
14. In steam systems, use ball- or globe-style control valves regardless of size.

2.2 BALL-STYLE CONTROL VALVES

A. Ball Valves with Single Port and Characterized Disk:
1. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
2. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
3. Close-off Pressure: 200 psig.
4. Process Temperature Range: Zero to 212 deg F.
5. Body and Tail Piece: Cast bronze ASTM B61, ASTM B62, ASTM B584, or forged brass with nickel plating.
6. End Connections: Threaded (NPT) ends.
7. Ball: Chrome-plated brass or bronze or 300 series stainless steel.
8. Stem and Stem Extension:

   a. Material to match ball.
   b. Blowout-proof design.
   c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.

9. Ball Seats: Reinforced PTFE.
10. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
11. Flow Characteristic: Equal percentage.

B. Ball Valves with Two Ports and Characterized Disk:
1. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
2. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
3. Close-off Pressure: 200 psig.
4. Process Temperature Range: Zero to 212 deg F.
5. Body and Tail Piece: Cast bronze ASTM B61, ASTM B62, ASTM B584, or forged brass with nickel plating.
6. End Connections: Threaded (NPT) ends.

7. Ball: Chrome-plated brass or bronze or 300 series stainless steel.
8. Stem and Stem Extension:

    a. Material to match ball.
    b. Blowout-proof design.
    c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.

9. Ball Seats: Reinforced PTFE.
10. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
11. Flow Characteristics for A-Port: Equal percentage.
12. Flow Characteristics for B-Port: Modified for constant common port flow.

C. Ball Valves with Single Port and Segmented Ball:
1. Performance:

    a. Process Temperature Rating: Minus 20 to plus 450 deg F.
    b. ASME B16.34, Class 150 or Class 300.
    c. Leakage: FCI 70-2, Class IV.
    d. Rangeability: 300 to 1.
    e. Rotation: Zero to 90 degrees.
    f. Equal percentage flow characteristic.

2. ASME B16.10 face-to-face dimensions.
3. Valves NPS 2 and Smaller: Threaded (NPT) ends.
4. Valves NPS 2-1/2 through NPS 6: Flanged ends suitable for mating to ASME B16.5 flanges.
5. Body: Carbon or stainless steel.
6. Ball and Shaft: Stainless steel.
7. Shaft and Segmented Ball: Pinned and welded.
8. Ball Seat: Graphite.
9. Packing: PTFE V-rings and graphite packing follower.
10. Replaceable seat, ball, and shaft packing.
11. Label each valve with following:

    a. Manufacturer's name, model number, and serial number.
    b. Body size.
    c. Flow directional arrow.

D. Ball Valves with Segmented Ball, Three-Way Pattern:
1. Arrangement: Two single-port valves mated to a fabricated tee with interconnecting mechanical linkage.
2. Performance:

    a. Process Temperature Rating: Minus 20 to plus 450 deg F.
    b. ASME B16.34, Class 150 or Class 300.
    c. Leakage: FCI 70-2, Class IV.

d. Rangeability: 300 to 1.
e. Rotation: Zero to 90 degrees.
f. Equal percentage flow characteristic.

3. Face-to-Face Dimensions: ASME B16.10.
4. Valves NPS 3 through NPS 6: Flanged ends suitable for mating to ASME B16.5 flanges.
5. Body: Carbon or stainless steel.
6. Ball and Shaft: Stainless steel.
7. Shaft and Segmented Ball: Pinned and welded.
8. Ball Seat: Graphite.
9. Packing: PTFE V-rings and graphite packing follower.
10. Replaceable seat, ball, and shaft packing.
11. Label each valve with following:

a. Manufacturer's name, model number, and serial number.
b. Body size.
c. Flow directional arrow.

E. Ball Valves with Full Ball and Characterized V-Notch:
1. Performance:

a. Process Temperature Rating: Minus 20 to plus 500 deg F.
b. ASME B16.34, Class 600 for NPS 2 and smaller; Class 150 or Class 300 for larger than NPS 2.
c. Leakage: FCI 70-2, Class VI, bi-directional.
d. Rangeability: Varies from 200 to 1 up to 800 to 1 based on notch pattern of ball.
e. Rotation: Zero to 90 degrees.
f. Equal percentage flow characteristic.
g. Full port.

2. Face-to-Face Dimension: ASME B16.10 long pattern.
3. Valves NPS 2 and Smaller: ASME B1.20.1 threaded (NPT) ends and three-piece body.
4. Valves NPS 2-1/2 through NPS 12: Flanged ends suitable for mating to ASME B16.5 flanges and two-piece body.
5. Hole in the stem slot of each ball equalizes pressure between the body cavity and the line media flow.
6. Replaceable seat, ball, and shaft packing.
7. Body: Carbon or stainless steel.
8. Ball and Shaft: Stainless steel.
9. Ball Seat: RPTFE.
10. Stem Seals for Valves NPS 2 and Smaller: Live-loaded, self-adjusting, primary and secondary sealing using belleville washers.

a. Primary Seal: Combination of thrust washer and thrust washer protector.
b. Secondary Seal: Adjustable stem packing composed of RPTFE V-rings.

11. Stem Seals for Valves Larger than NPS 2: Independent packing gland, adjusted without removing mounting hardware or operator, and contoured to uniformly distribute load across packing.

a. Primary Seal: Combination of thrust washer and thrust washer protector.
b. Secondary Seal: Adjustable stem packing composed of RPTFE V-rings.

12. Label each valve with following:

a. Manufacturer's name, model number, and serial number.
b. Body size.
c. Flow directional arrow.

F. Industrial-Grade Ball Valves:
1. Performance:

a. Process Temperature Rating: Minus 20 to plus 450 deg F.
b. ASME B16.34, Class 150 or Class 300.
c. Leakage: FCI 70-2, Class VI.
d. Rangeability: 300 to 1.
e. Rotation: Zero to 90 degrees.
f. Modified equal percentage flow characteristic.

2. Face-to-Face Dimensions: Comply with ASME B16.10 short pattern.
3. Body: Cast steel ASTM A216/A216M WCB.
4. Flanged Body: Suitable for mating to ASME B16.5 flanges.
5. Shaft: 316 stainless-steel ball, 17-4 PH stainless steel.
6. Ball Seat: Reinforced PTFE.
7. PTFE V-ring packing, 316 stainless-steel packing follower.
8. Replaceable seat, ball, and shaft packings.
9. Replaceable 316 stainless-steel shaft bushings with PTFE linings.
10. Corrosion-resistant nameplate indicating the following:

a. Manufacturer's name, model number, and serial number.
b. Body size.
c. Body and trim materials.
d. Trim type.
e. Body and flange rating.
f. Arrow indicating direction of flow.

G. Pressure-Independent Ball Valves NPS 2 and Smaller:
1. Performance:

a. Pressure Rating: 600 psig for NPS 1 and 400 psig for NPS 1-1/2 and NPS 2.
b. Close-off pressure of 200 psig.
c. Process Temperature Range: Between zero to 212 deg F.
d. Rangeability: 100 to 1.

2. Integral Pressure Regulator: Located upstream of ball to regulate pressure, to maintain a constant pressure differential while operating within a pressure differential range of 5 to 50 psig.
3. Body: Forged brass, nickel plated, and with threaded ends.
4. Ball: Chrome-plated brass.
5. Stem and Stem Extension: Chrome-plated brass, blowout-proof design.

6. Stem sleeve or other approved means to allow valve to be opened and closed without damaging field-applied insulation and insulation vapor barrier seal.
7. Ball Seats: Reinforced PTFE.
8. Stem Seal: Reinforced PTFE packing ring stem seal with threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if equivalent cycle endurance can be achieved.
9. Flow Characteristic: Equal percentage.

2.3 BUTTERFLY-STYLE CONTROL VALVES

A. Commercial-Grade, Two-Way Butterfly Valves:
1. Performance:
    a. Bi-directional bubble tight shutoff at 250 psig.
    b. Comply with MSS SP-67 or MSS SP-68.
    c. Rotation: Zero to 90 degrees.
    d. Linear or modified equal percentage flow characteristic.
2. Body: Cast iron ASTM A126, Class B, ductile iron ASTM A536 or cast steel ASTM A216/A216M WCB fully lugged, suitable for mating to ASME B16.5 flanges.
3. Disc: 316 stainless steel.
4. Shaft: 316 or 17-4 PH stainless steel.
5. Seat: Reinforced EPDM or reinforced PTFE with retaining ring.
6. Shaft Bushings: Reinforced PTFE or stainless steel.
7. Replaceable seat, disc, and shaft bushings.
8. Corrosion-resistant nameplate indicating:
    a. Manufacturer's name, model number, and serial number.
    b. Body size.
    c. Body and trim materials.
    d. Flow arrow.

B. Commercial-Grade, Three-Way Butterfly Valves:
1. Arrangement: Two valves mated to a fabricated tee with interconnecting mechanical linkage.
2. Performance:
    a. Bi-directional bubble tight shutoff at 250 psig.
    b. Comply with MSS SP-67 or MSS SP-68.
    c. Rotation: Zero to 90 degrees.
    d. Linear or modified equal percentage flow characteristic.
3. Body: Cast iron ASTM A126, Class B, ductile iron ASTM A536 or cast steel ASTM A216/A216M WCB fully lugged, suitable for mating to ASME B16.5 flanges.
4. Disc: 316 stainless steel.
5. Shaft: 316 or 17-4 PH stainless steel.
6. Seat: Reinforced EPDM or reinforced PTFE seat with retaining ring.
7. Shaft Bushings: Reinforced PTFE or stainless steel.

8. Replaceable seat, disc, and shaft bushings.
9. Corrosion-resistant nameplate indicating:

    a. Manufacturer's name, model number, and serial number.
    b. Body size.
    c. Body and trim materials.
    d. Flow arrow.

C. Industrial-Grade Butterfly Valves:
1. Performance:

    a. Process Temperature Rating: Minus 200 to plus 849 deg F.
    b. ASME B16.34, Class 150 or Class 300 for larger sizes.
    c. Complies with MSS SP-68.
    d. Leakage: FCI 70-2, Class VI, bi-directional.
    e. Rangeability: 100 to 1.
    f. Rotation: Zero to 90 degrees.
    g. Linear or modified equal percentage flow characteristic.

2. Body: Cast steel ASTM A216/A216M WCB, fully lugged, suitable for mating to ASME B16.5 flanges.
3. Disc: ASTM A351/A351M, CF3M or CF8M stainless steel.
4. Shaft: 17-4 PH stainless steel.
5. Seat: Reinforced PTFE with retaining ring.
6. Shaft Bushings: Reinforced PTFE or stainless steel.
7. Replaceable seat, disc, and shaft bushings.
8. Corrosion-resistant nameplate indicating:

    a. Manufacturer's name, model number, and serial number.
    b. Body size.
    c. Body and trim materials.
    d. Body rating.
    e. Arrow indicating direction of flow.

2.4 GLOBE-STYLE CONTROL VALVES

A. General Globe-Style Valve Requirements:

1. Globe-style control valve body dimensions shall comply with ISA 75.08.01.
2. Construct the valves to be serviceable from the top.
3. For cage guided valves, trim shall be field interchangeable for different valve flow characteristics, such as equal percentage, linear, and quick opening.
4. Reduced trim for one nominal size smaller shall be available for industrial valves NPS 1 and larger.
5. Replaceable seats and plugs.
6. Furnish each control valve with a corrosion-resistant nameplate indicating the following:

    a. Manufacturer's name, model number, and serial number.
    b. Body and trim size.

c. Arrow indicating direction of flow.

B. Two-Way Globe Valves NPS 2 and Smaller:
1. Globe Style: Single port.
2. Body: Cast bronze or forged brass with ASME B16.5, Class 250 rating.
3. End Connections: Threaded.
4. Bonnet: Screwed.
5. Packing: PTFE V-ring.
6. Plug: Top guided.
7. Plug, Seat, and Stem: Brass or stainless steel.
8. Process Temperature Range: 35 to 248 deg F.
9. Ambient Operating Temperature: 35 to 150 deg F.
10. Leakage: FCI 70-2, Class IV.
11. Rangeability: 25 to 1.
12. Equal percentage flow characteristic.

C. Three-Way Globe Valves NPS 2 and Smaller:
1. Globe Style: Mix flow pattern.
2. Body: Cast bronze or forged brass with ASME B16.5, Class 250 rating.
3. End Connections: Threaded.
4. Bonnet: Screwed.
5. Packing: PTFE V-ring.
6. Plug: Top guided.
7. Plug, Seat, and Stem: Brass or stainless steel.
8. Process Temperature Range: 35 to 248 deg F.
9. Ambient Operating Temperature: 35 to 150 deg F.
10. Leakage: FCI 70-2, Class IV.
11. Rangeability: 25 to 1.
12. Linear flow characteristic.

D. Two-Way Globe Valves NPS 2-1/2 to NPS 6:
1. Globe Style: Single port.
2. Body: Cast iron complying with ASME B61.1, Class 125.
3. End Connections: Flanged, suitable for mating to ASME B16.5, Class 150 flanges.
4. Bonnet: Bolted.
5. Packing: PTFE cone-ring.
6. Plug: Top or bottom guided.
7. Plug, Seat, and Stem: Brass or stainless steel.
8. Process Temperature Rating: 35 to 281 deg F.
9. Leakage: 0.1 percent of maximum flow.
10. Rangeability: Varies with valve size between 6 and 10 to 1.
11. Modified linear flow characteristic.

E. Three-Way Globe Valves NPS 2-1/2 to NPS 6:
1. Globe Style: Mix flow pattern.
2. Body: Cast iron complying with ASME B61.1, Class 125.
3. End Connections: Flanged suitable for mating to ASME B16.5, Class 150 flanges.
4. Bonnet: Bolted.
5. Packing: PTFE cone-ring.
6. Plug: Top or bottom guided.

7. Plug, Seat, and Stem: Brass or stainless steel.
8. Process Temperature Rating: 35 to 281 deg F.
9. Leakage: 0.1 percent of maximum flow.
10. Rangeability: Varies with valve size between 6 and 10 to 1.
11. Modified linear flow characteristic.

F. Industrial-Grade Straight-Through Globe Valves NPS 3/4 and Smaller:
1. Globe Style: Single port.
2. Body: ASTM B62 bronze complying with ASME B16.5, Class 250.
3. End Connections: Threaded.
4. Bonnet: Screwed or bolted.
5. Packing: PTFE V-ring.
6. Plug: Top or cage guided; balanced or unbalanced.
7. Plug, Seat, and Stem: 316 stainless steel, 17-4 PH stainless-steel cage.
8. Process Temperature Range: Minus 20 to plus 400 deg F.
9. Ambient Operating Temperature: Minus 20 to plus 150 deg F.
10. Leakage: FCI 70-2, Class IV.
11. Equal percentage flow characteristic.

G. Industrial-Grade Straight-Through Globe Valves NPS 1 and Larger:
1. Globe Style: Single port.
2. Body: Cast iron or cast steel.
3. End Connections for NPS 2: Threaded.
4. End Connections for NPS 2-1/2 and Larger: Raised face flanged.
5. Bonnet: Bolted.
6. Packing: PTFE V-ring.
7. Plug: Cage guided and unbalanced.
8. Plug, Seat, and Stem: 416 stainless-steel plug and seat, 17-4 PH stainless-steel cage and 316 stainless-steel stem.
9. Valve Stem: Thread and pin stem to plug.
10. Valve Stem Finish: Polished to 5 microinches rms or less.
11. Plug and Seat Surfaces: Hardened facing.
12. Process Temperature Range: Zero to 450 deg F.
13. Ambient Operating Temperature: Minus 20 to plus 150 deg F.
14. Leakage: FCI 70-2, Class IV, Class V, Class VI or as specified on drawings.
15. Flow Characteristic: Equal percentage, Linear, Quick opening or as specified on drawings.

2.5 SOLENOID VALVES

A. Description:

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

7. Solenoid Enclosure: NEMA 250, Type 4.

2.6 SELF-CONTAINED TEMPERATURE REGULATING VALVE

A. Description:

1. Self-contained and self-operated temperature regulating valve. Direct acting or reverse acting as required by application.
2. Direct Acting: A rise in temperature at the sensing bulb vaporizes some of the liquid in the bulb, forcing the remaining liquid through a capillary to apply pressure at the diaphragm, in turn closing the valve. The valve shall fail open.
3. Reverse Acting: A rise in temperature at the sensing bulb vaporizes some of the liquid in the bulb, forcing the remaining liquid through a capillary to apply pressure at the diaphragm, in turn opening the valve. The valve shall fail close.
4. Body: Carbon steel.
5. Trim and Seats: 300 series stainless steel.
6. Yoke: Cast iron.
7. Actuator: 300 series stainless steel.
8. End Connections: Threaded.
9. Capillary, Bulb, and Armor: 300 series stainless steel.
10. Thermal Fill Material: Match to the temperature range.
11. Thermowell: Type 316 stainless-steel thermowell sized to fit the bulb and pipe.

B. Operational Characteristics: Control flow from between 5 to 100 percent of rated capacity.

C. Interchangeable trim for one size smaller.

D. Valve Leakage: Comply with FCI 70-2, Class IV.

E. Temperature Range: Match application.

1. Drains from Hot Equipment to Sanitary Sewer System: 105 to 165 deg F.

F. Valve Size: Size to pass the design flow required with not more than 95 percent of the stem lift while operating at design pressure.

2.7 PNEUMATIC CONTROL VALVE ACTUATORS

A. Actuators for Hydronic Control Valves: Shutoff against system pump shutoff head.

B. Actuators for Steam Control Valves: Shutoff against 1.5 times steam design pressure.

C. Position indicator and graduated scale on each actuator.

D. Provide diaphragm action (air-to-open, air-to-close), as required by the sequence of operation, in the event of air supply failure.

E. For each modulating control valve, provide a positive positioner with the valve actuator. The positioners shall operate on a 3- to 15-psig input signal unless otherwise required to satisfy control sequences of operation. Integrally mount each positioner with an air regulator, air set, and gauges for supply, input and output. The positioner shall have the following performance characteristics:

1. Linearity: Plus or minus 1 percent of the output signal span.
2. Hysteresis: 0.5 percent of span.

F. Diaphragms shall be replaceable.

G. Actuator Construction:

1. Cast-iron or steel diaphragm casing and plate. Cast aluminum is acceptable on valves NPS 4 and smaller.
2. Cast iron or steel yoke. Cast aluminum is acceptable on valves NPS 4 and smaller.
3. Reinforced synthetic rubber or nitrile diaphragm.
4. Steel or steel alloy spring, stem, and spring adjuster.

H. Rate actuators for not less than 1.2 times the main air pressure to the valve, minimum 30 psig.

2.8 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS

A. Actuators for Hydronic Control Valves: Capable of closing valve against system pump shutoff head.

B. Actuators for Steam Control Valves: Shutoff against 1.5 times steam design pressure.

C. Position indicator and graduated scale on each actuator.

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

E. Voltage: 24-V ac, 120-V ac or as specified on drawings.

F. Deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.

G. Function properly within a range of 85 to 120 percent of nameplate voltage.

H. Construction:

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

I. Field Adjustment:

1. Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.
2. Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.

J. Two-Position Actuators: Single direction, spring return or reversing type.

K. Modulating Actuators:

1. Operation: Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:

a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position and other input drives actuator to close position. No signal of either input remains in last position.
b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10- or 2- to 10-V dc and 4- to 20-mA signals.
c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to pulse duration (length) of signal from a dry contact closure, triac sink, or source controller.
d. Programmable Multi-Function:

1) Control Input, Position Feedback, and Running Time: Factory or field programmable.
2) Diagnostic: Feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
3) Service Data: Include, at a minimum, number of hours powered and number of hours in motion.

L. Position Feedback:

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

M. Fail-Safe:

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

N. Integral Overload Protection:

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

O. Valve Attachment:

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

P. Temperature and Humidity:

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

Q. Enclosure:

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

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for valves installed in piping to verify actual locations of piping connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduits to comply with requirements indicated.

D. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Firestop penetrations made in fire-rated assemblies and seal penetrations made in acoustically rated assemblies.

F. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

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

H. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including. but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.

3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
5. Where control devices are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

3.4 CONTROL VALVES

A. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.

B. Install flanges or unions to allow drop-in and -out valve installation.

C. Valve Orientation:

1. Where possible, install globe and ball valves installed in horizontal piping with stems upright and not more than 15 degrees off of vertical, not inverted.
2. Install valves in a position to allow full stem movement.
3. Where possible, install butterfly valves that are installed in horizontal piping with stems in horizontal position and with low point of disc opening with direction of flow.

D. Clearance:

1. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
2. Install valves with at least 12 inches of clear space around valve and between valves and adjacent surfaces.

E. Threaded Valves:

1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
2. Align threads at point of assembly.
3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.

F. Flanged Valves:

1. Align flange surfaces parallel.
2. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with valve identification on valve and on face of ceiling directly below valves concealed above ceilings.

3.6 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.7 CHECKOUT PROCEDURES

A. Control Valve Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check valves for proper location and accessibility.
3. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. For pneumatic products, verify air supply for each product is properly installed.
5. For pneumatic valves, verify that pressure gauges are provided in each air line to valve actuator and positioner.
6. Verify that control valves are installed correctly for flow direction.
7. Verify that valve body attachment is properly secured and sealed.
8. Verify that valve actuator and linkage attachment are secure.
9. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
10. Verify that valve ball, disc, and plug travel are unobstructed.
11. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

3.8 ADJUSTMENT, CALIBRATION, AND TESTING

A. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressures.

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 230923.11

SECTION 230923.12 - CONTROL DAMPERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Rectangular control dampers.
2. Round control dampers.
3. Pneumatic actuators.
4. Electric and electronic control damper actuators.

1.2 DEFINITIONS

A. DDC: Direct digital control.

B. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of damper and actuator:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For control dampers to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

D. Backup Power Source: Systems and equipment served by a backup power source shall have associated control damper actuators served from a backup power source.

E. Environmental Conditions:

1. Provide electric control-damper actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control-damper actuators not available with integral enclosures, complying with requirements indicated, shall be housed in protective secondary enclosures.

    a. Hazardous Locations: Explosion-proof rating for condition.

F. Selection Criteria:

1. Dampers shall have stable operation throughout full range of operation, from design to minimum airflow over varying pressures and temperatures encountered.
2. Select modulating dampers for a pressure drop of 2 percent of fan total static pressure unless otherwise indicated.
3. Two-position dampers shall be full size of duct or equipment connection unless otherwise indicated.

2.2 RECTANGULAR CONTROL DAMPERS

A. General Requirements:

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

B. Rectangular Dampers with Aluminum Airfoil Blades:

1. Performance:

    a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure.

b. Pressure Drop: 0.05-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 6000 fpm.
d. Temperature: Minus 40 to plus 185 deg F.
e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:

a. Frame:

1) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, 0.07 inch thick.
2) Hat-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inch.
3) Width not less than 5 inches.

b. Blades:

1) Hollow, airfoil, extruded aluminum.
2) Parallel or opposed blade configuration as required by application.
3) Material: ASTM B211, Alloy 6063 T5 aluminum, 0.07 inch thick.
4) Width not to exceed 6 inches.
5) Length as required by close-off pressure, not to exceed 48 inches.

c. Seals:

1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch- diameter plated or stainless steel, mechanically attached to blades.
e. Bearings:

1) Molded synthetic or stainless steel sleeve mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Concealed in frame.
2) Constructed of aluminum and plated or stainless steel.
3) Hardware: Stainless steel.

g. Transition:

1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.

3) Damper size and sleeve shall be connection size plus 2 inches.
4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments:

1) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch thick.
2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

C. Rectangular Dampers with Steel Airfoil Blades:
1. Performance:

a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure.
b. Pressure Drop: 0.06-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 6000 fpm.
d. Temperature: Minus 40 to plus 185 deg F.
e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:

a. Frame:

1) Material: ASTM A653/A653M galvanized-steel profiles, 0.06 inch thick.
2) Hat-shaped channel with integral flanges. Mating face shall be a minimum of 1 inch.
3) Width not less than 5 inches.

b. Blades:

1) Hollow, airfoil, galvanized steel.
2) Parallel or opposed blade configuration as required by application.
3) Material: ASTM A653/A653M galvanized steel, 0.05 inch thick.
4) Width not to exceed 6 inches.
5) Length as required by close-off pressure, not to exceed 48 inches.

c. Seals:

1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch- diameter plated or stainless steel, mechanically attached to blades.
e. Bearings:

1) Stainless steel mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Concealed in frame.
2) Constructed of aluminum and plated or stainless steel.
3) Hardware: Stainless steel.

g. Transition:

1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.
3) Damper size and sleeve shall be connection size plus 2 inches.
4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments:

1) Provide epoxy finish for surfaces in contact with airstream.
2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

D. Industrial-Duty Rectangular Dampers with Steel Airfoil Blades:
1. Performance:

a. Leakage: Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure.
b. Pressure Drop: 0.06-in. wg at 2000 fpm across a 48-by-48-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 4000 fpm.
d. Temperature: Minus 40 to plus 250 deg F.
e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, minimum 10-in. wg.

2. Construction:

a. Frame:

1) Material: Galvanized or stainless steel, 0.11 inch thick.
2) C-shaped channel. Mating face shall be a minimum of 1 inch.
3) Width not less than 3 inches.

b. Blades:

1) Hollow, airfoil, galvanized or stainless steel.
2) Parallel or opposed blade configuration as required by application.

3) Material: Galvanized or stainless steel, 0.06 inch thick.
4) Width not to exceed 8 inches.
5) Length not to exceed 60 inches.

c. Seals:

1) Blades: Replaceable, mechanically attached EPDM or extruded silicone.
2) Jambs: Stainless steel, double compression type.

d. Axles: 0.5- or 0.75-inch- diameter plated or stainless steel, mechanically attached to blades and continuous from end to end.

e. Bearings:

1) Stainless steel sleeve type mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Face linkage exposed to airstream.
2) Constructed of plated or stainless steel.
3) Hardware: Stainless steel.

E. Rectangular Dampers with Aluminum Flat Blades:

1. Performance:

a. Leakage: Leakage shall not exceed 3.2 cfm/sq. ft. against 1-in. wg differential static pressure.
b. Pressure Drop: 0.07-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 2000 fpm.
d. Temperature: Minus 50 to plus 250 deg F.
e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, not to exceed 3-in. wg.
f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:

a. Frame:

1) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, 0.12 inch thick.
2) Hat-shaped channel with integral flanges.
3) Width not less than 5 inches.

b. Blades:

1) Flat blades of extruded aluminum.
2) Parallel or opposed blade configuration as required by application.
3) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, 0.12 inch thick.

4) Width not to exceed 6 inches.
5) Length as required by close-off pressure, not to exceed 48 inches.

c. Seals:

1) Blades: Replaceable, mechanically attached extruded silicone, vinyl or plastic composite.
2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch- diameter plated or stainless steel, mechanically attached to blades.
e. Bearings:

1) Molded-synthetic sleeve, mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Concealed in frame.
2) Constructed of plated or stainless steel.
3) Hardware: Stainless steel.

g. Transition:

1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.
3) Damper size and sleeve shall be connection size plus 2 inches.
4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments:

1) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch thick.
2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

F. Rectangular Dampers with Steel Flat Blades:
1. Performance:

a. Leakage: Leakage shall not exceed 4.8 cfm/sq. ft. against 1-in. wg differential static pressure.
b. Pressure Drop: 0.1-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 1500 fpm.
d. Temperature: Minus 25 to plus 180 deg F.
e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, not to exceed 4-in. wg.

f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:

a. Frame:

1) Material: Galvanized or stainless steel, 0.06 inch thick.
2) Hat-shaped channel with integral flanges.
3) Width not less than 5 inches.

b. Blades:

1) Flat blades with multiple grooves positioned axially for reinforcement.
2) Parallel or opposed blade configuration as required by application.
3) Material: Galvanized or stainless steel, 0.06 inch thick.
4) Width not to exceed 6 inches.
5) Length as required by close-off pressure, not to exceed 48 inches.

c. Seals:

1) Blades: Replaceable, mechanically attached, PVC-coated polyester.
2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch- diameter plated or stainless steel, mechanically attached to blades.
e. Bearings:

1) Molded-synthetic sleeve, mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Concealed in frame.
2) Constructed of plated or stainless steel.
3) Hardware: Stainless steel.

G. Insulated Rectangular Dampers:
1. Performance:

a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure and shall not exceed 4.9 cfm/sq. ft. against 4-in. wg differential static pressure at minus 40 deg F.
b. Pressure Drop: 0.1-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 4000 fpm.
d. Temperature: Minus 100 to plus 185 deg F.
e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:

a. Frame:

1) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, 0.08 inch thick.
2) C-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inch.
3) Width not less than 4 inches.
4) Entire frame shall be thermally broken by means of polyurethane resin pockets, complete with thermal cuts.
5) Damper frame shall be insulated with polystyrofoam on four sides.

b. Blades:

1) Hollow shaped, extruded aluminum.
2) Blades shall be internally insulated with expanded polyurethane foam and shall be thermally broken. Complete blade shall have an insulating factor of R-2.29 and a temperature index of 55.
3) Parallel or opposed blade configuration as required by application.
4) Material: ASTM B211, Alloy 6063 T5 aluminum, 0.08 inch thick.
5) Width not to exceed 6 inches.
6) Length as required by close-off pressure, not to exceed 48 inches.

c. Seals: Blade and frame seals shall be of flexible silicone and secured in an integral slot within the aluminum extrusions.
d. Axles: 0.44-inch- diameter plated or stainless steel, mechanically attached to blades.
e. Bearings:

1) Bearings shall be composed of a Celcon inner bearing fixed to axle, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Concealed in frame.
2) Constructed of aluminum and plated or stainless steel.
3) Hardware: Stainless steel.

g. Transition:

1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.
3) Damper size and sleeve shall be connection size plus 2 inches.
4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments:

1) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch thick.
2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

2.3 ROUND CONTROL DAMPERS

A. Round Dampers, Sleeve Type:
1. Performance:

a. Leakage: Leakage shall not exceed 0.15 cfm/in. of perimeter blade at 4-in. wg differential static pressure.
b. Pressure Drop: 0.02-in. wg at 1500 fpm across a 12-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 4000 fpm.
d. Temperature: Minus 25 to plus 200 deg F.
e. Pressure Rating: 8-in. wg for sizes through 12 inches, 6-in. wg for larger sizes.

2. Construction:

a. Frame:

1) Material: Galvanized or stainless steel, 0.04 in thick.
2) Outward rolled stiffener beads positioned approximately 1 inch inboard of each end.
3) Sleeve-type connection for mating to adjacent ductwork.
4) Size Range: 4 to 24 inches.
5) Length not less than 7 inches.
6) Provide 2-inch sheet metal stand-off for mounting actuator.

b. Blade: Double-thickness circular flat blades sandwiched together and constructed of galvanized or stainless steel.
c. Blade Seal: Polyethylene foam seal sandwiched between two sides of blades and fully encompassing blade edge.
d. Axle: 0.5-inch- diameter plated or stainless steel, mechanically attached to blade.
e. Bearings: Stainless steel sleeve pressed into frame.

B. Round Dampers, Flanged Type:
1. Performance:

a. Leakage: Leakage shall not exceed 0.15 cfm/in. of perimeter blade at 4-in. wg differential static pressure.
b. Pressure Drop: 0.03-in. wg at 1500 fpm across a 12-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 4000 fpm.
d. Temperature: Minus 25 to plus 250 deg F.

e. Pressure Rating: 8-in. wg for sizes through 36 inches in diameter, 6-in. wg for larger sizes.

2. Construction:

a. Frame:

1) Size Range: 4 to 60 inches.
2) Material: Galvanized or stainless steel.

a) Sizes through 24 Inches in Diameter: 0.15 inch thick.
b) Sizes 26 through 48 Inches in Diameter: 0.25 inch thick.
c) Larger Sizes: 0.31 inch thick.

3) Flanges:

a) Outward rolled with bolt holes on each end of frame for mating to adjacent ductwork.
b) Face: Not less than 1.25 inch for damper sizes through 12 inches in diameter, 1.5 inch for damper sizes 14 through 24 inches in diameter, and 2 inches for larger sizes.

4) Length (Flange Face to Face): Not less than 8 inches.
5) Provide 3-inch sheet metal stand-off for mounting actuator.

b. Blade: Reinforced circular flat blade constructed of galvanized or stainless steel.

1) Sizes through 24 Inches: 0.15 inch thick.
2) Sizes 26 through 48 Inches: 0.19 inch thick.
3) Larger Sizes: 0.25 inch thick.

c. Blade Stop: Full circumference, located in airstream, minimum 0.5 by 0.25 inch galvanized-steel or stainless steel bar.
d. Blade Seal: Neoprene, mechanically attached to blade and fully encompassing blade edge.
e. Axle: Plated or stainless steel, mechanically attached to blade.

1) Sizes through 14 Inches: 0.5 inch in diameter.
2) Sizes 16 through 42 Inches: 0.75 inch in diameter.
3) Larger Sizes: 1 inch in diameter.

f. Bearings: Stainless steel sleeve pressed into frame.

2.4 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

A. Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.

B. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.

C. The total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.

D. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.

E. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.

F. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.

G. Provide mounting hardware and linkages for connecting actuator to damper.

H. Select actuators to fail in desired position in the event of a power failure.

2.5 PNEUMATIC ACTUATORS

A. Where two or more actuators are installed for interrelated operation in unison, such as dampers used for mixing, provide the dampers with a positive positioner.

B. Equip pneumatic modulating actuators with a positive positioner, having the following performance characteristics:

1. Linearity: Plus or minus 1 percent of output signal span.
2. Hysteresis: 0.5 percent of the span.

C. Provide each positioner with an integrally mounted air set and pressure gauges for supply, input and output. Positioners shall operate on a 3- to 15-psig input signal unless otherwise required to satisfy the control sequences of operation.

D. Rate actuators for a pressure of at least 25 psig.

E. Provide actuators with replaceable diaphragms.

F. Actuator Construction:

1. Construct the diaphragm casing and plate of cast iron, steel, or cast aluminum.
2. Construct the yoke of cast iron, steel, or cast aluminum.
3. Construct the diaphragm of reinforced synthetic rubber or nitrile.
4. Construct the spring, stem, and spring adjuster of steel or steel alloy.

G. Provide actuator with adjustable stops for both maximum and minimum positions.

H. Provide a position indicator and graduated scale on each actuator. Indicate open and closed travel limits.

2.6 ELECTRIC AND ELECTRONIC CONTROL DAMPER ACTUATORS

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

B. Voltage:

1. 24 V or 120 V.
2. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
3. Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.

C. Construction:

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

D. Field Adjustment:

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

E. Two-Position Actuators: Single direction, spring return or reversing type.

F. Modulating Actuators:

1. Capable of stopping at all points across full range, and starting in either direction from any point in range.

G. Position Feedback:

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

H. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.

3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

I. Integral Overload Protection:

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

J. Damper Attachment:

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

K. Temperature and Humidity:

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

L. Enclosure:

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

M. Stroke Time:

1. Select operating speed to be compatible with equipment and system operation.
2. Actuators operating in smoke control systems comply with governing code and NFPA requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for dampers and instruments installed in duct systems to verify actual locations of connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Properly support dampers and actuators, tubing, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

C. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Seal penetrations made in fire-rated and acoustically rated assemblies.

E. Fastening Hardware:

1. Stillson wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

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

G. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:

   a. Laboratory exhaust airstreams.
   b. Process exhaust airstreams.

3. Use Type 316 stainless steel tubing and fittings when in contact with a corrosive environment.
4. When conduit is in contact with a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
5. Where actuators are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

3.4 CONTROL DAMPERS

A. Install smooth transitions, not exceeding 30 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.

B. Clearance:

1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
2. Install dampers with at least 24 inches of clear space on sides of dampers requiring service access.

C. Service Access:

1. Dampers and actuators shall be accessible for visual inspection and service.
2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 233300 "Air Duct Accessories."

D. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.

E. Attach actuator(s) to damper drive shaft.

F. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with damper identification on damper and on face of ceiling where damper is concealed above ceiling.

3.6 CHECKOUT PROCEDURES

A. Control-Damper Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.

2. Check dampers for proper location and accessibility.
3. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
4. For pneumatic products, verify air supply for each product is properly installed.
5. For pneumatic dampers, verify that pressure gages are provided in each air line to damper actuator and positioner.
6. Verify that control dampers are installed correctly for flow direction.
7. Verify that proper blade alignment, either parallel or opposed, has been provided.
8. Verify that damper frame attachment is properly secured and sealed.
9. Verify that damper actuator and linkage attachment are secure.
10. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
11. Verify that damper blade travel is unobstructed.

3.7 ADJUSTMENT, CALIBRATION, AND TESTING:

A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressure.

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 230923.12

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 control sequences for DDC for HVAC systems, subsystems, and equipment.

1.3 DEFINITIONS

A. Analog Output: Proportional output signal (zero- to 10-V dc, 4 to 20 mA).

B. Binary Output: On/off output signal or contact closure.

C. DDC: Direct digital control.

D. Digital Output: Data output that must be interpreted digitally.

1.4 ACTION SUBMITTALS

A. Product Data:

1. An instrumentation list for each controlled system. Label each element of the controlled system in table format. Show, in the table element name, type of device, manufacturer, model number, and control device product data sheet number.
2. A complete description of the operation of the control system, including sequences of operation. Include and reference a schematic diagram of the controlled system.

B. Shop Drawings:

1. Riser diagrams showing control network layout, communication protocol, and wire types.
2. Schematic diagram of each controlled system. Include all control points labeled with point names shown or listed. Show the location of control elements in the system.
3. Wiring diagram for each controlled system. Show all control elements labels. Where a control element is the same as that shown on the control system schematic, label with the same name. Label all terminals.

1.5 HEATING CONTROL SEQUENCES

A. Control Circulating Pump(s):

1. Input Device:

   a. Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
   b. Location: Outdoor-air or Room.
   c. Transference: DDC controller.

2. Output Device:

   a. Device: Command to electric relay.
   b. Location: Motor controller.
   c. Transference: Starter relay.

3. Action:

   a. Energize pump(s) at outdoor-air temperatures below 65 deg F if pumps are not required for re-heat.
   b. Enable additional circulating pump(s) , alternate pump(s) , heating-water supply temperature control and , heating-water supply temperature reset control sequences.

B. Additional Circulating Pump(s):

1. Input Device:

   a. Device: Liquid pressure differential switch or transmitter.
   b. Location: Between the primary supply and return piping.
   c. Transference: DDC controller.

2. Output Device:

   a. Device: Binary output.
   b. Location: Motor controller.
   c. Transference: Starter relay.

3. Action:

   a. Energize pump(s) and maintain operation when differential pressure drops below 30 percent of specified pump head.

C. Circulating Pump(s) Failure Alarm:

1. Input Device:

   a. Device: Liquid pressure differential switch or transmitter.
   b. Location: Between the primary supply and return piping.
   c. Transference: DDC controller.

2. Output Device:

a. Device: DDC controller.
b. Transference: Operator's workstation.

3. Action:

a. Signal alarm condition, no pressure differential between supply and return piping.

D. Alternate Pump(s):

1. Input:

a. Device: DDC controller.
b. Transference: Software.

2. Output Device:

a. Device: DDC controller.
b. Location: Motor controller.
c. Transference: Motor-controller relay.

3. Action: Operate pump(s) on lead-lag, alternating each startup.

E. Control Circulating Pump(s) Speed:

1. Input Device:

a. Device: Liquid pressure differential transmitter.
b. Location: Heating supply and return piping.
c. Transference: DDC controller.

2. Output Device:

a. Device: Analog command.
b. Location: Motor controller.
c. Transference: Variable-frequency motor controller.

3. Action:

a. Control pump speed to maintain pressure differential.

F. Heating-Water Supply Temperature Control:

1. Input:

a. Device: Liquid temperature sensor or liquid temperature sensor with liquid temperature transmitter.
b. Location: Heating-water supply.
c. Transference: DDC controller.

2. Output:

a. Device: Control-valve actuator.
b. Location: Heating-water supply.
c. Transference: Control-valve actuator.

3. Action:

a. Modulate control valve to maintain heating-water supply temperature.
b. Reset heating-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:

1) 195 deg F heating water when outdoor-air temperature is minus 30 deg F.
2) 130 deg F heating water when outdoor-air temperature is 75 deg F.

G. Heating-Water Supply Temperature Reset:

1. Input:

a. Device: Liquid temperature sensor or Liquid temperature sensor with liquid temperature transmitter.
b. Location: Outdoor-air and heating-water supply.
c. Transference: DDC controller.

2. Output:

a. Device: DDC controller to boiler controls.
b. Location: Local panel.
c. Transference: Boiler control panel.

3. Action:

a. Reset heating-water supply temperature in response to greatest heating demand to maintain at least one cooling control valve 90 percent open.
b. Reset heating-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:

1) 195 deg F heating water when outdoor-air temperature is minus 30 deg F.
2) 130 deg F heating water when outdoor-air temperature is 75 deg F.
3) 150 deg F minimum heating-water temperature.

H. Indicate the following on the operator's workstation display terminal:

1. DDC system graphic.
2. DDC system status, on-off.
3. Outdoor-air temperature.
4. Room temperature.
5. Circulating pump(s) on-off status (enabled or disabled).
6. Circulating pump(s) on-off indication (operating or not operating).
7. Additional circulating pump(s) pressure differential.
8. Additional circulating pump(s) pressure differential set point.
9. Additional circulating pump(s) on-off indication (operating or not operating).

10. Circulating pump(s) alarm pressure differential.
11. Circulating pump(s) alarm pressure differential set point.
12. Alarm (circulating pump(s) failure).
13. Circulating pump(s) speed pressure differential.
14. Circulating pump(s) speed pressure differential set point.
15. Circulating pump(s) speed.
16. Heating-water supply temperature.
17. Heating-water return temperature.
18. Heating-water control-valve position.
19. Heating-water supply temperature set point.
20. Heating-water control-point output valve.

1.6 CENTRAL CHILLED-WATER SYSTEM SEQUENCES

A. Central Chilled-Water System Time Schedule:

1. Occupied Time Schedule:

a. Input:

1) Device: DDC controller.
2) Location: Time schedule.
3) Transference: DDC controller.

b. Output:

1) Device: DDC controller.

c. Action:

1) Enable startup, initiation, and control.
2) Energize condenser-water pumps on occupied/unoccupied cycle.
3) Energize condenser-water pumps on day/night cycle.
4) After chilled-water system shutdown, operate pump(s) for an additional 3 minutes.

2. Display:

a. Time and time schedule.

B. Start and Stop Condenser-Water Pump(s):

1. Enable:

a. Input:

1) Device: Level or Liquid pressure switch.
2) Location: Cooling tower sump or Pump suction.

b. Output:

1) Device: Hard wired.
2) Location: Motor controller.
3) Transference: Motor-controller relay.

c. Action: Confirm adequate water level in cooling-tower sump at pump suction and energize pump(s).

2. Enable:

a. Input:

1) Device: Level transmitter or liquid pressure transmitter.
2) Location: Cooling tower sump or Pump suction.
3) Transference: DDC controller.

b. Output:

1) Device: Binary output.
2) Location: Motor controller.
3) Transference: Motor-controller relay.

c. Action: Confirm adequate water level in cooling-tower sump at pump suction.

3. Enable:

a. Input:

1) Device: DDC controller outdoor-air temperature.
2) Location: Outdoors.
3) Transference: Binary output.

b. Output:

1) Device: Hard wired.
2) Location: Motor controller.
3) Transference: Starter relay.

c. Action: Confirm outdoor-air temperature is above 50 deg F and energize pump(s).

4. Enable:

a. Input:

1) Device: DDC controller.
2) Location: Software demand.
3) Transference: Binary output.

b. Output:

1) Device: Hard wired.
2) Location: Motor controller.
3) Transference: Starter relay.

c. Action: Confirm cooling demand from ventilation system(s) and energize pump(s).

5. Display:

a. Low-level cooling-tower sump alarm.
b. Outdoor-air temperature.
c. Cooling (software) demand indication.
d. Time and time schedule.
e. Condenser-water pump(s) on-off status (enabled or disabled).
f. Condenser-water pump(s) on-off indication (operating or not operating).

C. Start and Stop Chilled-Water Pump(s):

1. Input:

a. Device: Flow or Pressure differential switch.
b. Location: Chilled-water piping.
c. Transference: Control voltage relay or DDC controller.

2. Output:

a. Device: Hard wired or Binary output.
b. Location: Motor controller.
c. Transference: Starter relay.

3. Action: Energize pump(s) when the condenser-water pump(s) and system start.
4. Display:

a. Chilled-water flow indication.
b. Chilled-water pump(s) on-off status (enabled or disabled).
c. Chilled-water pump(s) on-off indication (operating or not operating).

D. Start and Stop Cooling-Tower Fan(s):

1. Input:

a. Device: Flow or Pressure differential switch.
b. Location: Condenser-water piping.
c. Transference: Control relay or DDC controller.

2. Output:

a. Device: Hard wired or Binary output.
b. Location: Motor controller.
c. Transference: Starter relay.

3. Action: Energize fan(s) when the condenser-water pump(s) and system start.
4. Display:

    a. Condenser-water flow indication.
    b. Cooling-tower fan(s) on-off indication (operating or not operating).

E. Start and Stop Chillers:

1. Input:

    a. Device: Flow or pressure differential switch.
    b. Location: Chilled- and condenser-water piping.
    c. Transference: Chiller controls or DDC controller.

2. Output:

    a. Device: Hard wired or Binary output.
    b. Location: Chiller control panel.
    c. Transference: Chiller controls.

3. Action: Energize chiller(s) internal control circuit when the condenser-water and chilled-water pump(s), and system start.
4. Display:

    a. Condenser-water flow indication.
    b. Chilled-water flow indication.
    c. Chiller on-off indication (operating or not operating).
    d. Chilled-water supply and return temperature.
    e. Chilled-water temperature control-point adjustment.

F. Start and Stop Chiller(s):

1. Input:

    a. Device: Flow switches.
    b. Location: Condenser-water and chilled-water circuit.
    c. Transference: Chiller terminal strip or DDC system.

2. Output:

    a. Device: Hard wired or Binary output.
    b. Location: Chiller control panel.
    c. Transference: Chiller controls.

3. Action: Energize chiller internal control circuit when the condenser-water and chilled-water pump(s), and system start.
4. Display:

    a. Condenser-water flow indication.
    b. Chilled-water flow indication.

c. Chiller(s) on-off status (enabled or disabled).
d. Chiller(s) on-off indication (operating or not operating).
e. Chilled-water supply and return temperature.
f. Chilled-water temperature control-point adjustment.

G. Alternate Chiller(s):

1. Input:

a. Device: DDC controller.
b. Location: DDC software.
c. Transference: DDC software.

2. Output Device:

a. Device: DDC controller command to chiller.
b. Location: Chiller control panel.
c. Transference: Chiller controls.

3. Action:

a. Operate chiller(s) on lead-lag, alternating each startup.
b. Start additional chiller when load exceeds capacity of operating chillers as follows:

1) When common chilled-water supply temperature exceeds set point for a 30-minute-adjustable period.

c. Stop chiller when load capacity of operating chillers drops to less than 110-adjustable percent of capacity of next chiller to be shut down for a 30-minute-adjustable period.

4. Display: Chiller(s) on-off indication (operating or not operating).

H. Alarm Chiller(s) Start Failure:

1. Input:

a. Device: Software signal or Hardwired.
b. Location: Chiller control panel.
c. Transference: DDC controller.

2. Output:

a. Device: DDC controller.
b. Transference: Operator's workstation.

3. Action: Signal alarm on signal from chiller control panel.
4. Display:

a. Chiller "failure-to-start" indication.

I. Start and Stop Chiller(s):

1. Input:

a. Device: Chiller control panel.
b. Location: Chiller.
c. Transference: DDC controller.

2. Output:

a. Device: DDC controller.
b. Transference: Operator's workstation.

3. Action: Report chiller electronic control, operating, and alarm functions.
4. Display:

J. Chilled-Water Level:

1. Input:

a. Device: Level switch or Liquid level sensor.
b. Location: Expansion tank.
c. Transference: DDC controller.

2. Input:

a. Device: Liquid gage pressure switch.
b. Location: Makeup-water piping downstream from pressure-reducing valve.
c. Transference: DDC controller.

3. Output:

a. Device: DDC controller.
b. Transference: Operator's workstation.

4. Action: Signal alarm on expansion tank low level or low pressure.
5. Display: Expansion tank low-level or Low-pressure alarm.

K. Chilled-Water Supply Temperature:

1. Input:

a. Device: Liquid temperature sensor or liquid temperature sensor with liquid temperature transmitter.
b. Location: Common chilled-water supply piping.
c. Transference: DDC controller.

2. Output:

a. Device: DDC controller signal.
b. Location: Local panel.

c. Transference: Chiller control panel.

3. Action: Maintain chilled-water supply temperature.

a. Reset chilled-water supply temperature in response to greatest cooling demand to maintain at least one cooling control valve 90 percent open.
b. Reset chilled-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:

c. Reset chilled-water supply temperature based on constant return chilled-water temperature of 54 deg F -adjustable and in compliance with IECC.

4. Display:

a. Chilled-water supply temperature.
b. Chilled-water supply temperature set point.

L. Condenser-Water Temperature:

1. Input:

a. Device: Liquid temperature sensor or Liquid temperature sensor with liquid temperature transmitter.
b. Location: Cooling-tower sump or Common condenser-water supply piping.
c. Transference: DDC controller.

2. Output:

a. Device: Analog output.
b. Location: DDC controller.
c. Transference: Control-valve actuator.

3. Action: Modulate control valve open to cooling tower and closed to bypass to maintain when condenser-water supply temperature is above 85 deg F-adjustable temperature set point. Modulate control valve closed to cooling tower and open to bypass when condenser-water supply temperature is below 55 deg F -adjustable temperature set point.
4. Output:

a. Device: DDC controller control relay.
b. Location: DDC controller.
c. Transference: Fan starter relay.

5. Action: Cycle tower fan(s) on and off to maintain 55 deg F temperature set point.
6. Action: Cycle tower fan(s) on and off to maintain condenser-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:

a. 85 deg F condenser water when outdoor-air temperature is 80 deg F.
b. 55 deg F condenser water when outdoor-air temperature is 55 deg F.

7. Output:

a. Device: DDC controller digital output.
b. Location: DDC controller.
c. Transference: Fan variable-speed controller.

8. Action: Cycle tower fan(s) on and modulate fan speed from minimum to maximum to maintain 55 deg F temperature set point.
9. Action: Cycle tower fan(s) on and off to maintain condenser-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:

a. 85 deg F condenser water when outdoor-air temperature is 80 deg F.
b. 55 deg F condenser water when outdoor-air temperature is 55 deg F.

10. Display:

a. Control-valve(s) position.
b. Cooling-tower fan(s) on-off indication (operating or not operating).
c. Cooling-tower fan(s) speed.
d. Condenser-water supply temperature.
e. Condenser-water supply temperature set point.
f. Condenser-water return temperature.

M. Cooling-Tower Sump Heater:

1. Input:

a. Device: Two-stage thermostat.
b. Location: Cooling tower sump.
c. Transference: Heater relay and control-valve actuator.

2. Output:

a. Device: Heater relay and control-valve actuator.
b. Location: Electric heater control panel and control-valve actuator in sump drain.
c. Transference: Electric heater contactor and control-valve actuator.

3. Action:

a. Energize sump heater if sump temperature falls below 40 deg F temperature set point.
b. Open control valve in sump heater drain piping if sump temperature falls below 35 deg F temperature set point.

4. Display:

a. Cooling-tower sump temperature.
b. Cooling-tower sump heater on-off indication (operating or not operating).
c. Cooling-tower control valve open-close indication.

N. Cooling-Tower Sump Heater:

1. Input:

   a. Device: Liquid temperature sensor or liquid temperature sensor with liquid temperature transmitter.
   b. Location: Cooling tower sump.
   c. Transference: DDC controller.

2. Output:

   a. Device: Binary output.
   b. Location: Electric heater control panel and solenoid valve in sump drain and control-valve actuator in sump drain.
   c. Transference: Electric heater contactor and solenoid valve and control-valve actuator.

3. Action:

   a. Energize sump heater if sump temperature falls below manufacturers recommended temperature set point.
   b. Open control valve in sump heater drain piping if sump temperature falls below manufacturers recommended temperature set point.

4. Display:

   a. Cooling-tower sump temperature.
   b. Cooling-tower sump heater on-off indication (operating or not operating).
   c. Cooling-tower control valve open-close indication.

O. Control Circulating Pump(s) Speed:

1. Input Device:

   a. Device: Liquid pressure differential transmitter, Liquid flow meter or Liquid flow sensor.
   b. Location: Chilled-water supply and return piping and condenser-water supply and return piping to chiller.
   c. Transference: DDC controller.

2. Output Device:

   a. Device: DDC controller.
   b. Location: Motor controller.
   c. Transference: Pump variable-speed controller.

3. Action:

   a. Control pump speed to maintain flow through chiller.
   b. Report pressure drop and flow.

P. Circulation through Chiller:

1. Input Device:

   a. Device: Liquid pressure differential transmitter, Liquid flow meter or Liquid flow sensor.
   b. Location: Chilled-water supply and return piping and condenser-water supply and return piping to chiller.
   c. Transference: DDC controller.

2. Output Device:

   a. Device: DDC controller.

3. Action:

   a. Report pressure drop and flow through chiller.

Q. Indicate the following on the operator's workstation display terminal:

1. DDC system graphic.
2. DDC system status, on-off.
3. Low-level cooling-tower sump alarm.
4. Outdoor temperature.
5. Cooling (software) demand indication.
6. Time and time schedule.
7. Condenser-water pump(s) on-off status (enabled or disabled).
8. Condenser-water pump(s) on-off indication (operating or not operating).
9. Condenser-water flow indication.
10. Chilled-water pump(s) on-off status (enabled or disabled).
11. Chilled-water pump(s) on-off indication (operating or not operating).
12. Cooling-tower fan(s) on-off indication (operating or not operating).
13. Chilled-water flow indication.
14. Refrigeration machine on-off indication (operating or not operating).
15. Chilled-water supply temperature.
16. Chilled-water return temperature.
17. Chilled-water temperature control-point adjustment.
18. Chiller(s) on-off status (enabled or disabled).
19. Chiller(s) on-off indication (operating or not operating).
20. Chiller "failure-to-start" indication.
21. Expansion tank low-level alarm.
22. Condenser-water sump (return) control-point temperature.
23. Condenser-water sump (return) temperature.
24. Condenser-water control-valve position.
25. Cooling-tower fan(s) on-off indication (operating or not operating).
26. Condenser-water supply temperature.
27. Cooling-tower sump temperature.
28. Cooling-tower sump heater on-off indication (operating or not operating).
29. Cooling-tower sump drain indication.
30. Chiller(s) power input (instantaneous).
31. Chilled-water pressure drop through chiller.
32. Chilled-water flow through chiller.

33. Condenser-water pressure drop through chiller.
34. Condenser-water flow through chiller.
35. Chiller condenser-water supply and return temperature.
36. Chiller chilled-water supply and return temperature.
37. System capacity in tons.

1.7 AIR-HANDLING-UNIT CONTROL SEQUENCES

A. Air-Handling Unit Time Schedule:

1. Occupied Time Schedule:

a. Input:

1) Device: DDC controller.
2) Location: Time schedule.
3) Transference: DDC controller.

b. Output:

1) Device: DDC controller.

c. Action:

1) Enable startup, initiation, and control.
2) Energize unit on occupied/unoccupied cycle.
3) Energize unit on day/night cycle.
4) Energize unit on duty cycle.
5) Energize return-air fans 30 seconds after supply fans are energized.
6) Do not enable mixed-air control during morning warm-up period.

a) Unoccupied: Position outdoor-air and relief-air dampers closed and return-air dampers open.

7) Do not enable humidifier control during morning warm-up period.
8) Enable control of heating coil(s) during morning warm-up period.
9) Energize coil circulating pump(s).
10) Return heating control valves to normal position when unit is cycled on.
11) Do not enable cooling-coil control during morning warm-up period.

B. Start and Stop Supply Fan(s):

1. Enable:

a. Input:

1) Device: Low limit temperature switch with manual or automatic reset.
2) Location: Upstream of cooling coil.
3) Transference: Starter relay.

b. Output:

1) Device: Hard wired to motor controller and DDC controller.
2) Location: Motor controller.
3) Transference: Starter relay.

c. Action:

1) Allow start if temperature is above 37 deg F.
2) Signal alarm if fan fails to start as commanded.

2. Enable:

a. Input:

1) Device: Low limit temperature switch with manual or automatic reset.
2) Location: Supply airstream.
3) Transference: Starter relay.

b. Output:

1) Device: Hard wired to motor controller and DDC controller.
2) Location: Motor controller.
3) Input Transference: Starter relay.

c. Action:

1) Allow start if temperature is below 120 deg F.
2) Signal alarm if fan fails to start as commanded.

3. Enable:

a. Input:

1) Device: Smoke detector with auxiliary contact manual or automatic reset.
2) Location: Duct mounted before and afterair-handling unit.
3) Transference: Starter relay.

b. Output:

1) Device: Hard wired.
2) Location: Motor controller.
3) Transference: Starter relay.

c. Output Device: Hard wired through motor controller; DDC controller alarm.
d. Action:

1) Allow start if airstream is free of products of combustion.
2) Signal alarm if fan fails to start as commanded.

C. Supply Fan(s) Variable-Volume Control:

1. Fan Speed Control:

   a. Input:

      1) Device: Air pressure transmitter.
      2) Location: Supply-duct static pressure referenced to ambient-space static pressure.
      3) Transference: DDC controller.

   b. Output:

      1) Device: Analog output.
      2) Transference: Variable-frequency motor controller.

   c. Action:

      1) Maintain constant supply-duct static-pressure set point.
      2) Set-Point Reset (for Systems with DDC of Individual Zone Terminals): Reset static-pressure set point based on the zone requiring the most pressure; reset set point lower until one zone damper is nearly wide open.
      3) Set variable-frequency drive to minimum speed when fan is stopped.

2. Fan Airflow:

   a. Input:

      1) Device: Airflow sensor or transmitter.
      2) Location: Supply duct.
      3) Transference: DDC controller.

   b. Output:

      1) Device: DDC controller.

   c. Action: Report supply-duct airflow.

3. High Pressure:

   a. Input:

      1) Device: Air pressure switch.
      2) Location: Supply duct referenced to outside the duct.
      3) Transference: DDC controller.

   b. Output:

      1) Device: Binary output; DDC controller.
      2) Transference: Starter relay; operator's workstation.

   c. Action: When static pressure rises above excessive-static-pressure set point.

1) Stop fan.
2) Signal alarm.

D. Return Fan(s) Variable-Volume Control:

1. Fan Speed Control:

a. Input:

1) Device: Airflow sensor or transmitter.
2) Location: Supply airstream and return airstream.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Variable-frequency drive.
3) Transference: Variable-frequency drive controller.

c. Action:

1) Maintain constant airflow offset between supply- and return-air fans.
2) Set variable-frequency drive to minimum speed when fan is stopped.

2. Fan Speed Control:

a. Input:

1) Device: Air pressure sensor or differential transmitter.
2) Location: Indoor space static pressure referenced to outdoor static pressure.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Transference: Variable-frequency motor controller.

c. Action:

1) Maintain constant indoor static-pressure set point of 0.02-inch wg positive for outdoors.
2) Set variable-frequency drive to minimum speed when fan is stopped.

d. Action: Maintain constant indoor static pressure.

E. Preheat Coil:

1. Freeze Protection:

a. Input:

1) Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter or Thermostat.
2) Location: After preheat coil.
3) Transference: DDC controller or Starter relay.

b. Output:

1) Device: Binary output or Hard wired.
2) Location: Motor controller.
3) Transference: Starter relay.

c. Action: Allow start if duct temperature is above 33 deg F.

2. Low-Temperature Operation:

a. Input:

1) Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
2) Location: Outdoor air.
3) Transference: DDC controller.

b. Output Device:

1) Device: Binary output.
2) Location: Motor controller.
3) Transference: Starter relay.

c. Action:

1) Energize coil circulating pump(s) at outdoor-air temperatures below 35 deg F.

3. Supply-Air Temperature:

a. Input:

1) Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
2) Location: Supply airstream.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Control valve.
3) Transference: Control-valve actuator.

c. Action: Maintain air-temperature set point of 55 deg F.

F. Mixed-Air Control:

1. Minimum Position:

a. Input:

1) Device: DDC controller.
2) Location: Time schedule.
3) Transference: DDC controller.

b. Input:

1) Device: Flow measuring station.
2) Location: Outdoor-air intake.
3) Transference: DDC controller.

c. Output:

1) Device: Analog output.
2) Location: Outdoor damper.
3) Transference: Damper actuator(s).

d. Action:

1) Open outdoor-air dampers to minimum position.

2. Heating Reset:

a. Input:

1) Device: DDC controller.
2) Location: Software.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Outdoor dampers.
3) Transference: Damper actuator(s).

c. Action: Set outdoor-air dampers to minimum position.

3. Carbon Dioxide Reset:

a. Input:

1) Device: Carbon dioxide transmitter.
2) Location: Space.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Dampers.
3) Transference: Damper actuator(s).

c. Action: Reset minimum outdoor-air damper position to maintain carbon dioxide set point of 800 ppm-adjustable.

4. Supply or Mixed-Air Temperature:

a. Input:

1) Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
2) Location: Supply-airstream or Mixed-air plenum.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Damper section.
3) Transference: Damper actuator(s).

c. Action:

1) Modulate outdoor-, return-, and relief-air dampers to maintain air-temperature set point of 55 deg F.
2) Do not enable control during morning warm-up period.

5. Cooling Reset:

a. Input:

1) Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter and moisture sensors and transmitters.
2) Location: Outdoor- and return-air ducts.
3) Input Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Outdoor- and return-air ducts.
3) Transference: Damper actuator(s).

c. Action: Set outdoor-air dampers to minimum position when outdoor-air enthalpy exceeds return-air enthalpy.

G. Humidifier:

1. Input:

a. Device: Moisture sensor and transmitter.
b. Location: Return airstream or Space.
c. Transference: DDC controller.

2. Output:

a. Device: Analog output.
b. Location: Humidifier.
c. Transference: Valve actuator and pump.

3. Action:

a. Modulate humidity control valve, Cycle humidifier pump or Cycle humidifier pump and modulate humidity control valve.
b. Maintain humidity in straight-line relationship for the following conditions:

1) 20 percent when outdoor-air temperature is minus 30 deg F.
2) 40 percent when outdoor-air temperature is 75 deg F.

H. Evaporative Cooler:

1. Temperature:

a. Input:

1) Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
2) Location: Supply airstream.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Evaporative cooler.
3) Transference: Valve actuator and pump.

c. Action:

1) Modulate evaporative cooler control valve and cycle evaporative cooler pump.
2) Maintain air-temperature set point of 55 deg F.

2. Humidity Limit:

a. Input:

1) Device: Moisture sensor and transmitter.
2) Location: Return airstream or Space.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Evaporative cooler.
3) Transference: Valve actuator and pump.

c. Action:

1) Return humidity control valve, humidifier pump or humidifier pump and humidity control valve to their normal position.
2) Signal high humidity alarm.

I. Filters:

1. Differential Pressure:

a. Input:

1) Device: Pressure differential switch or transmitter.
2) Location: Filter bank.
3) Transference: DDC controller.

b. Output:

1) Device: DDC controller.
2) Location: DDC controller.
3) Transference: Operator's workstation.

c. Action: Signal alarm on low- and high-pressure conditions.

J. Hydronic or Steam Heating Coil:

1. Supply-Air Temperature:

a. Input:

1) Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
2) Location: Supply-air duct.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Heating-coil control valve.
3) Input Transference: Normally open or closed valve actuator.

c. Action:

1) Maintain supply-air-temperature set point of 55 deg F by modulating heating-coil control valve.

2) Maintain supply-air-temperature set point in straight-line relationship for the following conditions:

a) 65 deg F when return-air temperature is 70 deg F.
b) 55 deg F when return-air temperature is 75 deg F.

3) During morning warm-up period, maintain supply-air-temperature set point of 80 deg F.

2. Space Temperature Reset:

a. Input:

1) Device: Space air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
2) Location: Indoor spaces served by system.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Heating-coil control valve.
3) Input Transference: Normally open or closed valve actuator.

c. Action:

1) Reset supply-air temperature in response to greatest heating demand.
2) Supply-Air-Temperature Reset: Reset the supply-air temperature to outdoor temperature at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

3. Low-Temperature Operation:

a. Input Device:

1) Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
2) Location: Outdoor air.
3) Transference: DDC controller.

b. Output Device:

1) Device: Binary output.
2) Location: Motor controller.
3) Transference: Starter relay.

c. Action:

1) Energize coil circulating pump(s) at outdoor-air temperatures below 35 deg F.

K. Hydronic Cooling Coil:

1. Supply-Air Temperature:

a. Input:

1) Device: Air-temperature sensor or transmitter.
2) Location: Supply-air duct.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Cooling-coil valve.
3) Input Transference: Valve actuator.

c. Action:

1) Maintain supply-air-temperature set point of 55 deg F by modulating cooling-coil control valve.
2) Maintain supply-air-temperature set point within limits in response to space temperature reset:

a) Minimum 55 deg F.
b) Maximum 68 deg F.

3) Supply-Air-Temperature Reset: Reset the supply-air temperature to outdoor temperature at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

2. Temperature Reset:

a. Input:

1) Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
2) Location: Return-air duct.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Cooling-coil control valve.
3) Transference: Valve actuator.

c. Action: Reset supply-air temperature in straight-line relationship for the following conditions:

1) 65 deg F when return-air temperature is 70 deg F.
2) 55 deg F when return-air temperature is 75 deg F.

d. Action:

1) Reset supply-air temperature in response to greatest cooling demand.
2) Supply-Air-Temperature Reset: Reset the supply-air temperature to outdoor temperature at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

3. Space Temperature Reset:

a. Input:

1) Device: Space air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
2) Location: Spaces served by system.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Cooling coil.
3) Input Transference: Valve actuator.

c. Action:

1) Reset supply-air temperature in response to greatest cooling demand.
2) Supply-Air-Temperature Reset: Reset the supply-air temperature to outdoor temperature at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

4. Space Humidity Reset:

a. Input:

1) Device: Humidity sensor and transmitter.
2) Location: Return-air duct.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Cooling-coil control valve.
3) Transference: Valve actuator.

c. Action: Reset supply-air temperature to 55 deg F to maintain space relative humidity of 45.

L. Multizone Damper Control:

1. Spaces Temperature:

a. Input Device:

1) Device: Air-temperature sensors or air-temperature sensor with air-temperature RTD transmitter.
2) Location: Spaces served by system.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Multizone head.
3) Transference: Damper actuators.

c. Action: Maintain the following space temperature set points:

1) Occupied Cooling Temperature: 75 deg F.
2) Occupied Heating Temperature: 70 deg F.
3) Unoccupied Cooling Temperature: 85 deg F.
4) Unoccupied Heating Temperature: 65 deg F.

M. Coordination of Air-Handling Unit Sequences: Ensure that preheat, mixed-air, heating-coil, and cooling-coil controls have common inputs and do not overlap in function.

N. Indicate the following on the operator's workstation display terminal:

1. DDC system graphic.
2. DDC system on-off indication (operating or not operating).
3. DDC system occupied/unoccupied mode.
4. Outdoor-air-temperature indication.
5. Supply-fan on-off indication (operating or not operating).
6. Supply duct static-pressure indication.
7. Supply duct static-pressure set point.
8. Supply-fan airflow rate.
9. Supply-fan speed.
10. Return-fan on-off indication (operating or not operating).
11. Space static-pressure indication.
12. Space static-pressure set point.
13. Return-fan airflow rate.
14. Return-fan speed.
15. Preheat-coil air-temperature indication.
16. Preheat-coil air-temperature set point.
17. Preheat-coil pump on-off indication (operating or not operating).
18. Preheat-coil control-valve position.
19. Mixed-air-temperature indication.
20. Mixed-air-temperature set point.
21. Mixed-air damper position.
22. Relative humidity indication.
23. Relative humidity set point.
24. Relative humidity control-valve position.
25. Filter air-pressure-drop indication.

26. Filter low-air-pressure drop set point.
27. Filter high-air-pressure drop set point.
28. Supply Discharge-air-temperature indication.
29. Supply Discharge-air-temperature set point.
30. Heating-coil leaving-air-temperature indication.
31. Heating-coil leaving-air-temperature set point.
32. Heating-coil pump on-off indication (operating or not operating).
33. Heating-coil control-valve position.
34. Hot-deck air-temperature indication.
35. Hot-deck air-temperature set point.
36. Cooling-coil leaving-air-temperature indication.
37. Cooling-coil leaving-air-temperature set point.
38. Cooling-coil control-valve position.
39. Cold-deck air-temperature indication.
40. Cold-deck air-temperature set point.
41. Space temperature indication.
42. Space temperature set point.
43. Multizone damper position.

1.8 TERMINAL UNIT OPERATING SEQUENCE

A. Cabinet Unit Heater, Hydronic or Steam:

1. Space Temperature:

   a. Input:

      1) Device: Line-voltage thermostat.
      2) Location: Space.

   b. Output:

      1) Device: Hard wired.
      2) Location: Motor controller.
      3) Transference: Starter relay.

   c. Action: Cycle fan to maintain 75 deg F space temperature.

2. Space Temperature:

   a. Input:

      1) Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
      2) Location: Occupied space.
      3) Transference: DDC controller.

   b. Output Device:

1) Device: Binary output.
2) Location: Motor controller.
3) Transference: Starter relay.

c. Output Device:

1) Device: Analog output.
2) Location: Control valve.
3) Transference: Control-valve actuator.

d. Action: Cycle fan or Modulate valve to maintain 75 deg F space temperature.

3. Low-Temperature Safety:

a. Input Device: Line-voltage, on-off thermostat; mounted.

1) Device: Line-voltage thermostat.
2) Location: Return heating-water or Condensate pipe.

b. Output Device:

1) Device: Hard wired.
2) Location: Motor controller.
3) Input Transference: Starter relay.

c. Action: Stop fan when return heating-water or condensate temperature falls below 35 deg F.

B. Cabinet Unit Heater, Electric:

1. Input:

a. Device: Line-voltage thermostat.
b. Location: Occupied space.

2. Output:

a. Device: Hard wired.
b. Location: Motor-controller and heater relay.
c. Transference: Starter relay.

3. Action: Cycle fan to maintain 75 deg F space temperature.

C. Unit Heater, Hydronic or Steam:

1. Space Temperature:

a. Input:

1) Device: Line-voltage thermostat.
2) Location: Space.

b. Output:

1) Device: Hard wired.
2) Location: Motor controller.
3) Transference: Starter relay.

c. Action: Cycle fan to maintain 75 deg F space temperature.

2. Space Temperature:

a. Input:

1) Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
2) Location: Space.
3) Transference: DDC controller.

b. Output Device:

1) Device: Binary output.
2) Transference: Starter relay.

c. Output Device:

1) Device: Analog output.
2) Location: Control valve.
3) Transference: Control-valve actuator.

d. Action: Cycle fan or Modulate valve to maintain 75 deg F space temperature.

3. Low-Temperature Safety:

a. Input Device: Line-voltage, on-off thermostat; pipe mounted.

1) Device: Line-voltage thermostat.
2) Location: Return heating-water or Condensate pipe.

b. Output Device:

1) Device: Hard wired.
2) Location: Motor controller.
3) Input Transference: Starter relay.

c. Action: Stop fan when return heating-water or condensate temperature falls below 35 deg F.

D. Unit Heater, Electric: Space thermostat cycles fan and sequences stages of heating.

1. Space Temperature:

a. Input:

1) Device: Electric multistage thermostat.
2) Location: Space.

b. Output:

1) Device: Hard wired.
2) Location: Unit control panel.
3) Transference: Electric multistage contactors.

c. Action: Sequence electric coil stages to maintain 75 deg F space temperature.

E. Combustion-Air Unit Heaters:

1. Space Temperature:

a. Input:

1) Device: Thermostat.
2) Location: Space.

b. Output:

1) Device: Low-voltage wiring.
2) Location: Control valve.
3) Transference: Valve actuator.

c. Input:

1) Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
2) Location: Space.
3) Transference: DDC controller.

d. Output:

1) Device: Analog output.
2) Location: Control valve.
3) Transference: Valve actuator.

e. Action: Modulate valve to maintain 75 deg F space temperature.

F. Radiant Heating Cable, Electric:

1. Space Temperature:

a. Input:

1) Device: Electric thermostat.
2) Location: Space.

b. Output:

1) Device: Line-voltage wiring.
2) Location: Junction box.
3) Transference: Cable.

c. Action: Cycle power to maintain 75 deg F space temperature set point.

G. Radiant Heating Panel, Electric:

1. Space Temperature:

a. Input:

1) Device: Electronic thermostat.
2) Location: Space.

b. Output:

1) Device: Low-voltage wiring.
2) Location: Junction box.
3) Transference: Line-voltage relay.

c. Action: Cycle power to maintain the following space temperature set points:

1) Occupied: 75 deg F.
2) Unoccupied: 65 deg F.

d. Radiant Heating Panel, Hydronic:

2. Space Temperature:

a. Input:

1) Device: Electronic thermostat.
2) Location: Space.

b. Output:

1) Device: Low-voltage wiring.
2) Location: Control valve.
3) Transference: Valve actuator.

c. Action: Cycle valve open and closed to maintain temperature set point.
d. Input:

1) Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
2) Location: Space.
3) Transference: DDC controller.

e. Output:

1) Device: DDC analog output.
2) Location: Control valve.
3) Transference: Valve actuator.

f. Action: Modulate valve to maintain the following space temperature set points:

1) Occupied: 75 deg F.
2) Unoccupied: 65 deg F.

H. Two-Pipe, Single-Coil, Fan-Coil Unit:

1. Manual Start:

a. Input:

1) Device: Fan switch.
2) Location: Integral to thermostat.

b. Output:

1) Device: Hard wired.
2) Location: Motor controller.
3) Transference: Starter relay.

c. Action: Start and stop fan.

2. Space Temperature:

a. Input:

1) Device: Electronic thermostat.
2) Location: Space.

b. Output:

1) Device: Low-voltage wiring.
2) Location: Control valve.
3) Transference: Valve.

c. Action: Modulate valve to maintain the following space temperature set points:

1) Occupied Cooling Temperature: 75 deg F.
2) Occupied Heating Temperature: 70 deg F.
3) Unoccupied Cooling Temperature: 85 deg F.
4) Unoccupied Heating Temperature: 65 deg F.

3. Occupied Time Schedule:

a. Input:

1) Device: DDC controller.

2) Location: Time schedule.
3) Transference: DDC controller.

b. Output:

1) Device: Binary output.
2) Location: Motor controller.
3) Transference: Starter relay.

c. Action: Start and stop fan.

4. Space Temperature:

a. Input:

1) Device: Air-temperature sensor.
2) Location: Space.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Control valve.
3) Transference: Valve actuator.

c. Action: Modulate valve to maintain the following space temperature set points:

1) Occupied: 75 deg F.
2) Unoccupied: 65 deg F.

d. System Changeover:
e. Input:

1) Device: Liquid temperature sensor or liquid temperature sensor with liquid transmitter.
2) Location: Supply-water piping.
3) Transference: DDC controller.

f. Output:

1) Device: Binary output.
2) Location: Control valve.
3) Transference: Valve actuator.

g. Action: Reverse control-valve action to switch from heating to cooling.

I. Four-Pipe, Hydronic Fan-Coil Unit:

1. Occupied Time Schedule:

a. Input:

1) Device: DDC controller.
2) Location: Time schedule.
3) Transference: DDC controller.

b. Output:

1) Device: Binary output.
2) Location: Motor controller.
3) Transference: Starter relay.

c. Action: Start and stop fan, and enable control.

2. Space Temperature:

a. Input:

1) Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
2) Location: Space.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Control valve.
3) Transference: Valve actuators.

c. Action: Modulate control valves to maintain the following space temperature set points:

1) Occupied Cooling Temperature: 75 deg F.
2) Occupied Heating Temperature: 70 deg F.
3) Unoccupied Cooling Temperature: 85 deg F.
4) Unoccupied Heating Temperature: 65 deg F.

J. Unit Ventilator:

1. Occupied Time Schedule:

a. Input:

1) Device: DDC controller.
2) Location: Time schedule.
3) Transference: DDC controller.

b. Output:

1) Device: Binary output.
2) Location: Fan motor controller and damper.
3) Transference: Starter relay and damper actuators.

c. Action: Start and stop fan, move outdoor- and return-air dampers to minimum maximum outdoor-air position, and enable control.

2. Space Temperature - Valves:

a. Input:

1) Device: Air-temperature sensor or transmitter.
2) Location: Space.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Control valve.
3) Transference: Valve actuator.

c. Action: Modulate heating-water control valve and chilled-water control valve in sequence to maintain the following space temperature set points:

1) Occupied Cooling Temperature: 75 deg F.
2) Occupied Heating Temperature: 70 deg F.
3) Unoccupied Cooling Temperature: 85 deg F.
4) Unoccupied Heating Temperature: 65 deg F.

3. Space Temperature - Dampers:

a. Input:

1) Device: Air-temperature sensor or air-temperature RTD transmitter.
2) Location: Mixed-air plenum.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Dampers.
3) Transference: Damper actuators.

c. Action: Modulate outdoor- and return-air dampers to maintain the following space temperature set points:

1) Occupied Cooling Temperature: 75 deg F.
2) Occupied Heating Temperature: 70 deg F.
3) Unoccupied Cooling Temperature: 85 deg F.
4) Unoccupied Heating Temperature: 65 deg F.

4. Supply-Air-Temperature Limit:

a. Input:

1) Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
2) Location: Discharge air.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Control valve and dampers.
3) Transference: Valve and damper actuators.

c. Action: Override space temperature set point to control valves and dampers to prevent discharge air from dropping below a minimum set point of.

5. Warm-up Cycle:

a. Input:

1) Device: DDC controller.
2) Location: Time schedule.
3) Input Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Control valve and damper.
3) Transference: Valve and damper actuators.

c. Action: Open heating-water control valve, close outdoor-air damper, and open return-air damper.

K. Heating Coils, Hydronic or Steam:

1. Space Temperature:

a. Input:

1) Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
2) Location: Space.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Control valve.
3) Transference: Valve actuator.

c. Action: Modulate valve to maintain the following space temperature set points:

1) Occupied Cooling Temperature: 75 deg F.
2) Occupied Heating Temperature: 70 deg F.
3) Unoccupied Cooling Temperature: 85 deg F.
4) Unoccupied Heating Temperature: 65 deg F.

L. Heating Coils, Electric:

1. Space Temperature:

a. Input:

1) Device: Electric thermostat.
2) Location: Space.
3) Transference: Low-voltage control.

b. Output:

1) Device: Pilot relays.
2) Location: Heating-coil electrical cabinet.
3) Transference: Line-voltage relays.

c. Action: Sequence stages of heating to maintain 75 deg F space temperature.

M. Radiators and Convectors, Hydronic or Steam:

1. Occupancy:

a. Input:

1) Device: Occupancy sensor.
2) Location: Space.
3) Transference: DDC controller.

b. Output:

1) Device: DDC controller.

c. Action: Report occupancy and enable occupied temperature set point.

2. Space Temperature:

a. Input:

1) Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
2) Location: Space.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.

2) Location: Control valve.
3) Transference: Valve actuator.

c. Action: Modulate valve to maintain 75 deg F space temperature set point.

1) Occupied Temperature: 75 deg F.
2) Unoccupied Temperature: 65 deg F.

N. Radiators and Convectors, Electric:

1. Space Temperature:

a. Input:

1) Device: Electric thermostat.
2) Location: Space.
3) Transference: Low-voltage control.

b. Output:

1) Device: Pilot relays.
2) Location: Radiator electrical cabinet.
3) Transference: Line-voltage relays.

c. Action: Sequence stages of heating to maintain 75 deg F space temperature set point.

O. Constant-Volume, Terminal Air Units, Hydronic or Steam:

1. Occupancy:

a. Input:

1) Device: Occupancy sensor.
2) Location: Space.
3) Transference: DDC controller.

b. Output:

1) Device: DDC controller.

c. Action: Report occupancy and enable occupied temperature set point.

2. Space Temperature:

a. Input:

1) Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
2) Location: Space.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Control valve.
3) Transference: Valve actuator.

c. Action: Modulate valve to maintain the following space temperature set points:

1) Occupied Cooling Temperature: 75 deg F.
2) Occupied Heating Temperature: 70 deg F.
3) Unoccupied Cooling Temperature: 85 deg F.
4) Unoccupied Heating Temperature: 65 deg F.

P. Variable-Air-Volume Terminal Air Units with Hydronic or Steam Coils:

1. Occupancy:

a. Input:

1) Device: Occupancy sensor.
2) Location: Space.
3) Transference: DDC controller.

b. Device: DDC controller.
c. Action: Report occupancy and enable occupied temperature set point.

1) Occupied Cooling Temperature: 75 deg F.
2) Occupied Heating Temperature: 70 deg F.
3) Unoccupied Cooling Temperature: 85 deg F.
4) Unoccupied Heating Temperature: 65 deg F.

2. Space Temperature:

a. Input:

1) Device: Air-temperature sensor or transmitter.
2) Location: Space.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Control damper and valve actuators.
3) Input Transference: Control damper and valves.

c. Action: Modulate damper and valve to maintain the following space temperature set points:

1) Occupied Cooling Temperature: 75 deg F.
2) Occupied Heating Temperature: 70 deg F.

3) Unoccupied Cooling Temperature: 85 deg F.
4) Unoccupied Heating Temperature: 65 deg F.
5) Modulate damper actuator from full open to minimum position.
6) When damper is at minimum position, modulate reheat coil valve from closed to open.
7) If occupied space temperature is not maintained with valve open, modulate damper actuator from minimum position to 100 percent open.
8) Reverse the sequence for full heating to full cooling.

Q. Dual-Duct, Variable-Air-Volume Terminal Air Units:

1. Occupancy:

a. Input:

1) Device: Occupancy sensor.
2) Location: Space.
3) Transference: DDC controller.

b. Output:

1) Device: DDC controller.

c. Action: Report occupancy and enable occupied temperature set point.

1) Occupied Temperature: 75 deg F.
2) Unoccupied Temperature: 65 deg F.

2. Space Temperature:

a. Input:

1) Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
2) Location: Space.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Damper actuator(s).
3) Transference: Dampers.

c. Action: Modulate dampers to maintain the following space temperature set points:

1) Occupied Cooling Temperature: 75 deg F.
2) Occupied Heating Temperature: 70 deg F.
3) Unoccupied Cooling Temperature: 85 deg F.
4) Unoccupied Heating Temperature: 65 deg F.

5) When occupied space temperature is below set point, close cold-deck damper to minimum position and open hot-deck damper.
6) When occupied space temperature is above set point, close hot-deck damper to minimum position and open cold-deck damper.

R. Sequence Control:

1. Space Temperature:

a. Input:

1) Device: Air-temperature sensor or air-temperature sensor with air-temperature RTD transmitter.
2) Location: Space.
3) Transference: DDC controller.

b. Output:

1) Device: Analog output.
2) Location: Control damper and valve actuators.
3) Input Transference: Control dampers and valves.

c. Action: Modulate valves and dampers to maintain the following space temperature set points:

1) Occupied Cooling Temperature: 75 deg F.
2) Occupied Heating Temperature: 70 deg F.
3) Unoccupied Cooling Temperature: 85 deg F.
4) Unoccupied Heating Temperature: 65 deg F.
5) Modulate damper actuator from open to minimum position.
6) When damper is at minimum position, modulate finned-tube radiation valve from closed to fully open.
7) When finned-tube radiation valve is fully open, modulate reheat coil valve from closed to fully open.
8) If occupied space temperature is not maintained with both valves open, modulate damper actuator from minimum position to 100 percent open.
9) Reverse the sequence for full heating to full cooling.

S. Indicate the following on the operator's workstation display terminal:

1. DDC system graphic.
2. DDC system on-off indication (operating or not operating).
3. DDC system occupied/unoccupied mode.
4. Outdoor-air-temperature indication.
5. Cabinet Unit Heater, Hydronic:

a. Space temperature indication.
b. Space temperature set point.
c. Fan on.

6. Unit Heater, Hydronic:

    a. Space temperature indication.
    b. Space temperature set point.
    c. Fan on.

7. Combustion-Air Unit Heaters:

    a. Space temperature indication.
    b. Space temperature set point.
    c. Control-valve position.

8. Radiant Heating Panel, Hydronic:

    a. Space temperature indication.
    b. Space temperature set point.
    c. Control-valve position.

9. Two-Pipe, Single-Coil, Fan-Coil Unit:

    a. Space temperature indication.
    b. Space temperature set point.
    c. Control-valve position.
    d. Supply-water temperature indication.

10. Four-Pipe, Hydronic Fan-Coil Unit:

    a. Space temperature indication.
    b. Space temperature set point.
    c. Control-valve position.

11. Unit Ventilator:

    a. DDC system on-off indication (operating or not operating).
    b. Space temperature indication.
    c. Space temperature set point.
    d. Control-valve position.
    e. Damper position.

12. Heating Coils, Hydronic:

    a. Space temperature indication.
    b. Space temperature set point.
    c. Control-valve position.

13. Radiators and Convectors, Hydronic:

    a. Space/area served.
    b. Space temperature indication.
    c. Space temperature set point.

d. Space temperature set point, occupied.
e. Space temperature set point, occupied standby.
f. Space temperature set point, unoccupied.
g. Control-valve position as percentage open.

14. Constant-Volume, Terminal Air Units, Hydronic:

a. Space/area served.
b. Space occupied/unoccupied.
c. Space temperature indication.
d. Space temperature set point, occupied.
e. Space temperature set point, unoccupied.
f. Control-valve position as percentage open.

15. Variable-Air-Volume Terminal Air Units with Hydronic Coils:

a. Space/area served.
b. Space occupied/unoccupied.
c. Space temperature indication.
d. Space temperature set point.
e. Space cooling and heating temperature set point, occupied.
f. Space cooling and heating temperature set point, unoccupied.
g. Air-damper position as percentage open.
h. Control-valve position as percentage open.

16. Dual-Duct, Variable-Air-Volume Terminal Air Units:

a. Space/area served.
b. Space occupied/unoccupied.
c. Occupied space temperature indication.
d. Occupied space temperature set point, occupied.
e. Occupied space temperature set point, unoccupied.
f. Hot-deck damper position as percentage open.
g. Cold-deck damper position as percentage open.

17. Sequence Control:

a. Space/area served.
b. Space occupied/unoccupied.
c. Space temperature indication.
d. Space temperature set point, occupied.
e. Space temperature set point, unoccupied.
f. Damper position as percentage open.
g. Control-valve positions as percentage open.

1.9 VENTILATION SEQUENCES

A. Combustion-Air, Makeup Unit Control, Electric:

1. Initiation:

   a. Input:

      1) Device: Auxiliary contact.
      2) Location: Served appliance.

   b. Output:

      1) Device: Hard wired.
      2) Location: Served appliance.
      3) Transference: Starter relay and electric solenoid.

   c. Action: Start fan when appliance burner starts.

2. Space Temperature:

   a. Input:

      1) Device: Electronic multistage thermostat.
      2) Location: Space.

   b. Output:

      1) Device: Hard wired.
      2) Location: Unit control panel.
      3) Transference: Electric multistage contactors.

   c. Action: Sequence electric coil stages to maintain 75 deg F space temperature.

B. Combustion-Air, Makeup Unit Control, Hydronic or Steam:

1. Initiation:

   a. Input:

      1) Device: Auxiliary contact.
      2) Location: Served appliance.

   b. Output:

      1) Device: Hard wired.
      2) Location: Motor controller.
      3) Transference: Starter relay and electric solenoid.

   c. Action: Start fan when appliance burner starts.

2. Space Temperature:

   a. Input:

1) Device: Electronic thermostat.
2) Location: Space.

b. Output:

1) Device: Hard wired.
2) Location: Control valve.
3) Transference: Valve actuator.

c. Action: Modulate control valve to maintain 75 deg F space temperature set point.

C. Gravity Roof Ventilator:

1. Input:

a. Device: Occupancy sensor or Electric thermostat.
b. Location: Space.

2. Output:

a. Device: Hard wired.
b. Location: Control damper.
c. Transference: Damper actuator.

3. Action: Open control damper when space is occupied or temperature rises above set point.

D. Exhaust Fan: Occupancy sensor, Light switch or Room thermostat.

1. Input:

a. Device: Occupancy sensor, Light switch or Electric thermostat.
b. Location: Space.

2. Output:

a. Device: Hard wired.
b. Location: Motor controller.
c. Transference: Starter relay.

3. Action: Cycle fan on when space is occupied, lights are turned on or space temperature rises above set point.

E. Kitchen Exhaust Fan: Occupancy sensor.

1. Input:

a. Device: Occupancy sensor.
b. Location: Space.

2. Output:

a. Device: Hard wired.
b. Location: Motor controller.
c. Transference: Starter relay.

3. Action: Start fan and energize makeup air unit when space is occupied.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230993.11

SECTION 232113 - HYDRONIC PIPING

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. Copper tube and fittings.
2. Steel pipe and fittings.
3. Plastic pipe and fittings.
4. Fiberglass pipe and fittings.
5. Joining materials.
6. Transition fittings.
7. Dielectric fittings.
8. Bypass chemical feeder.

1.3 ACTION SUBMITTALS

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

1. Pipe and tube.
2. Fittings.
3. Joining materials.
4. Transition fittings.
5. Bypass chemical feeder.

B. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.

E. Preconstruction Test Reports:

1. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
2. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP shall be certified by manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.

B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

1.6 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on water quality.

1.7 WARRANTY

A. PP-R Manufacturer's Warranty: Manufacturer agrees to repair or replace PP-R pipe and fittings that fail in materials or workmanship within 10 years from date of Substantial Completion.

1. Warranty is to cover labor and material costs of repairing and/or replacing defective materials and repairing any incidental damage caused by failure of the piping system due to defects in materials or manufacturing.
2. Warranty is to be in effect only upon submission by the Contractor to the manufacturer of valid pressure/leak documentation indicating that the system was tested and passed the manufacturer's pressure/leak test.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Hot-Water Heating Piping: 100 psig psig at 200 deg F .
2. Chilled-Water Piping: 150 psig psig at 73 deg F .
3. Dual-Temperature Heating and Cooling Water Piping: 100 psig at 180 deg F .
4. Condenser-Water Piping: 150 psig at 73 deg F .
5. Glycol Cooling-Water Piping: 150 psig at 150 deg F .
6. Makeup-Water Piping: 150 psig at 73 deg F .
7. Condensate-Drain Piping: 180 deg F .
8. Blowdown-Drain Piping: 200 deg F .
9. Air-Vent Piping: 200 deg F .
10. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tube: ASTM B88, Type K ASTM B88, Type L and ASTM B88, Type M if specified on drawings.

B. Annealed-Temper Copper Tube: ASTM B88, Type K ASTM B88, Type L and ASTM B88, Type M if specified on drawings.

C. DWV Copper Tube: ASTM B306, Type DWV.

D. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

E. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, pressure fittings.

F. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

G. Cast Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.

H. Wrought Copper Unions: ASME B16.22.

I. Copper-Tube, Mechanically Formed Tee Fitting: For forming T-branch on copper water tube.

1.
2. Description: Tee formed in copper tube in accordance with ASTM F2014.

J. Grooved, Mechanical-Joint, Copper Tube Appurtenances:

1.
2. Grooved-End Copper Fittings: ASTM B75, copper tube or ASTM B584, bronze castings.
3. Grooved-End-Tube Couplings: To fit copper-tube dimensions; rigid pattern unless otherwise indicated; gasketed fitting EPDM-rubber gasket rated for minimum 230 deg F for use with ferrous housing, and steel bolts and nuts; 300 psig minimum CWP pressure rating.

K. Copper-Tube, Pressure-Seal-Joint Fittings:

1.
2. Fittings: Cast-brass, cast-bronze, or wrought-copper with EPDM O-ring seal in each end.
3. Minimum 200-psig working-pressure rating at 250 deg F.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A234/A234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Grooved Mechanical-Joint Fittings and Couplings:

1.

2. Joint Fittings: ASTM A536, Grade 65-45-12 ductile iron; ASTM A47/A47M, Grade 32510 malleable iron; ASTM A53/A53M, Type F, E, or S, Grade B fabricated steel; or ASTM A106/A106M, 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.
3. 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.

I. Plain-End Mechanical-Joint Couplings:

1.
2. Housing: ASTM A536 Grade 65-45-12 segmented ductile iron or type 304 stainless steel.
3. Housing coating: None.
4. Gasket: EPDM or NBR.
5. Sealing Mechanism: Double-lip sealing system or carbon steel case-hardened jaws.
6. Bolts, hex nuts, washers, or lock bars based on manufacturer's design.
7. Minimum Pressure Rating: Equal to that of the joined pipes.

J. Steel Pressure-Seal Fittings:

1.
2. Housing: Steel.
3. O-Rings and Pipe Stop: EPDM.
4. Tools: Manufacturer's special tool.
5. Minimum 300-psig working-pressure rating at 230 deg F.

K. Steel Pipe Nipples: ASTM A733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 PLASTIC PIPE AND FITTINGS

A. CPVC Plastic Pipe: ASTM F441/F441M, with wall thickness as indicated in "Piping Applications" Article.

1.
2. CPVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F438 for Schedule 40 pipe; ASTM F439 for Schedule 80 pipe.

B. PVC Plastic Pipe: ASTM D1785, with wall thickness as indicated in "Piping Applications" Article.

1.
2. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D2466 for Schedule 40 pipe; ASTM D2467 for Schedule 80 pipe.

C. Polypropylene (PP-R) Pipe:

1.

D. Polypropylene Pipe: ASTM F2389, pipe pressure rating to comply with temperature and pressure ratings of code requirements for the applicable service.

1. Polypropylene Fittings: ASTM F2389, socket fusion, butt fusion, electrofusion, or fusion outlet fittings to be used for fusion-welded joints between pipe and fittings.
2. Mechanical fittings and transition fittings to be used where transitions are made to other piping materials or to valves and appurtenances.
3. Polypropylene pipe is to be unthreaded. Threaded transition fittings per ASTM F2389 to be used where a threaded connection is required.

E. Smoke and Fire Ratings:

1. Where indicated on the Drawings that a plenum-rated piping system is required, the pipe is to be wrapped and/or insulated with fiberglass or mineral wool pipe insulation, field installed.

a. The system is to have a flame spread classification of less than 25 and smoke development rating of less than 50.
b. Pipe, wrap, or insulation as a system to meet the requirements of CAN/ULC-S102.2-03, ASTM E84 or UL 2846.
c. For insulation required for thermal and condensation reasons, see Section 230719 "HVAC Piping Insulation."

2.5 FIBERGLASS PIPE AND FITTINGS

A. RTRP: ASTM D2996, filament-wound pipe with tapered bell and spigot ends for adhesive joints.

B. RTRF: Compression or spray-up/contact molded of same material, pressure class, and joining method as pipe.

C. Flanges: ASTM D4024. Full-face gaskets suitable for the service, minimum 1/8-inch thick, 60-70 durometer. ASTM A307, Grade B, hex head bolts with washers.

2.6 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

D. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

F. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. Solvent Cements for CPVC Piping: ASTM F493.

H. Solvent Cements for PVC Piping: ASTM D2564. Include primer according to ASTM F656.

I. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.7 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings:

1.
2. One-piece fitting with one threaded brass or copper insert and one solvent-cement-joint end of material and wall thickness to match plastic pipe material.

B. Plastic-to-Metal Transition Unions:

1.
2. Brass or copper end, solvent-cement-joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

2.8 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1.
2. Description:

a. Standard: ASSE 1079.
b. Pressure Rating: 125 psig minimum at 180 deg F.
c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1.

2. Description:

a. Standard: ASSE 1079.
b. Factory-fabricated, bolted, companion-flange assembly.
c. Pressure Rating: 125 psig minimum at 180 deg F.
d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1.
2. Description:

a. Nonconducting materials for field assembly of companion flanges.
b. Pressure Rating: 150 psig .
c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

1.
2. Description:

a. Standard: IAPMO PS 66.
b. Electroplated steel nipple, complying with ASTM F1545.
c. Pressure Rating: 300 psig at 225 deg F.
d. End Connections: Male threaded or grooved.
e. Lining: Inert and noncorrosive, propylene.

2.9 BYPASS CHEMICAL FEEDER

A. Description: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.

1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be any of the following:

1. Type L Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed or pressure-seal joints.

2. Schedule 40, Grade B steel pipe; Class 125, cast-iron, Class 150, malleable-iron , Class 250, cast-iron or Class 300, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
3. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
4. Schedule 40 or Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints.

B. Hot-water heating piping, aboveground, NPS 2-1/2 and larger pipe, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
4. Schedule 40 steel pipe, plain-end mechanical-coupled joints.
5. Schedule 40 or Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints.
6. RTRP and RTRF with adhesive or flanged joints.

C. Hot-water heating piping installed belowground and within slabs shall be either of the following:

1. Type K, drawn- annealed-temper copper tubing, wrought-copper fittings, and soldered or brazed joints. Use the fewest possible joints.
2. RTRP and RTRF with adhesive or flanged joints.

D. Chilled-water piping, aboveground, NPS 2 and smaller pipe size, shall be any of the following:

1. Type L or Type M if specified on drawings, drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed or pressure-seal joints.
2. Schedule 40 steel pipe; Class 125, cast-iron, Class 150, malleable-iron , Class 250, cast-iron or Class 300, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
3. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
4. Schedule 40 or Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints.

E. Chilled-water piping, aboveground, NPS 2-1/2 and larger pipe, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
4. Schedule 40 steel pipe, plain-end mechanical-coupled joints.
5. Schedule 40 or Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints.
6. RTRP and RTRF with adhesive or flanged joints.

F. Chilled-water piping installed belowground and within slabs shall be either of the following:

1. Type K, drawn or annealed-temper copper tubing, wrought-copper fittings, and soldered or brazed joints. Use the fewest possible joints.
2. RTRP and RTRF with adhesive or flanged joints.

G. Dual-temperature heating and cooling water piping, aboveground, NPS 2 and smaller pipe size, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered brazed pressure-seal joints.
2. Schedule 40 Schedule 30 Schedule 20 steel pipe; Class 125, cast-iron Class 150, malleable-iron Class 250, cast-iron Class 300, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
3. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
4. Schedule 40 Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints.

H. Dual-temperature heating and cooling water piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
4. Schedule 40 steel pipe, plain-end mechanical-coupled joints.
5. Schedule 40 or Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints.
6. RTRP and RTRF with adhesive or flanged joints.

I. Dual-temperature heating and cooling water piping installed belowground and within slabs shall be either of the following:

1. Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered brazed joints. Use the fewest possible joints.
2. RTRP and RTRF with adhesive or flanged joints.

J. Condenser-water piping, aboveground, NPS 2 and smaller pipe size, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered brazed pressure-seal joints.
2. Schedule 80 or Schedule 40 steel pipe; Class 125, cast-iron, Class 150, malleable-iron, Class 250, cast-iron or Class 300, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
3. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
4. Schedule 40 or Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints.
5. PP-R plastic piping and fittings with heat fusion joints.

K. Condenser-water piping, aboveground, NPS 2-1/2 and larger pipe size, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
2. Schedule 80 or Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
3. Schedule 80 Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
4. Schedule 40 schedule steel pipe, plain-end mechanical-coupled joints.
5. Schedule 40 or Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints.
6. RTRP and RTRF with adhesive or flanged joints.
7. PP piping and fittings with heat fusion joints.

L. Condenser-water piping installed belowground and within slabs shall be either of the following:

1. Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered brazed joints. Use the fewest possible joints.
2. RTRP and RTRF with adhesive or flanged joints.
3. PP piping and fittings with heat fusion joints.

M. Glycol cooling-water piping, aboveground, NPS 2 and smaller pipe size, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed or pressure-seal joints.
2. Schedule 40 steel pipe; Class 125, cast-iron, Class 150, malleable-iron, Class 250, cast-iron or Class 300, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
3. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
4. Schedule 40 or Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints.

N. Glycol cooling-water piping, aboveground, NPS 2-1/2 and larger pipe size, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
4. Schedule 40 schedule steel pipe, plain-end mechanical-coupled joints.
5. Schedule 40 or Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints.
6. RTRP and RTRF with adhesive or flanged joints.

O. Glycol cooling-water piping installed belowground and within slabs shall be either of the following:

1. Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered or brazed joints. Use the fewest possible joints.
2. RTRP and RTRF with adhesive or flanged joints.

P. Makeup-water piping installed aboveground shall be either of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
2. Schedule 40 or Schedule 80 CPVC plastic pipe and fittings, and solvent-welded joints.

Q. Makeup-Water Piping Installed Belowground and within Slabs: Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.

R. Condensate-Drain Piping, Copper: Type M Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints or Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.

S. Condensate-Drain Piping, PVC: Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.

T. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

U. Air-Vent Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

V. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

3.2 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.3 INSTALLATION OF PIPING

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to the following:

1. Section 230523.11 "Globe Valves for HVAC Piping."
2. Section 230523.12 "Ball Valves for HVAC Piping."
3. Section 230523.13 "Butterfly Valves for HVAC Piping."
4. Section 230523.14 "Check Valves for HVAC Piping."
5. Section 230523.15 "Gate Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 pipe size and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 pipe size and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

U. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

H. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
2. CPVC Piping: Join according to ASTM D2846/D2846M Appendix.
3. PVC Pressure Piping: Join ASTM D1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D2855.
4. PVC Nonpressure Piping: Join according to ASTM D2855.

I. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

J. Grooved Joints: 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.

K. Plain-End Mechanical-Coupled Joints: Prepare, assemble, and test joints in accordance with manufacturer's written installation instructions.

L. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tools and procedure, and brazed joints.

M. Pressure-Sealed Joints: Use manufacturer-recommended tools and procedure. Leave insertion marks on pipe after assembly.

3.5 INSTALLATION OF DIELECTRIC FITTINGS

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 pipe size and Smaller: Use dielectric nipples or unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4 pipe size range: Use dielectric flanges, flange kits or nipples.

D. Dielectric Fittings for NPS 5 pipe size and Larger: Use dielectric flange kits.

3.6 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.

1. .

C. Install hangers for copper tubing and steel piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Install hangers for plastic piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Install hangers for fiberglass piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

F. Support horizontal piping within 12 inches dimension of each fitting and coupling.

G. Support vertical runs of copper tubing and steel piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

H. Support vertical runs of CPVC, PVC and PP-R piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

I. Support vertical runs of fiberglass piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gauges and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."

3.8 CHEMICAL TREATMENT

A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:

1. pH: 9.0 to 10.5 values.
2. "P" Alkalinity: 100 to 500 values ppm.
3. Boron: 100 to 200 values ppm.
4. Chemical Oxygen Demand: Maximum of 100 value ppm. Revise this value if closed system contains glycol.
5. Corrosion Inhibitor:

    a. Sodium Nitrate: 1000 to 1500 values ppm.
    b. Molybdate: 200 to 300 values ppm.
    c. Chromate: 200 to 300 values ppm.
    d. Sodium Nitrate Plus Molybdate: 100 to 200 values ppm each.
    e. Chromate Plus Molybdate: 50 to 100 values ppm each.

6. Soluble Copper: Maximum of 0.20 value ppm.
7. Tolyiriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum of 10 value ppm.
8. Total Suspended Solids: Maximum of 10 value ppm.

9. Ammonia: Maximum of 20 value ppm.
10. Free Caustic Alkalinity: Maximum of 20 value ppm.
11. Microbiological Limits:
    a. Total Aerobic Plate Count: Maximum of 1000 number organisms/mL.
    b. Total Anaerobic Plate Count: Maximum of 100 number organisms/mL.
    c. Nitrate Reducers: 100 number organisms/mL.
    d. Sulfate Reducers: Maximum of zero number organisms/mL.
    e. Iron Bacteria: Maximum of zero number organisms/mL.

B. Install bypass chemical feeders in each hydronic system where indicated.

1. Install in upright position with top of funnel not more than 48 inches above the floor.
2. Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections.
3. Install NPS 3/4 pipe from chemical feeder drain to nearest equipment drain and include a full-size, full-port, ball valve.

C. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

D. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

E. Fill systems that have antifreeze or glycol solutions with the following concentrations:

1. Hot-Water Heating Piping: Minimum of 30 percent propylene glycol.
2. Chilled-Water Piping: Minimum of 30 percent propylene glycol.
3. Dual-Temperature Heating and Cooling Water Piping: Minimum of 30 percent propylene glycol.
4. Glycol Cooling-Water Piping: Minimum of 30 percent propylene glycol.

3.9 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 230553 "Identification for HVAC Piping and Equipment."

3.10 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.

4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 232113

SECTION 232116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hydronic specialty valves.
2. Air vents.
3. Expansion tanks and fittings.
4. Air/dirt separators and purgers.
5. Strainers.
6. Flexible connectors.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product:

1. Include construction details and material descriptions for hydronic piping specialties.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For hydronic piping specialties to include in emergency, operation, and maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.5 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators in accordance with ASME BPVC, Section IX.

B. Pressure-relief and safety-relief valves and pressure vessels bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME BPVC, Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

A. Bronze, Calibrated-Orifice, Balancing Valves:

1.
2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig.
10. Maximum Operating Temperature: 250 deg F.

B. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1.
2. Body: Cast-iron or steel body, ball, butterfly, plug, or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass- and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. CWP Rating: Minimum 125 psig.
11. Maximum Operating Temperature: 250 deg F.

C. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.

1.
2. Body: Bronze or brass.
3. Disc: Brass or EPDM.
4. Seat: Brass or Steel.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPDM.
7. Low inlet-pressure check valve.
8. Inlet Strainer: removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size and Capacity: As indicated on Drawings.
11. Operating Pressure: Factory set and field adjustable.

D. Diaphragm-Operated Pressure-Relief Valves: ASME labeled.

1.

2. Body: Bronze or brass.
3. Disc: Brass or Steel.
4. Seat: Brass or Steel.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPDM.
7. Valve Seat and Stem: Noncorrosive.
8. Valve Size, Capacity, and Operating Pressure: Comply with ASME BPVC, Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

E. Automatic Flow-Control Valves:

1.
2. Body: Brass or ferrous metal.
3. Combination Assemblies: Include bronze or brass-alloy ball valve.
4. Identification Tag: Marked with zone identification, valve number, and flow rate.
5. Size and Capacity: For each application, provide a valve with rated capacity equal to or greater than capacity of device being served.
6. Performance: Maintain constant flow within plus or minus 10 percent, regardless of system pressure fluctuations.
7. Minimum CWP Rating: 175 psig.
8. Maximum Operating Temperature: 250 deg F.

2.2 AIR VENTS

A. Manual Air Vents:

1.
2. Body: Bronze.
3. Internal Parts: Nonferrous.
4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/8.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 225 deg F.

B. Automatic Air Vents:

1.
2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/4.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 240 deg F.

2.3 EXPANSION TANKS AND FITTINGS

A. Expansion Tanks with Direct Air/Water Interface:

1.
2. Tank: Welded steel, rated for 125 psig working pressure and 375 deg F maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gauge glass. Tanks are factory tested after taps are fabricated and labeled in accordance with ASME BPVC, Section VIII, Division 1.
3. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless steel ball check, 100 gal. unit only; sized for expansion tank diameter. Provide tank fittings for 125 psig working pressure and 250 deg F maximum operating temperature.
4. Tank Drain Fitting: Brass body, nonferrous internal parts; 125 psig working pressure and 240 deg F maximum operating temperature; constructed to admit air to expansion tank, drain water, and close off system.
5. Gauge Glass: Full height with dual manual shutoff valves, 3/4-inch- diameter gauge glass, and slotted-metal glass guard.

B. Diaphragm-Type ASME Expansion Tanks:

1.
2. Tank: Welded steel, rated for 125 psig working pressure and 375 deg F maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled in accordance with ASME BPVC, Section VIII, Division 1.
3. Diaphragm: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
4. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

C. Bladder-Type ASME Expansion Tanks:

1.
2. Tank: Welded steel, rated for 125 psig working pressure and 375 deg F maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled in accordance with ASME BPVC, Section VIII, Division 1.
3. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity. Field-replaceable bladder.
4. Sight glass.
5. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

D. Diaphragm-Type Non-ASME Expansion Tanks:

1.
2. Tank: Carbon steel, non-ASME constructed, rated for minimum 100 psig working pressure at minimum 200 deg F maximum operating temperature.
3. Diaphragm: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
4. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

2.4 AIR/DIRT SEPARATORS AND PURGERS

A. Coalescing-Type Air and Dirt Separators:

1.
2. Tank: Fabricated steel tank; ASME constructed and stamped for 125 psig working pressure and 270 deg F maximum operating temperature.
3. Coalescing Medium: Copper or Stainless steel.
4. Air Vent: Threaded to top of separator.
5. Inline Inlet and Outlet Connections: Threaded for NPS 2 (DN 50) and smaller; Class 150 flanged connections for NPS 2-1/2 and larger.
6. Blowdown Connection: Threaded to bottom of separator.
7. Size: Match system flow capacity.

B. Tangential-Type Air Separators:

1.
2. Tank: Welded steel; ASME constructed and labeled for 125 psig minimum working pressure and 375 deg F maximum operating temperature.
3. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
4. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
5. Blowdown Connection: Threaded.
6. Size: Match system flow capacity.

C. In-Line Air Separators:

1.
2. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
3. Maximum Working Pressure: Up to 175 psig.
4. Maximum Operating Temperature: Up to 300 deg F.

D. Air Purgers:

1.
2. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
3. Maximum Working Pressure: 150 psig.
4. Maximum Operating Temperature: 250 deg F.

2.5 STRAINERS

A. Y-Pattern Strainers:

1.
2. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.

3. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
4. Strainer Screen: Stainless steel.
5. CWP Rating: 125 psig.

B. Basket Strainers:

1.
2. Body: ASTM A126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
3. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
4. Strainer Screen: stainless steel.
5. CWP Rating: 125 psig.

C. T-Pattern Strainers:

1.
2. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
3. End Connections: Grooved ends.
4. Strainer Screen: stainless steel.
5. CWP Rating: 750 psig.

2.6 FLEXIBLE CONNECTORS

A. Stainless Steel Bellows, Flexible Connectors:

1.
2. Body: Stainless steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
3. End Connections: Threaded or flanged to match equipment connected.
4. Performance: Capable of 3/4-inch misalignment.
5. CWP Rating: 150 psig.
6. Maximum Operating Temperature: 250 deg F.

B. Spherical, Rubber, Flexible Connectors:

1.
2. Body: Fiber-reinforced rubber body.
3. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
4. Performance: Capable of misalignment.
5. CWP Rating: 150 psig.
6. Maximum Operating Temperature: 250 deg F.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine all piping specialties for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Examine threads on all devices for form and cleanliness.

C. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

D. Do not attempt to repair defective piping specialties; replace with new devices. Remove defective piping specialties from site.

3.2 INSTALLATION OF VALVES

A. Install calibrated-orifice balancing valve at each branch connection to return main.

B. Install calibrated-orifice, balancing valve in the return pipe of each heating or cooling terminal.

C. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

D. Install pressure-relief and safety-relief valves at hot-water generators and elsewhere as required by ASME BPVC. Pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME BPVC, Section VIII, Division 1, for installation requirements.

3.3 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install automatic air vents at high points of system piping in mechanical equipment rooms only.

1. Provide air outlet drain line full size of air outlet to floor drain or to other point indicated on Drawings.

C. Install manual vents at heat-transfer coils and elsewhere as required for air venting.

D. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.

E. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve full size of separator outlet; extend full size to nearest floor drain.

F. Install expansion tanks having direct air/water interface above the air separator or air purger. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.

1. Install tank fittings that are shipped loose.
2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, and fittings, plus tank full of water. Do not overload building components and structural members.
3. Install piping from air separator or air purger to expansion tank with a 2 percent upward slope toward tank to avoid air entrapment.

G. Install diaphragm- or bladder-type expansion tanks on the floor.

H. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION 232116

SECTION 232213 - STEAM AND CONDENSATE PIPING

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. Steel pipe and fittings.
2. Stainless steel pipe and fittings.
3. Fiberglass pipe and fittings.
4. Joining materials.

1.3 ACTION SUBMITTALS

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

1. Steel pipe and fittings.
2. Stainless steel pipe and fittings.
3. Fiberglass pipe and fittings.
4. Joining materials.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Other building services.
3. Structural members.

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

1. Fiberglass Pipe and Fitting Installers: Installers of fiberglass pipe and fittings shall be certified by the manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.

B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Pipe Welding: Qualify procedures and operators according to the following:

1. ASME Compliance: Comply with ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black steel, plain ends, welded and seamless, Grade B, and Schedule as indicated in piping applications articles.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125, 150, and 300 as indicated in piping applications articles.

C. Malleable-Iron Threaded Fittings: ASME B16.3; Classes 150 and 300 as indicated in piping applications articles.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in piping applications articles.

E. Cast-Iron Threaded Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250 as indicated in piping applications articles; raised ground face, and bolt holes spot faced.

F. Wrought-Steel Fittings: ASTM A234/A234M, wall thickness to match adjoining pipe.

G. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M, black steel of same Type, Grade, and Schedule as pipe in which installed.

2.2 STAINLESS STEEL PIPE AND FITTINGS

A. Stainless Steel Pipe: ASTM A312/A312M, plain ends, seamless; stainless steel of types and schedules as indicated in piping application articles.

B. Stainless Steel Socket Weld Fittings: Stainless steel, wrought or forged, of types and classes as indicated in piping application articles.

C. Stainless Steel Flanges and Flanged Fittings: ASME B16.5, Class 150, wrought, raised face weld neck, including gaskets, bolts, and nuts of material to match pipe.

2.3 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.

a. Full-Face Type: For flat-face flanges.
b. Narrow-Face Type: For raised-face flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel or stainless steel of type to match pipe unless otherwise indicated.

C. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

D. Welding Materials: Comply with Section II, Part C, of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

E. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

PART 3 - EXECUTION

3.1 LP STEAM PIPING APPLICATIONS

A. LP Steam Piping, NPS 2 and Smaller: Schedule 40 or Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

B. LP Steam Piping, NPS 2-1/2 through NPS 12: Schedule 40 or Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

C. LP Steam Piping, NPS 14 through NPS 18: Schedule 30, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

D. LP Steam Piping, NPS 20 and Larger: Schedule 20, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

E. Condensate piping above grade, NPS 2 and smaller, shall be either of the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
2. RTRP and Glass-Fiber-Reinforced Thermosetting-Resin pipe with adhesive or flanged joints.

F. Condensate piping above grade, NPS 2-1/2 and larger, shall be either of the following:

1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
2. RTRP and Glass-Fiber-Reinforced Thermosetting-Resin pipe with adhesive or flanged joints.

G. Condensate piping below grade, NPS 2 and smaller, shall be either of the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
2. RTRP and Glass-Fiber-Reinforced Thermosetting-Resin pipe with adhesive or flanged joints.

H. Condensate piping below grade, NPS 2-1/2 and larger, shall be either of the following:

1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
2. RTRP and Glass-Fiber-Reinforced Thermosetting-Resin pipe with adhesive or flanged joints.

I. LP Clean Steam Piping:

1. LP clean steam piping above grade, NPS 2 and smaller, to be the following:

   a. Schedule 40 or Schedule 80, Type 304 or Type 316 stainless steel pipe; wrought or forged, Class 2000 or Class 3000, same type stainless steel socket weld fittings.

2. LP clean steam piping above grade, NPS 2-1/2 and larger, to be the following:

   a. Schedule 40 or Schedule 80, Type 304 or Type 316 stainless steel pipe; same type stainless steel flanges and wrought stainless steel flanged fittings.

J. Clean Steam Condensate Piping:

1. Clean steam condensate piping above grade, NPS 2 and smaller, to be the following:

   a. Schedule 40 or Schedule 80, Type 304 or Type 316 stainless steel pipe; wrought or forged Class 2000 or Class 3000 same type stainless steel socket weld fittings.

2. Clean steam condensate piping above grade, NPS 2-1/2 and larger, to be the following:

   a. Schedule 40 or Schedule 80, Type 304 or Type 316 stainless steel pipe; same type stainless steel flanges and wrought stainless steel flanged fittings.

3.2 HP STEAM PIPING APPLICATIONS

A. HP Steam Piping, NPS 2 and Smaller: Schedule 40 or Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

B. HP Steam Piping, NPS 2-1/2 through NPS 12: Schedule 40 or Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

C. HP Steam Piping, NPS 14 through NPS 18: Schedule 30, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

D. HP Steam Piping, NPS 20 and Larger: Schedule 20, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

E. Condensate piping above grade, NPS 2 and smaller, shall be either of the following:

   1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
   2. RTRP and Glass-Fiber-Reinforced Thermosetting-Resin pipe with adhesive or flanged joints.

F. Condensate piping above grade, NPS 2-1/2 and larger, shall be either of the following:

   1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
   2. RTRP and Glass-Fiber-Reinforced Thermosetting-Resin pipe with adhesive or flanged joints.

G. Condensate piping below grade, NPS 2 and smaller, shall be either of the following:

   1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
   2. RTRP and Glass-Fiber-Reinforced Thermosetting-Resin pipe with adhesive or flanged joints.

H. Condensate piping below grade, NPS 2-1/2 and larger, shall be either of the following:

   1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
   2. RTRP and Glass-Fiber-Reinforced Thermosetting-Resin pipe with adhesive or flanged joints.

3.3 ANCILLARY PIPING APPLICATIONS

A. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

B. Vacuum-Breaker Piping: Outlet, same as service where installed.

C. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.4 INSTALLATION OF PIPING

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless otherwise indicated.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Install piping to allow application of insulation.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

K. Install drains, consisting of a tee fitting, NPS 3/4 full port-ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

L. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.

M. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side down.

O. Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to top of main pipe.

P. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

Q. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

R. Install shutoff valve immediately upstream of each dielectric fitting.

S. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

T. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.

1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 300 feet.
2. Size drip legs same size as main. In steam mains NPS 6 and larger, drip leg size can be reduced, but to no less than NPS 4.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

A. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.

B. Install hangers for steel steam supply piping and steel steam condensate piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

C. Install hangers for fiberglass piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Support horizontal piping within 12 inches of each fitting.

E. Support vertical runs of steel steam supply piping and steel steam condensate piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

F. Support vertical runs of fiberglass piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

E. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install traps and control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install vacuum breakers downstream from control valve, close to coil inlet connection.

E. Install a drip leg at coil outlet.

3.8 FIELD QUALITY CONTROL

A. Prepare steam and condensate piping according to ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping," and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.

3. Flush system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

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

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

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

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.
3. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

E. Prepare test and inspection reports.

END OF SECTION 232213

SECTION 232216 - STEAM AND CONDENSATE HEATING PIPING SPECIALTIES

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. Strainers.
2. Flash tanks.
3. Stop-check valves.
4. Steam safety valves.
5. Pressure-reducing valves.
6. Steam traps.
7. Thermostatic air vents and vacuum breakers.
8. Flexible connectors.
9. Steam meters.
10. Condensate meters.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Strainer.
2. Flash tank.
3. Valve.
4. Steam trap.
5. Air vent and vacuum breaker.
6. Connector.
7. Meter.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, steam traps, air vents, vacuum breakers, and meters to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to the following:

1. ASME Compliance: Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 STRAINERS

A. Y-Pattern Strainers, Cast Iron:

1. Body: ASTM A126, Class B cast iron, with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
3. Strainer Screen: Stainless steel, 40-mesh strainer or perforated stainless-steel basket.
4. Tapped blowoff plug.
5. Rating: 250-psig working steam pressure.

B. Y-Pattern Strainers, Stainless Steel:

1. Body: ASTM A351 stainless steel, with bolted cover and bottom drain connection.
2. End Connections: Socket weld or Threaded for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
3. Strainer Screen: 1/16 inch perforations in stainless steel strainer screen.
4. Tapped blowoff plug.
5. Rating: Class 600 for socket weld or threaded; Class 150 or Class 300 for flanged.

C. Basket Strainers:

1. Body: ASTM A126, Class B cast iron, with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for strainers NPS 2 and smaller; flanged ends for strainers NPS 2-1/2 and larger.
3. Strainer Screen: Stainless steel, 20-mesh strainer and perforated stainless steel basket with 50 percent free area.
4. Rating: 250-psig working steam pressure.

2.2 FLASH TANKS

A. Shop or factory fabricated of welded steel according to ASME Boiler and Pressure Vessel Code for 150-psig rating, and bearing ASME label. Fabricate with tappings for low-pressure steam and condensate outlets, high-pressure condensate inlet, air vent, safety valve, and legs.

2.3 STOP-CHECK VALVES

A. Stop-Check Valves:

1. Body and Bonnet: Malleable iron.
2. End Connections: Flanged.
3. Disc: Cylindrical with removable liner and machined seat.
4. Stem: Brass alloy.
5. Operator: Outside screw and yoke with cast-iron handwheel.
6. Packing: PTFE-impregnated packing with two-piece packing gland assembly.
7. Pressure Class: 250.

2.4 STEAM SAFETY VALVES

A. Bronze or Brass Steam Safety Valves: ASME labeled.

1. Disc Material: Forged copper alloy.
2. End Connections: Threaded inlet and outlet.
3. Spring: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
4. Pressure Class: 250.
5. Drip-Pan Elbow: Cast iron and having threaded inlet and outlet, with threads complying with ASME B1.20.1.
6. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

B. Cast-Iron Steam Safety Valves: ASME labeled.

1. Disc Material: Forged copper alloy with bronze nozzle.
2. End Connections: Raised-face flanged inlet and threaded or flanged outlet connections.
3. Spring: Fully enclosed cadmium-plated steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
4. Pressure Class: 250.
5. Drip-Pan Elbow: Cast iron and having threaded inlet, outlet, and drain, with threads complying with ASME B1.20.1.
6. Exhaust Head: Cast iron and having threaded inlet and drain, with threads complying with ASME B1.20.1.
7. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

2.5 PRESSURE-REDUCING VALVES

A. ASME labeled.

B. Size, Capacity, and Pressure Rating: Factory set for inlet and outlet pressures indicated.

C. Description: Pilot-actuated diaphragm type, with adjustable pressure range and positive shutoff.

D. Body: Cast iron.

E. End Connections: Threaded connections for valves NPS 2 and smaller and flanged connections for valves NPS 2-1/2 and larger.

F. Trim: Hardened stainless steel.

G. Head and Seat: Replaceable, main head stem guide fitted with flushing and pressure-arresting device cover over pilot diaphragm.

H. Gaskets: Non-asbestos materials.

2.6 STEAM TRAPS

A. Thermostatic Steam Traps, Bronze:

1. Body: Bronze angle-pattern body with integral union tailpiece and screw-in cap.
2. Trap Type: Balanced pressure.
3. Bellows: Stainless steel or monel.
4. Head and Seat: Replaceable, hardened stainless steel.
5. Pressure Class: 125.

B. Thermostatic Steam Traps, Stainless Steel:

1. Body: Type 316L or Type 316 stainless steel.
2. Trap Type: Balanced pressure.
3. Bellows: Type 316L or Type 316 stainless steel.
4. Maximum Operating Pressure: At least 100 psig at saturated steam temperature.

C. Thermodynamic Steam Traps, Stainless Steel:

1. Body: stainless steel with screw-in cap.
2. End Connections: Threaded.
3. Disc and Seat: stainless steel.
4. Maximum Operating Pressure: 600 psig.

D. Float and Thermostatic Steam Traps, Cast Iron:

1. Body and Bolted Cap: ASTM A126 cast iron.
2. End Connections: Threaded.
3. Float Mechanism: Replaceable, stainless steel.
4. Seat: Hardened stainless steel.
5. Trap Type: Balanced pressure.

6. Thermostatic Bellows: Stainless steel or monel.
7. Thermostatic air vent capable of withstanding 45 deg F of superheat and resisting water hammer without sustaining damage.
8. Vacuum Breaker: Thermostatic with phosphor bronze bellows, and stainless steel cage, valve, and seat.
9. Maximum Operating Pressure: 125 psig.

E. Float and Thermostatic Steam Traps, Stainless Steel:
1. Body and Bolted Cover: stainless steel.
2. End Connections: Threaded.
3. Float Mechanism: stainless steel.
4. Seat: stainless steel.
5. Strainer: Integral, stainless steel, with blowdown valve.
6. Trap Type: Balanced pressure.
7. Thermostatic air vent.

F. Inverted Bucket Steam Traps, Cast Iron:

1. Body and Cap: Cast iron.
2. End Connections: Threaded.
3. Head and Seat: Stainless steel.
4. Valve Retainer, Lever, and Guide Pin Assembly: Stainless steel.
5. Bucket: Brass or stainless steel.
6. Strainer: Integral stainless steel inlet strainer within the trap body.
7. Air Vent: Stainless steel thermostatic vent.
8. Pressure Rating: 250 psig.

G. Inverted Bucket Steam Traps, Stainless Steel:

1. Body and Cap: stainless steel.
2. End Connections: Threaded.
3. Head and Seat: Stainless steel.
4. Valve Retainer, Lever, and Guide Pin Assembly: Stainless steel.
5. Bucket: Stainless steel.
6. Strainer: Integral stainless steel inlet strainer within the trap body.
7. Air Vent: Stainless steel thermostatic vent.
8. Pressure Rating: Minimum 200 psig at 450 deg F.

2.7 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS

A. Thermostatic Air Vents:

1. Body: Cast iron, bronze, or stainless steel.
2. End Connections: Threaded.
3. Float, Valve, and Seat: Stainless steel.
4. Thermostatic Element: Phosphor bronze bellows in a stainless steel cage.

5. Pressure Rating: 125 psig or 300 psig.
6. Maximum Temperature Rating: 350 deg F.

B. Vacuum Breakers:

1. Body: Cast iron, bronze, or stainless steel.
2. End Connections: Threaded.
3. Sealing Ball, Retainer, Spring, and Screen: Stainless steel.
4. O-Ring Seal: Ethylene propylene rubber.
5. Pressure Rating: 125 psig or 300 psig.
6. Maximum Temperature Rating: 350 deg F.

2.8 FLEXIBLE CONNECTORS

A. Stainless Steel Bellows, Flexible Connectors:

1. Body: Stainless steel bellows with woven, flexible, bronze, wire-reinforced, protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

2.9 STEAM METERS

A. Meters shall have a microprocessor to display totalizer flow, flow rate, temperature, pressure, time, and date; alarms for high and low flow rate and temperature.

1. Computer shall have 4- to 20-mA or 2- to 10-V output for temperature, pressure, and contact closure for flow increments.
2. Independent timers to store four peak flow rates and total flow.
3. Microprocessor Enclosure: NEMA 250, Type 4.

B. Sensor:

1. Venturi, of stainless steel or carbon steel construction, for insertion in pipeline between flanges. At least 10:1 turndown with plus or minus 1 percent accuracy over full-flow range.
2. Vortex type with stainless steel wetted parts and wafer or flange connections; and with a piezoelectric sensor removable and serviceable without shutting down the process. At least 10:1 turndown with plus or minus 1 percent accuracy over full-flow range.
3. Spring-loaded, variable-area flowmeter type; density compensated with stainless steel wetted parts and wafer or flange connections. At least 10:1 turndown with plus or minus 2 percent accuracy over full-flow range.

2.10 CONDENSATE METERS

A. Body: Cast iron, bronze, or brass.

B. Turbine: Copper, brass, or stainless steel.

C. Connections: Threaded for NPS 2 and smaller and flanged for NPS 2-1/2.

D. Totalizer: Meters shall have a microprocessor to display flow, flow rate, time, and date; alarms for high and low flow rate, pressure, and temperature.

1. Computer shall have 4- to 20-mA or 2- to 10-V output for temperature, pressure, and contact closure for flow increments.
2. Independent timers to store four peak flow rates and total flow.
3. Microprocessor Enclosure: NEMA 250, Type 4.

E. Pressure Rating: Atmospheric.

F. Maximum Temperature Rating: 250 deg F.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.

B. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

3.2 INSTALLATION OF PIPING

A. Install piping to permit valve servicing.

B. Install drains, consisting of a tee fitting, NPS 3/4 full-port ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

C. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment and elsewhere as indicated.

D. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

E. Install shutoff valve immediately upstream of each dielectric fitting.

F. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full-port ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

G. Flash Tank:

1. Pitch condensate piping down toward flash tank.
2. If more than one condensate pipe discharges into flash tank, install a check valve in each line.
3. Install thermostatic air vent at tank top.
4. Install safety valve at tank top.
5. Install full-port ball valve, and swing check valve on condensate outlet.
6. Install inverted bucket or float and thermostatic trap at low-pressure condensate outlet, sized for 3 times the calculated heat load.

3.3 INSTALLATION OF STEAM TRAPS

A. Install steam traps in accessible locations as close as possible to connected equipment.

B. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, and full-port ball valve downstream from trap unless otherwise indicated.

3.4 INSTALLATION OF PRESSURE-REDUCING VALVES

A. Install pressure-reducing valves in accessible location for maintenance and inspection.

B. Install bypass piping around pressure-reducing valves, with globe valve equal in size to area of pressure-reducing valve seat ring, unless otherwise indicated.

C. Install gate valves on both sides of pressure-reducing valves.

D. Install unions or flanges on both sides of pressure-reducing valves having threaded- or flanged-end connections, respectively.

E. Install strainers upstream for pressure-reducing valve.

F. Install safety valve downstream from pressure-reducing valve station.

3.5 INSTALLATION OF STEAM OR CONDENSATE METERS

A. Install meters with lengths of straight pipe upstream and downstream according to steam meter manufacturer's written instructions.

3.6 INSTALLATION OF SAFETY VALVES

A. Install safety valves according to ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping."

B. Pipe safety-valve discharge without valves to atmosphere outside the building.

C. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.

D. Install exhaust head with drain to waste, on vents equal to or larger than NPS 2-1/2.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Install traps and control valves in accessible locations close to connected equipment.

B. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

C. Install vacuum breakers downstream from control valve, close to coil inlet connection.

END OF SECTION 232216

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round and flat-oval ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.
7. Seismic-restraint devices.

B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233116 "Nonmetal Ducts" for fibrous-glass ducts, thermoset fiber-reinforced plastic ducts, thermoplastic ducts, PVC ducts, and concrete ducts.
3. Section 233119 "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
4. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 DEFINITIONS

A. OSHPD: Office of Statewide Health Planning and Development (State of California).

1.4 ACTION SUBMITTALS

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

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top and bottom of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

C. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports.

1.5 INFORMATIONAL SUBMITTALS

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

B. Welding certificates.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for duct joint and seam welding.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7.

C. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."

E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

F. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.
2. For ducts exposed to weather, construct of Type 304 or Type 316 stainless steel indicated by manufacturer to be suitable for outdoor installation.

B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.
3. Where specified for specific applications, all joints shall be welded.

C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." All longitudinal seams shall be Pittsburgh lock seams unless otherwise specified for specific application.

1. Where specified for specific applications, all joints shall be welded.

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.
2. For ducts exposed to weather, construct of Type 304 or Type 316 stainless steel indicated by manufacturer to be suitable for outdoor installation.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

C. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

E. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 SHEET METAL MATERIALS

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

B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G60, indoors and G90 outdoors.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G60.
2. Minimum Thickness for Factory-Applied PVC Coating: 4 mils thick on sheet metal surface of ducts and fittings exposed to corrosive conditions, and minimum 1 mil thick on opposite surface.
3. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.

D. Carbon-Steel Sheets: Comply with ASTM A1008/A1008M, with oiled, matte finish for exposed ducts.

E. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.

F. Aluminum Sheets: Comply with ASTM B209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

G. Factory- or Shop-Applied Antimicrobial Coating:

1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested in accordance with ASTM D3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
5. Shop-Applied Coating Color: Black or White.

6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

H. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

I. Tie Rods: Galvanized steel, 1/4-inch- minimum diameter for lengths 36 inches or less; 3/8-inch- minimum diameter for lengths longer than 36 inches.

2.5 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity:

a. Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
b. Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

2. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Solvent or Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C916.

B. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C534/C534M, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
2. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

C. Fiberglass-Free Duct Liner: Made from partially recycled cotton or polyester products and containing no fiberglass. Airstream surface overlaid with fire-resistant facing to prevent surface erosion by airstream, complying with NFPA 90A or NFPA 90B. Treat natural-fiber products with antimicrobial coating.

1. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature when tested in accordance with ASTM C518.
2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with ASTM E84; certified by an NRTL.
3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

D. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- or 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick galvanized steel, aluminum or stainless steel; with beveled edge sized as required to hold insulation securely in place, but not less than 1-1/2 inches in diameter.

E. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

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

   a. Fan discharges.
   b. Intervals of lined duct preceding unlined duct.
   c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.

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

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

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

2.6 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 3 inches, 4 inches or 6 inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
9. Service: Indoor or outdoor.
10. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C920.

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

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

G. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.7 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

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

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A492.

F. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.

B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

J. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.

K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

M. Elbows: Use long-radius elbows wherever they fit.

1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

N. Branch Connections: Use lateral or conical branch connections.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCTWORK EXPOSED TO WEATHER

A. All external joints are to have secure watertight mechanical connections. Seal all openings to provide weatherproof construction.

B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather. Provide necessary supporting structures.

C. Single Wall:

1. Ductwork shall be Type 304 or Type 316 stainless steel.
2. Ductwork shall be galvanized steel.

    a. If duct outer surface is uninsulated, protect outer surface with suitable paint. Paint materials and application requirements are specified in Section 099113 "Exterior Painting."

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

3.4 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.6 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 PAINTING

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

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

C. Duct system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.9 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. For cleaning of existing ductwork, see Section 230130.52 "Existing HVAC Air Distribution System Cleaning."

C. Use duct cleaning methodology as indicated in NADCA ACR.

D. Use service openings for entry and inspection.

1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and

liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

E. Particulate Collection and Odor Control:

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

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

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

G. Mechanical Cleaning Methodology:

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

3.10 STARTUP

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

3.11 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.
2. Underground Ducts: Concrete-encased, PVC-coated, galvanized sheet steel with thicker coating on duct exterior or stainless steel.

B. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

    a. Pressure Class: Positive 2 inch wg.
    b. Minimum SMACNA Seal Class: B.
    c. In compliance with IECC.
    d. SMACNA Leakage Class for Rectangular: 12.
    e. SMACNA Leakage Class for Round and Flat Oval: 6.

2. Ducts Connected to Constant-Volume Air-Handling Units:

    a. Pressure Class: Positive 2 inch wg.
    b. Minimum SMACNA Seal Class: B.
    c. In compliance with IECC.
    d. SMACNA Leakage Class for Rectangular: 12.
    e. SMACNA Leakage Class for Round and Flat Oval: 6.

3. Ducts Connected to Variable-Air-Volume Air-Handling Units:

    a. Pressure Class: Positive 3 inch wg.
    b. Minimum SMACNA Seal Class: B.
    c. In compliance with IECC.
    d. SMACNA Leakage Class for Rectangular: 12.
    e. SMACNA Leakage Class for Round and Flat Oval: 6.

4. Ducts Connected to Equipment Not Listed Above:

    a. Pressure Class: Positive 2 inch wg.
    b. Minimum SMACNA Seal Class: B.
    c. In compliance with IECC.
    d. SMACNA Leakage Class for Rectangular: 12.
    e. SMACNA Leakage Class for Round and Flat Oval: 6.

C. Return Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

   a. Pressure Class: Positive or negative 2 inch wg.
   b. Minimum SMACNA Seal Class: B.
   c. In compliance with IECC.
   d. SMACNA Leakage Class for Rectangular: 12.
   e. SMACNA Leakage Class for Round and Flat Oval: 6.

2. Ducts Connected to Air-Handling Units:

   a. Pressure Class: Positive or negative 3 inch wg.
   b. Minimum SMACNA Seal Class: B.
   c. In compliance with IECC.
   d. SMACNA Leakage Class for Rectangular: 12.
   e. SMACNA Leakage Class for Round and Flat Oval: 6.

3. Ducts Connected to Equipment Not Listed above:

   a. Pressure Class: Positive or negative 2 inch wg.
   b. Minimum SMACNA Seal Class: B.
   c. In compliance with IECC.
   d. SMACNA Leakage Class for Rectangular: 12.
   e. SMACNA Leakage Class for Round and Flat Oval: 6.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

   a. Pressure Class: Negative 2 inch wg.
   b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.
   c. In compliance with IECC.
   d. SMACNA Leakage Class for Rectangular: 12.
   e. SMACNA Leakage Class for Round and Flat Oval: 6.

2. Ducts Connected to Air-Handling Units:

   a. Pressure Class: Positive or negative 2 inch wg.
   b. Minimum SMACNA Seal Class: B if negative pressure, and A if positive pressure.
   c. In compliance with IECC.
   d. SMACNA Leakage Class for Rectangular: 12.
   e. SMACNA Leakage Class for Round and Flat Oval: 6.

3. Ducts Connected to Commercial Kitchen Hoods: Comply with NFPA 96 and IMC.

   a. Exposed to View: Type 304, stainless-steel sheet, No. 4 or No. 3 finish.
   b. Concealed: Type 304, stainless-steel sheet, No. 2D finish or Carbon-steel sheet.
   c. Welded seams and joints.
   d. Pressure Class: Positive or negative 2 or as specified inch wg.
   e. Airtight/watertight.

4. Ducts Connected to Dishwashers, Dishwasher Hoods, and Other High-Humidity Locations:

    a. Type 304, stainless-steel sheet.
    b. Exposed to View: No. 4 or No. 3 finish.
    c. Concealed: No. 2D finish.
    d. Welded longitudinal seams; welded or flanged transverse joints with watertight EPDM gaskets.
    e. Pressure Class: Positive or negative 2 or as specified inch wg.
    f. Airtight/watertight.

5. Ducts Connected to Fans Exhausting Fume Hood, Laboratory, and Process (ASHRAE 62.1, Class 3 and Class 4) Air:

    a. Type 316 or Type 304, stainless-steel sheet.

        1) Exposed to View: No. 4 or No. 3 finish.
        2) Concealed: No. 2B or No. 2D finish.

    b. PVC-coated, galvanized sheet steel with thicker coating on duct interior.
    c. Pressure Class: Positive or negative 3 or as specified inch wg.
    d. Minimum SMACNA Seal Class A Welded seams and joints.
    e. SMACNA Leakage Class 2.
    f. Airtight/watertight.

6. Ducts Connected to Equipment Not Listed above:

    a. Pressure Class: Positive or negative 2- inch wg.
    b. Minimum SMACNA Seal Class: B if negative pressure; A if positive pressure.
    c. SMACNA Leakage Class for Rectangular: 12.
    d. SMACNA Leakage Class for Round and Flat Oval: 6.

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

    a. Pressure Class: Positive or negative 2 inch wg.
    b. Minimum SMACNA Seal Class: B.
    c. SMACNA Leakage Class for Rectangular: 12.
    d. SMACNA Leakage Class for Round and Flat Oval: 6.

2. Ducts Connected to Air-Handling Units:

    a. Pressure Class: Positive or negative 2 inch wg.
    b. Minimum SMACNA Seal Class: B.
    c. SMACNA Leakage Class for Rectangular: 12.
    d. SMACNA Leakage Class for Round and Flat Oval: 6.

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative 2 inch wg.
b. Minimum SMACNA Seal Class: B.
c. SMACNA Leakage Class for Rectangular: 12.
d. SMACNA Leakage Class for Round and Flat Oval: 6.

F. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.
2. PVC-Coated Ducts:

a. Exposed to Airstream: Match duct material.
b. Not Exposed to Airstream: Galvanized or Match duct material.

3. Stainless-Steel Ducts:

a. Exposed to Airstream: Match duct material.
b. Not Exposed to Airstream: Galvanized or Match duct material.

4. Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

G. Liner:

1. Supply-Air Ducts: Fibrous glass, Type I, Flexible elastomeric or Natural fiber with R-value in compliance with IECC.
2. Return-Air Ducts: Fibrous glass, Type I, Flexible elastomeric or Natural fiber with R-value in compliance with IECC.
3. Exhaust-Air Ducts: Fibrous glass, Type I, Flexible elastomeric or Natural fiber with R-value in compliance with IECC.
4. Supply Fan Plenums: Fibrous glass, Type II, Flexible elastomeric or Natural fiber with R-value in compliance with IECC.
5. Return- and Exhaust-Fan Plenums: Fibrous glass, Type II, Flexible elastomeric or Natural fiber with R-value in compliance with IECC.
6. Transfer Ducts: Fibrous glass, Type I, Flexible elastomeric or Natural fiber with R-value in compliance with IECC.

H. Double-Wall Duct Interstitial Insulation:

1. Supply-Air Ducts: 1-1/2 with R-value in compliance with IECC.
2. Return-Air Ducts: 1-1/2 with R-value in compliance with IECC.
3. Exhaust-Air Ducts: 1-1/2 with R-value in compliance with IECC.

I. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Velocity 1000 fpm or Lower:

1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.

2) Mitered Type RE 4 without vanes.

b. Velocity 1000 to 1500 fpm:

1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

c. Velocity 1500 fpm or Higher:

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
4) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam or Welded.

J. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

    a. Rectangular Main to Rectangular Branch: 45-degree entry.
    b. Rectangular Main to Round Branch: Conical spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

    a. Velocity 1000 fpm or Lower: 90-degree tap.
    b. Velocity 1000 to 1500 fpm: Conical tap.
    c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Barometric relief dampers.
3. Manual volume dampers.
4. Control dampers.
5. Fire dampers.
6. Ceiling radiation dampers.
7. Smoke dampers.
8. Combination fire and smoke dampers.
9. Corridor dampers.
10. Flange connectors.
11. Duct silencers.
12. Turning vanes.
13. Remote damper operators.
14. Duct-mounted access doors.
15. Duct access panel assemblies.
16. Flexible connectors.
17. Duct security bars.
18. Duct accessory hardware.

B. Related Requirements:

1. Section 233346 "Flexible Ducts" for insulated and non-insulated flexible ducts.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For duct silencers, include pressure drop, dynamic insertion loss, and self-generated noise data. Include breakout noise calculations for high-transmission-loss casings.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details, and attachments to other work.

1. Detail duct accessories' fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

   a. Special fittings.
   b. Manual volume damper installations.
   c. Control-damper installations.
   d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor-damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
   e. Duct security bars.
   f. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

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

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

   1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 90A and NFPA 90B.

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

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Description: Gravity balanced.

B. Construction:

1. Frame:

a. Hat shaped.
b. Galvanized sheet steel, with welded or mechanically attached corners and mounting flange.

2. Blades:

a. Multiple single-piece blades.

3. Blade Action: Parallel.

C. Blade Seals: Vinyl foam, Extruded vinyl, mechanically locked or Neoprene, mechanically locked.

D. Blade Axles:

1. Material: Nonferrous metal, Galvanized steel, Plated steel or Stainless steel Nonmetallic Aluminum.

E. Tie Bars and Brackets: Aluminum or Galvanized steel.

F. Return Spring: Adjustable tension.

G. Bearings: Steel ball, Brass sleeve or synthetic pivot bushings.

H. Damper Actuator - Electric:

1. Electric - 120 V ac or 24 V ac.
2. UL 873 plenum rated.
3. Two position or Fully modulating with fail-safe spring return.

a. Sufficient motor torque and spring torque to drive damper fully closed with adequate force to achieve required damper seal.
b. Minimum 90-degree drive rotation.

4. Clockwise or counterclockwise drive rotation as required for application.
5. Environmental Operating Range:

a. Temperature: Minus 40 to plus 130 deg F.
b. Humidity: 5 to 95 percent relative humidity noncondensing.

6. Environmental Enclosure: NEMA 2.
7. Actuator to be factory mounted and provided with a single-point wiring connection.

I. Damper Actuator - Pneumatic:

1. Operated by 0 to 20 psig pneumatic signal.
2. Two position with or Fully modulating with positioner and fail-safe spring return.

   a. Sufficient power and spring force to drive damper fully closed with adequate force to achieve required damper seal.
   b. Maximum 15-second full-stroke closure.

3. Actuator to be factory mounted.

J. Controllers, Electrical Devices, and Wiring:
1. Electrical Connection: 115 V, single phase, 60 Hz or 24 V, 60 Hz.

K. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Chain pulls.
4. Screen Mounting:

   a. Front Rear mounted in sleeve.

      1) Sleeve Thickness: 20 gauge minimum.
      2) Sleeve Length: 6 inches minimum.

5. Screen Material: Galvanized steel or Aluminum.
6. Screen Type: Bird.
7. 90-degree stops.

2.3 BAROMETRIC RELIEF DAMPERS

A. General Requirements:

1. Suitable for horizontal or vertical mounting.

B. Construction:

1. Frame: galvanized sheet steel, with welded corners or mechanically attached and mounting flange.
2. Blades:

   a. Multiple, Galvanized sheet steel.
   b. Maximum Width: 6 inches.
   c. Action: Parallel.
   d. Balance: Gravity.

3. Blade Seals: Vinyl or Neoprene.
4. Blade Axles: Galvanized steel, Nonferrous metal, Plated steel or Stainless steel.

5. Tie Bars and Brackets:

    a. Material: Aluminum or Galvanized steel.
    b. Rattle free with 90-degree stop.

6. Bearings: Synthetic or Stainless steel.

C. Pressure Adjustment: Return spring or counter weight with adjustable tension.

D. Accessories:

1. Flange on intake.
2. Adjustment device to permit setting for varying differential static pressures.

2.4 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Performance:

    a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. against 1-inch wg differential static pressure.

2. Construction:

    a. Linkage out of airstream.
    b. Suitable for horizontal or vertical airflow applications.

3. Frames:

    a. Hat-shaped galvanized sheet steel.
    b. Mitered and welded corners.
    c. Flanges for attaching to walls and flangeless frames for installing in ducts.

4. Blades:

    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Galvanized or Stainless steel; 16 gauge thick.

5. Blade Axles: Galvanized steel, Stainless steel or Nonferrous metal.
6. Bearings:

    a. Oil-impregnated bronze, Molded synthetic, Oil-impregnated stainless steel sleeve or Stainless steel sleeve.
    b. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.

7. Tie Bars and Brackets: Galvanized steel.

8. Locking device to hold damper blades in a fixed position without vibration.

B. Standard, Aluminum, Manual Volume Dampers:

1. Performance:
   a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. against 1-inch wg differential static pressure.
2. Construction:
   a. Linkage out of airstream.
   b. Suitable for horizontal or vertical airflow applications.
3. Frames:
   a. Hat-shaped, 0.10-inch- thick, aluminum sheet channels.
   b. Flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
   e. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.
5. Blade Axles: Galvanized steel, Stainless steel or Nonferrous metal.
6. Bearings:
   a. Oil-impregnated bronze, Molded synthetic or Stainless steel sleeve.
   b. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.
7. Tie Bars and Brackets: Aluminum.
8. Locking device to hold damper blades in a fixed position without vibration.

C. Low-Leakage, Steel, Manual Volume Dampers:

1. Performance:
   a. AMCA Certification: Test and rate in accordance with AMCA 511.
   b. Leakage:
      1) Class IA: Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.
      2) Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.

3) Class II: Leakage shall not exceed 10 cfm/sq. ft. against 1-inch wg differential static pressure.

2. Construction:

a. Linkage: Out of airstream.
b. Suitable for horizontal or vertical airflow applications.

3. Frames:

a. Hat, U, or angle shaped.
b. Thickness: 16-gauge galvanized sheet steel or 18-gauge stainless steel.
c. Mitered and welded corners.
d. Flanges for attaching to walls and flangeless frames for installing in ducts.

4. Blades:

a. Multiple or single blade.
b. Parallel- or opposed-blade design.
c. Stiffen damper blades for stability.
d. Galvanized or Stainless, roll-formed steel; 16 gauge thick.

5. Blade Edging Seals:

a. Closed-cell neoprene or PVC.
b. Inflatable seal blade edging or replaceable rubber seals.

6. Blade Jamb Seals: Vinyl or Neoprene.
7. Blade Axles: Galvanized steel, Stainless steel or Nonferrous metal.
8. Bearings:

a. Oil-impregnated bronze, Molded synthetic, Oil-impregnated stainless steel sleeve or Stainless steel sleeve.
b. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.

9. Tie Bars and Brackets: Galvanized steel or Aluminum.
10. Locking device to hold damper blades in a fixed position without vibration.

D. Low-Leakage, Aluminum, Manual Volume Dampers:

1. Performance:

a. AMCA Certification: Test and rate in accordance with AMCA 511.
b. Leakage:

1) Class IA: Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.

2) Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.
3) Class II: Leakage shall not exceed 10 cfm/sq. ft. against 1-inch wg differential static pressure.

2. Construction:

a. Linkage out of airstream.
b. Suitable for horizontal or vertical airflow applications.

3. Frames:

a. Hat, U, or angle shaped.
b. Thickness: 0.08-inch aluminum sheet channels.
c. Flanges for attaching to walls and flangeless frames for installing in ducts.

4. Blades:

a. Multiple or single blade.
b. Parallel- or opposed-blade design.
c. Roll-Formed Aluminum Blades:0.072-inch thick aluminum sheet.
d. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.

5. Blade Edging Seals:

a. Closed-cell neoprene or PVC.
b. Inflatable seal blade edging or replaceable rubber seals.

6. Blade Jamb Seals: Vinyl orNeoprene.
7. Blade Axles: Galvanized steel, Stainless steelor Nonferrous metal.
8. Bearings:

a. Oil-impregnated bronze, Molded synthetic, Oil-impregnated stainless steel sleeve or Stainless steel sleeve.
b. Dampers mounted with vertical blades to have thrust bearings at each end of every blade.

9. Tie Bars and Brackets: Galvanized steel or Aluminum.
10. Locking device to hold damper blades in a fixed position without vibration.

E. Jackshaft:

1. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
2. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

F. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle, made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.5 CONTROL DAMPERS

A. General Requirements:

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

B. Performance:

1. AMCA Certification: Test and rate in accordance with AMCA 511.
2. Leakage:

   a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.
   b. Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.
   c. Class II: Leakage shall not exceed 10 cfm/sq. ft. against 1-inch wg differential static pressure.
   d. Class III: Leakage shall not exceed 40 cfm/sq. ft. against 1-inch wg differential static pressure.

3. Pressure Drop: 0.05 inch wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, Figure 5.3.
4. Velocity: Up to 3000 fpm.
5. Temperature: Minus 25 to plus 180 deg F.
6. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

C. Construction:

1. Linkage out of airstream.
2. Suitable for horizontal or vertical airflow applications.
3. Frames:

   a. Hat, U, or angle shaped.
   b. 0.08-inch- thick extruded aluminum, 16-gauge- thick, galvanized sheet steel or 18-gauge- thick stainless steel.
   c. Mitered and welded or Interlocking, gusseted corners.
   d. Flanges for attaching to walls and flangeless frames for installing in ducts.

4. Blades:

a. Multiple blade with maximum blade width of 8 inches.
b. Parallel or Opposed-blade design.
c. Galvanized steel, Stainless steel or Aluminum.
d. 16-gauge- thick single skin or 14-gauge- thick air foil dual skin.

5. Blade Edging Seals:

a. Replaceable Closed-cell neoprene or PVC.
b. Inflatable seal blade edging, or replaceable rubber seals.

6. Blade Jamb Seal: Flexible stainless steel, compression type.
7. Blade Axles: 1/2-inch diameter; galvanized or stainless steel.
8. Blade-Linkage Hardware: Zinc-plated steel and brass; ends sealed against blade bearings. Linkage mounted out of air stream.
9. Bearings:

a. Oil-impregnated bronze, Molded synthetic, Oil-impregnated stainless steel sleeve or Stainless steel sleeve.
b. Dampers mounted with vertical blades to have thrust bearings at each end of every blade.

D. Damper Actuator - Electric:

1. Electric - 120 V ac or 24 V ac.
2. UL 873, plenum rated.
3. Two position or Fully modulating with fail-safe spring return.

a. Sufficient motor torque and spring torque to drive damper fully open and fully closed with adequate force to achieve required damper seal.
b. Minimum 90-degree drive rotation.

4. Clockwise or counterclockwise drive rotation as required for application.
5. Environmental Operating Range:

a. Temperature: Minus 40 to plus 130 deg F.
b. Humidity: 5 to 95 percent relative humidity noncondensing.

6. Environmental enclosure: NEMA 2.
7. Actuator to be factory mounted and provided with a single-point wiring connection.

E. Damper Actuator - Pneumatic:

1. Operated by 0 to 20 psig pneumatic signal.
2. Two position with or Fully modulating with positioner and fail-safe spring return.

a. Sufficient power and spring force to drive damper fully open and fully closed with adequate force to achieve required damper seal.
b. Maximum 15-second full-stroke closure.

3. Actuator to be factory mounted.

F. Controllers, Electrical Devices, and Wiring:

1. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Electrical Connection: 115 V, single phase, 60 Hzor 24 V, 60 Hz.

2.6 FIRE DAMPERS

A. Type: Static and dynamic; rated and labeled in accordance with UL 555 by an NRTL.

B. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000 fpm velocity.

C. Fire Rating: 1-1/2 and 3 hours.

D. Frame: Fabricated with roll-formed galvanized steel; with mitered and interlocking corners; gauge in accordance with UL listing.

E. Mounting Sleeve: Factory- or field-installed, galvanized sheet or stainless steel; gauge in accordance with UL listing.

F. Mounting Orientation: Vertical or horizontal as indicated.

G. Blades: Roll-formed galvanized sheet steel, stainless steel, interlocking or full-length steel blade connectors. Material gauge is to be in accordance with UL listing.

H. Horizontal Dampers: Include blade lock and stainless steel closure spring.

I. Heat-Responsive Device:

1. Replaceable, 165 deg F or 212 deg F rated as required, fusible links.
2. Electric, Pneumatic, resettable or replaceable link and switch package, factory installed, 165 deg F and 212 deg F rated.

2.7 CEILING RADIATION DAMPERS

A. General Requirements:

1. Labeled according to UL 555C by an NRTL.
2. Comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory."

B. Frame: Galvanized sheet steel, round or rectangular, style to suit ceiling construction; gauge in accordance with UL listing.

C. Blades: Galvanized sheet steel with refractory insulation; gauge in accordance with UL listing.

D. Heat-Responsive Device: Replaceable, 165 deg F or 212 deg F rated as required, fusible links.

E. Fire Rating: 1 2 3 <Insert number> hour(s).

2.8 SMOKE DAMPERS

A. General Requirements:

1. Label to indicate conformance to UL 555 and UL 555S by an NRTL.
2. Label to indicate conformance to NFPA 80 and NFPA 90A by an NRTL.
3. Unless otherwise indicated, use parallel-blade configuration.
4. Factory or field assemble multiple damper sections to provide a single damper assembly of size required by the application.
5. Factory install damper actuator by damper manufacturer as integral part of damper assembly. Coordinate actuator location, mounting, and electrical requirements with damper manufacturer.

B. Performance:

1. AMCA Certification: Test and rate in accordance with AMCA Publication 511.
2. Leakage:

   a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.
   b. Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.
   c. Class II: Leakage shall not exceed 10 cfm/sq. ft. against 1-inch wg differential static pressure.

3. Pressure Drop: 0.05 inch wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, Figure 5.3.
4. Velocity: Up to 3000 fpm.
5. Temperature: Minus 25 to plus 180 deg F.
6. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

C. Construction:

1. Suitable for horizontal or vertical airflow applications.
2. Linkage out of airstream.
3. Frame:

   a. Hat shaped.
   b. Galvanized sheet steel Stainless steel, with welded interlocking, gusseted or mechanically attached corners and mounting flange.
   c. Gauge in accordance with UL listing.

4. Blades:

   a. Roll-formed, horizontal, v-groove, airfoil, galvanized sheet steel, stainless steel or extruded aluminum.
   b. Maximum width and gauge in accordance with UL listing.

5. Blade Edging Seals:

a. Silicone rubber.

6. Blade Jamb Seal: Flexible stainless steel, compression type.
7. Blade Axles: 1/2-inch diameter; galvanized steel or stainless steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings. Linkage is to be mounted out of airstream.
8. Bearings:

 a. Oil-impregnated bronze, Molded synthetic, Oil-impregnated stainless steel sleeve or Stainless steel sleeve.

D. Mounting Sleeve: Factory-installed, galvanized sheet steel; length to suit wall or floor application; gauge in accordance with UL listing.

E. Damper Actuator - Electric:

1. Electric - 120 V ac or 24 V ac.
2. UL 873, plenum rated.
3. Designed to operate in smoke-control systems complying with UL 555S requirements.
4. Two position or Fully modulating with fail-safe spring return.

 a. Sufficient motor torque and spring torque to drive damper fully open and fully closed with adequate force to achieve required damper seal.
 b. Maximum 15-second full-stroke closure.
 c. Minimum 90-degree drive rotation.

5. Clockwise or counterclockwise drive rotation as required for application.
6. Environmental Operating Range:

 a. Temperature: Minus 40 to plus 130 deg F.
 b. Humidity: 5 to 95 percent relative humidity noncondensing.

7. Environmental Enclosure: NEMA 2.
8. Actuator to be factory mounted and provided with single-point wiring connection.

F. Damper Actuator - Pneumatic:

1. Operated by 0 to 20 psig pneumatic signal.
2. Designed to operate in smoke-control systems complying with UL 555S requirements.
3. Two position with or Fully modulating with positioner and fail-safe spring return.

 a. Sufficient power and spring force to drive damper fully open and fully closed with adequate force to achieve required damper seal.
 b. Maximum 15-second full-stroke closure.

4. Actuator to be factory mounted.

G. Controllers, Electrical Devices, and Wiring:

1. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Electrical Connection: 115 V, single phase, 60 Hz or 24 V, 60 Hz.

H. Accessories:

1. Auxiliary switches for signaling, fan control or position indication.
2. Momentary test switch, Test and reset switches, damper remote mounted.
3. Smoke Detector: Integral, factory wired for single-point connection.

2.9 COMBINATION FIRE AND SMOKE DAMPERS

A. General Requirements:

1. Label to indicate conformance to UL 555 and UL 555S by an NRTL.
2. Label to indicate conformance to NFPA 80 and NFPA 90A by an NRTL.
3. Unless otherwise indicated, use parallel-blade configuration.

B. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000 fpm velocity.

C. Fire Rating: 1-1/2 and 3 hours as required.

D. Performance:

1. AMCA Certification: Test and rate in accordance with AMCE Publication 511.
2. Leakage:

   a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.
   b. Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.
   c. Class II: Leakage shall not exceed 10 cfm/sq. ft. against 1-inch wg differential static pressure.

3. Pressure Drop: 0.05 in. wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, Figure 5.3.
4. Velocity: Up to 3000 fpm.
5. Temperature: Minus 25 to plus 180 deg F.
6. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

E. Construction:

1. Suitable or horizontal or vertical airflow applications.
2. Linkage out of airstream.
3. Frame:

   a. Hat shaped.

b. Galvanized sheet steel, Stainless steel, with welded interlocking, gusseted or mechanically attached corners and mounting flange.
c. Gauge is to be in accordance with UL listing.

4. Blades:

a. Roll-formed, horizontal, v-groove, airfoil, galvanized sheet steel, stainless steel or extruded aluminum.
b. Maximum width and gauge in accordance with UL listing.

5. Blade Edging Seals:

a. Silicone rubber.

6. Blade Jamb Seal: Flexible stainless steel, compression type.
7. Blade Axles: 1/2-inch- diameter; galvanized steel or stainless steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings. Linkage mounted out of airstream.
8. Bearings:

a. Oil-impregnated bronze, Molded synthetic, Oil-impregnated stainless steel sleeve or Stainless steel sleeve.

F. Mounting Sleeve:

1. Factory installed, galvanized sheet steel.
2. Length to suit wall or floor application.
3. Gauge in accordance with UL listing.

G. Heat-Responsive Device:

1. Resettable or Replaceable, 165 deg F or 212 deg F rated as required, fusible links fire-closure device.
2. Electric or Pneumatic resettable link or device and switch package, factory installed, rated.

H. Master control panel for use in dynamic smoke-management systems.

I. Damper Actuator - Electric:

1. Electric - 120 V acor 24 V ac.
2. UL 873, plenum rated.
3. Designed to operate in smoke-control systems complying with UL 555S requirements.
4. Two position or Fully modulating with fail-safe spring return.

a. Sufficient motor torque and spring torque to drive damper fully open and fully closed with adequate force to achieve required damper seal.
b. Maximum 15-second full-stroke closure.
c. Minimum 90-degree drive rotation.

5. Clockwise or counterclockwise drive rotation as required for application.
6. Environmental Operating Range:

    a. Temperature: Minus 40 to plus 130 deg F.
    b. Humidity: 5 to 95 percent relative humidity noncondensing.

7. Environmental Enclosure: NEMA 2.
8. Actuator to be factory mounted and provided with single-point wiring connection.

J. Damper Actuator - Pneumatic:

1. Operated by 0 to 20 psig pneumatic signal.
2. Designed to operate in smoke control systems complying with UL 555S requirements.
3. Two position with or Fully modulating with positioner and fail-safe spring return.

    a. Sufficient power and spring force to drive damper fully open and fully closed with adequate force to achieve required damper seal.
    b. Maximum 15-second full-stroke closure.

4. Actuator to be factory mounted.

K. Controllers, Electrical Devices, and Wiring:

1. Electrical Connection: 115 V, single phase, 60 Hz or 24 V, 60 Hz.

L. Accessories:

1. Auxiliary switches for signaling, fan control or position indication.
2. Momentary test switch, Test and reset switches, damper remote mounted.
3. Smoke Detector: Integral, factory wired for single-point connection.

2.10 CORRIDOR DAMPERS

A. General Requirements:

1. Label to indicate conformance to UL 555 and UL 555S by an NRTL.
2. Label to indicate conformance to NFPA 90A by an NRTL.

B. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000 fpm velocity.

C. Fire Rating: 1, 1-1/2 or 2 hours as required.

D. Performance:

1. AMCA Certification: Test and rate in accordance with AMCA Publication 511.
2. Leakage:

    a. Class 1A: Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.

b. Class 1: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.
c. Class II: Leakage shall not exceed 10 cfm/sq. ft. against 1-inch wg differential static pressure.

E. Construction:

1. Frame: Hat shaped, galvanized sheet steel, with welded, interlocking, gusseted or mechanically attached corners and mounting flange; gauge in accordance with UL listing.
2. Blades: Roll-formed, horizontal, interlocking or overlapping, galvanized sheet steel; gauge in accordance with UL listing.

F. Mounting Sleeve:

1. Factory installed, galvanized sheet steel.
2. Length to suit wall or floor application with factory-furnished silicone caulking.
3. Gauge in accordance with UL listing.

G. Heat-Responsive Device:

1. Resettable Replaceable, 165 deg F or 212 deg F rated as required, fusible links fire-closure device.
2. Electric or Pneumatic resettable link or device and switch package, factory installed, rated.

H. Damper Actuator - Electric:

1. Electric - 120 V ac or 24 V ac.
2. UL 873, plenum rated.
3. Designed to operate in smoke-control systems complying with UL 555S requirements.
4. Two position with fail-safe spring return.

   a. Sufficient motor torque and spring torque to drive damper fully open and fully closed with adequate force to achieve required damper seal.
   b. Maximum 15-second full-stroke closure.
   c. Minimum 90-degree drive rotation.

5. Clockwise or counterclockwise drive rotation as required for application.
6. Environmental Operating Range:

   a. Temperature: Minus 40 to plus 130 deg F.
   b. Humidity: 5 to 95 percent relative humidity noncondensing.

7. Environmental enclosure: NEMA 2.
8. Actuator to be factory mounted and provided with single-point wiring connection.

I. Damper Actuator - Pneumatic:

1. Operated by 0 to 20 psig pneumatic signal.
2. Designed to operate in smoke-control systems complying with UL 555S requirements.

3. Two position with fail-safe spring return.

    a. Sufficient power and spring force to drive damper fully open and fully closed with adequate force to achieve required damper seal.
    b. Maximum 15-second full-stroke closure.

4. Actuator to be factory mounted.

J. Controllers, Electrical Devices, and Wiring:

1. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Electrical Connection: 115 V, single phase, 60 Hz or 24 V, 60 Hz.

K. Accessories:

1. Auxiliary switches for signaling, fan control or position indication.
2. Momentary test switch, Test and reset switches, damper remote mounted.
3. Smoke Detector: Integral, factory wired for single-point connection.

2.11 FLANGE CONNECTORS

A. Description: Add-on or roll-formed, factory fabricated, slide-on transverse flange connectors, gaskets, and components.

B. Material: Galvanized steel.

C. Gauge and Shape: Match connecting ductwork.

2.12 DUCT SILENCERS

A. General Requirements:

1. Factory fabricated.
2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
4. Bearing AMCA's Certified Ratings Seal for prefabricated silencer sound and air performance.

B. Shape:

1. Rectangular straight with splitters or baffles.
2. Round straight with center bodies or pods.
3. Rectangular elbow with splitters or baffles.
4. Round elbow with center bodies or pods.

5. Rectangular transitional with splitters or baffles.

C. Rectangular Silencer Outer Casing: ASTM A653/A653M, G90 or G60, galvanized sheet steel, 0.034 inch or 0.040 inch thick.

D. Round Silencer Outer Casing: ASTM A653/A653M, G90 or G60, galvanized sheet steel.

1. Sheet Metal Thickness for Units up to 24 Inches in Diameter: 22 gauge thick.
2. Sheet Metal Thickness for Units 26 through 40 Inches in Diameter: 20 gauge thick.
3. Sheet Metal Thickness for Units 42 through 52 Inches in Diameter: 18 gauge thick.
4. Sheet Metal Thickness for Units 54 through 60 Inches in Diameter: 16 gauge thick.

E. Inner Casing and Baffles: ASTM A653/A653M, G90 or G60 galvanized sheet metal, 22 gauge thick, and with 1/8-inch- diameter perforations.

F. Special Construction:

1. Suitable for outdoor use.
2. High transmission loss to achieve STC 45.

G. Connection Sizes: Match connecting ductwork unless otherwise indicated.

H. Principal Sound-Absorbing Mechanism:

1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
2. Dissipativeor Film-lined type with fill material.

   a. Fill Material: Inert and vermin-proof fibrous material, packed under not less than 5 percent compression, Inert and vermin-proof fibrous material, packed under not less than 15 percent compression or Moisture-proof nonfibrous material.
   b. Erosion Barrier: Polymer bag enclosing fill, heat-sealed before assembly.

I. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.

1. Joints: Lock formed and sealed, Continuously welded or flanged connections.
2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
3. Reinforcement: Cross or trapeze angles for rigid suspension.

J. Accessories:

1. Integral 1-1/2 or 3-hour fire damper as required with access door. Access door to be high transmission loss to match silencer.
2. Factory-installed end caps to prevent contamination during shipping.
3. Removable splitters.
4. Airflow-measuring devices.

K. Source Quality Control:

1. Test in accordance with ASTM E477.
2. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000 fpm face velocity.
3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.

2.13 TURNING VANES

A. Manufactured Turning Vanes for Metal Ducts: Fabricate curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

   1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

B. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

D. Vane Construction:

   1. Single or Double wall.
   2. Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.14 REMOTE DAMPER OPERATORS

A. Description: Cable system designed for remote manual damper adjustment.

B. Tubing: Brass, Copper or Aluminum.

C. Cable: Stainless steel or Steel.

D. Wall-Box Mounting: Recessed or Surface as required.

E. Wall-Box Cover-Plate Material: Steel or Stainless steel.

2.15 DUCT-MOUNTED ACCESS DOORS

A. Duct-Mounted Access Doors: Fabricate access panels in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 7-2 (7-2M), "Duct Access Doors and Panels," and Figure 7-3, "Access Doors - Round Duct."

   1. Door:

a. Double wall, rectangular.
b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
c. 24-gauge- thick galvanized steel or 0.032-inch thick aluminum or 24-gauge- thick stainless steel door panel.
d. Vision panel.
e. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
f. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

a. 24-gauge- thick galvanized steel or 0.032-inch- thick aluminum <Insert value> frame.

3. Number of Hinges and Locks:

a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
b. Access Doors up to 18 Inches Square: Two hinges or Continuous and two sash locks.
c. Access Doors up to 24 by 48 Inches: Three hinges or Continuous and two compression latches with outside and inside handles.
d. Access Doors Larger Than 24 by 48 Inches: Four hinges or Continuous and two compression latches with outside and inside handles.

B. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.

a. 24-gauge- thick galvanized steel or 0.032?inch- thick aluminum or 24-gauge- thick stainless steel door panel.

2. Door: Single wall or Double wall with insulation fill with metal thickness applicable for duct pressure class.
3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Doors close when pressures are within set-point range.
5. Hinge: Continuous piano.
6. Latches: Cam.
7. Seal: Neoprene or foam rubber.
8. Insulation Fill: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.16 DUCT ACCESS PANEL ASSEMBLIES

A. Access panels used in cooking applications:

1. Labeled compliant to NFPA 96 for grease duct access doors.
2. Labeled in accordance with UL 1978 by an NRTL.

B. Panel and Frame: Minimum thickness 16-gauge carbon or16-gauge stainless steel.

C. Fasteners: Carbon or Stainless steel. Panel fasteners shall not penetrate duct wall.

D. Gasket: Comply with NFPA 96, grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

E. Minimum Pressure Rating: 10 inches wg positive or negative.

2.17 FLEXIBLE CONNECTORS

A. Fire-Performance Characteristics: Adhesives, sealants, fabric materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Materials: Flame-retardant or noncombustible fabrics.

D. Coatings and Adhesives: Comply with UL 181, Class 1.

E. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches or 5-3/4 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.

F. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

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

G. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd..
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

H. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.

1. Minimum Weight: 16 oz./sq. yd..
2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F.

I. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.

1. Minimum Weight: 14 oz./sq. yd..
2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F.

J. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.18 DUCT SECURITY BARS

A. Description: Field-fabricated, Factory-fabricated and field-installed or Field- or factory-fabricated and field-installed duct security bars.

B. Configuration:

1. Flat frame of 2 by 1/4 inch or Angle frame of 2-1/2 by 2-1/2 by 1/4 inch.
2. Sleeve: 0.1345-inch or 3/16-inch, continuously welded or bent steel frames with 1-by-1-by-3/16-inch or 1-1/2-by-1-1/2-by-1/8-inch angle frame factory welded to one end or furnished loose for field welding on other end. To be poured in place or set with concrete block or welded or bolted to wall, one side only. Duct connections on both sides.
3. Horizontal Bars: 1/2 inch or 2 by 1/4 inch.
4. Vertical Bars: 1/2 inch, 3/4 inch, 1 inch or 2 by 1/4 inch.
5. Bar Spacing: 6 inches.

2.19 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.20 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G60 or G90.
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, one-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B221, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories in accordance with applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116 for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless steel accessories in stainless steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft or control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Where multiple damper sections are necessary to achieve required dimensions, provide reinforcement to fully support damper assembly when fully closed at full system design static pressure.

E. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

F. Set dampers to fully open position before testing, adjusting, and balancing.

G. Install test holes at fan inlets and outlets and elsewhere as indicated and as needed for testing and balancing.

H. Install fire and smoke dampers in accordance with UL listing.

I. Duct security bars:

1. Construct duct security bars from 0.164-inch steel sleeve, continuously welded at all joints, and 1/2-inch- diameter steel bars, 6 inches o.c. in each direction in center of sleeve. Weld each bar to steel sleeve and each crossing bar. Weld 2-1/2-by-2-1/2-by-1/4-inch steel angle to four sides and both ends of sleeve.
2. Connect duct security bars to ducts with flexible connections. Provide 12-by-12-inch hinged access panel with cam lock in duct in each side of sleeve.
3. Secure duct security bar assembly to building structure as detailed and as indicated in manufacturer's installation instructions.

J. Connect ducts to duct silencers with flexible duct connectors or rigidly.

K. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream and downstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-ft. spacing.
8. Upstream and downstream from turning vanes.
9. Upstream or downstream from duct silencers.
10. For grease ducts, install at locations and spacing as required by NFPA 96.
11. Control devices requiring inspection.
12. Elsewhere as indicated.

L. Install access doors with swing against duct static pressure.

M. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.
3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.

N. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

O. Install flexible connectors to connect ducts to equipment.

P. For fans developing static pressures of 5 inches wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

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

R. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

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

END OF SECTION 233300

SECTION 233346 - FLEXIBLE DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Non-insulated flexible ducts.
2. Insulated flexible ducts.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For flexible ducts.

1. Include plans showing locations and mounting and attachment details.

1.4 INFORMATIONAL SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

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

C. Comply with the Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1."

D. Comply with ASTM E96/E96M, "Test Methods for Water Vapor Transmission of Materials."

2.2 NON-INSULATED FLEXIBLE DUCTS

A. Non-Insulated, Flexible Duct: UL 181, Class 1, two-ply vinyl film supported by helically wound, spring-steel wire.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.

B. Non-Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire.

1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 175 deg F.

C. Non-Insulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 210 deg F.

D. Non-Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 210 deg F.

E. Non-Insulated, Flexible Duct: UL 181, Class 0, interlocking spiral of aluminum foil.

1. Pressure Rating: 8-inch wg positive or negative.
2. Maximum Air Velocity: 5000 fpm.
3. Temperature Range: Minus 100 to plus 435 deg F.

2.3 INSULATED FLEXIBLE DUCTS

A. Insulated, Flexible Duct: UL 181, Class 1, two-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene OR aluminized vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 10 to plus 160 deg F.
4. Insulation R-Value: Comply with ASHRAE/IES 90.1 and IECC.

B. Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene aluminized vapor-barrier film.

1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 175 deg F.
4. Insulation R-Value: Comply with ASHRAE/IES 90.1 and IECC.

C. Insulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene or aluminized vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 210 deg F.
4. Insulation R-Value: Comply with ASHRAE/IES 90.1 and IECC.

D. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene aluminized vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 210 deg F.
4. Insulation R-Value: Comply with ASHRAE/IES 90.1 and IECC.

E. Insulated, Flexible Duct: UL 181, Class 0, interlocking spiral of aluminum foil; fibrous-glass insulation; polyethylene aluminized vapor-barrier film.

1. Pressure Rating: 8-inch wg positive or negative.
2. Maximum Air Velocity: 5000 fpm.
3. Temperature Range: Minus 20 to plus 250 deg F.
4. Insulation R-Value: Comply with ASHRAE/IES 90.1 and IECC.

2.4 FLEXIBLE DUCT CONNECTORS

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

B. Non-Clamp Connectors: Adhesive, Liquid adhesive plus tape or Adhesive plus sheet metal screws.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install flexible ducts according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install in indoor applications only. Flexible ductwork should not be exposed to UV lighting.

C. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

D. Connect diffusers or light troffer boots to ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.

E. Connect flexible ducts to metal ducts with adhesive, liquid adhesive plus tape, draw bands or adhesive plus sheet metal screws.

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

G. Installation:

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

H. Supporting Flexible Ducts:

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

END OF SECTION 233346

SECTION 233413 - AXIAL HVAC FANS

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. Tube axial fans.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
2. Include rated capacities, furnished specialties, and accessories for each fan.
3. Fans:

    a. Certified fan performance curves with system operating conditions indicated.
    b. Certified fan sound-power ratings.
    c. Fan construction and accessories.
    d. Motor ratings and electrical characteristics, plus motor and electrical accessories.
    e. Fan speed controllers.

4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

B. Startup service reports.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fans, include the following:

1. Operation in normal and emergency modes.
2. Operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.

2.2 TUBEAXIAL FANS

A. Manufacturers
1. Greenheck
2. Loren Cook
3. Soler Palau

B. Source Limitations: Obtain tubeaxial fans from single manufacturer.

C. Description: Fan wheel and housing, factory-mounted motor with direct drive, an inlet cone section, and accessories.

D. Housings: Steel with flanged inlet and outlet connections.

E. Wheel Assemblies: Cast or extruded aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.

F. Accessories:

1. Companion Flanges: Rolled flanges of same material as housing.

2. Inspection Door: Bolted door allowing limited access to internal parts of fan, of same material as housing.
3. Propeller Access Section Door: Short duct section bolted to fan inlet and outlet allowing access to internal parts of fan for inspection and cleaning, of same material as housing.
4. Mounting Clips: Horizontal ceiling clips welded to fan housing, of same material as housing.
5. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.
6. Outlet Screen: On unducted fan outlet - wire-mesh screen, of same material as housing.
7. Backdraft Dampers: Butterfly style, for bolting to fan discharge or outlet cone, of same material as housing.
8. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
9. Inlet Vanes: Adjustable; with peripheral control linkage operated from outside of airstream, bronze sleeve bearings on each end of vane support, and provision for manual or automatic operation, of same material as housing.
10. Inlet Cone: Round-to-round transition, of same material as housing.
11. Outlet Cone: Round-to-round transition, of same material as housing.
12. Direct-Driven Units: Encase motor in housing outside of airstream. Extend lubrication lines to outside of casing and terminate with grease fittings.
13. Factory-wired motor disconnect switch located on outside of fan housing.

G. Factory Finishes:

1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.

2.3 SOURCE QUALITY CONTROL

A. AMCA Certification for Fan Sound Performance Rating: Test, rate, and label in accordance with AMCA 311.

B. AMCA Certification for Fan Aerodynamic Performance Ratings: Test, rate, and label in accordance with AMCA 211.

C. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install axial fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, in accordance with manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting:

1. Support duct-mounted and other hanging axial fans directly from the building structure, using suitable hanging systems as specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Install units with adequate clearances for service and maintenance.

F. Label fans in accordance with requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Where installing ducts adjacent to fans, allow space for service and maintenance.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 STARTUP SERVICE:

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
4. Verify that cleaning and adjusting are complete.
5. For direct-drive fans, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.
6. For belt-drive fans, disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
7. Adjust belt tension.
8. Adjust damper linkages for proper damper operation.
9. Verify lubrication for bearings and other moving parts.
10. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
11. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
12. Shut unit down and reconnect automatic temperature-control operators.
13. Remove and replace malfunctioning units and retest as specified above.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

D. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.7 CLEANING

A. After completing system installation and testing, adjusting, and balancing and after completing startup service, clean fans internally to remove foreign material and construction dirt and dust.

3.8 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safeties.

3. Fans and components will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain axial HVAC fans.

END OF SECTION 233413

SECTION 233416 - CENTRIFUGAL HVAC FANS

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. Backward-inclined centrifugal fans, including airfoil and curved blade fans.
2. Forward-curved centrifugal fans.
3. Square in-line centrifugal fans.
4. Tubular in-line centrifugal fans.
5. Plenum fans.
6. Plug fans.
7. Utility set fans.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
2. Rated capacities, operating characteristics, and furnished specialties and accessories.
3. Certified fan performance curves with system operating conditions indicated.
4. Certified fan sound-power ratings.
5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
6. Material thickness and finishes, including color charts.
7. Dampers, including housings, linkages, and operators.
8. Fan speed controllers.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Fan room layout and relationships between components and adjacent structural and mechanical elements, drawn to scale, and coordinated with each other, using input from installers of the items involved.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For centrifugal fans to include in normal operation, emergency operation, and maintenance manuals with replacement parts listing.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Seismic Performance: Centrifugal fans shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

2.2 BACKWARD-INCLINED CENTRIFUGAL FANS

A. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, belt- or direct-driven centrifugal fans, consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
2. Factory-installed and -wired disconnect switch.

B. Housings:

1. Housing Material: Reinforced steel, Shaped fiberglass-reinforced plastic, Aluminum, Stainless steel or as specified on drawings.
2. Housing Coating: None, Thermoplastic vinyl, Epoxy, Synthetic resin, Phenolic, Hot-dip galvanized, Powder-baked enamel or as specified on drawings.

3. Housing Assembly: Sideplates continuously welded or spot welded or attached by continuous Pittsburgh lock seal or similar seal.
4. Formed panels to make curved-scroll housings with shaped cutoff.
5. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
6. Horizontally split, bolted-flange housing.
7. Spun inlet cone with flange.
8. Outlet flange.
9. Discharge Arrangement: Fan scroll housing is field rotatable to discharge positions. Provide fan with discharge positioned in proper direction to minimize connected duct turns.

C. Wheels:

1. Wheel Configuration: SWSI or DWDI construction with a precision-spun curved inlet flange and a backplate fastened to shaft with setscrews. Wheels shall be statically and dynamically balanced, and nonoverloading.
2. Wheel and Blade Material: Steel, Aluminum, One-piece fiberglass-reinforced plastic, Stainless steel or as specified on drawings.

    a. Spark-Resistant Construction: Classified according to AMCA 99, Section 8, Type A, Type B or Type C as specified on drawings.

3. Wheel and Blade Coating: None, Thermoplastic vinyl, Epoxy, Synthetic resin, Phenolic, Hot-dip galvanized, Powder-baked enamel or as specified on drawings.
4. Cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.
5. Backward-Inclined Airfoil Blades:

    a. Aerodynamic design.
    b. Heavy backplate.
    c. Hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.

6. Backward-Inclined Curved Blades:

    a. Curved design.
    b. Heavy backplate.
    c. Single-thickness blades continuously welded at tip flange and backplate.

D. Shafts:

1. Statically and dynamically balanced, and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

E. Bearings:

1. Prelubricated and Sealed Shaft Bearings:

   a. Self-aligning, pillow-block-type ball bearings.
   b. Ball-Bearing Rating Life: ABMA 9, L(10) at 120,000 hours.
   c. Roller-Bearing Rating Life: ABMA 11, L(10) at 120,000 hours.

2. Grease-Lubricated Shaft Bearings, Tapered Roller:

   a. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
   b. Roller-Bearing Rating Life: ABMA 11, L(10) at 120,000 hours.
   c. Extended Lubrication Lines: Extend lines to accessible location.

3. Grease-Lubricated Shaft Bearings, Ball or Roller:

   a. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
   b. Ball-Bearing Rating Life: ABMA 9, L(10) at 120,000 hours.
   c. Roller-Bearing Rating Life: ABMA 11, L(10) at 120,000 hours.
   d. Extended Lubrication Lines: Extend lines to accessible location.

F. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: 1.5.
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch pulleys for use with motors larger than 5 hp.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Comply with OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.146 inch- thick, 3/4-inch diamond-mesh wire screen, welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
7. Motor Mount: Adjustable for belt tensioning.

G. Motor Enclosure: Open, dripproof, Totally enclosed, fan cooled, Explosion proof, Totally enclosed, air over or as specified on drawings.

H. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Scroll Drain Connection: NPS 1 steel pipe coupling welded to low point of fan scroll.
3. Companion Flanges: Rolled flanges for duct connections of same material as housing.
4. Discharge Dampers: Assembly with parallel or opposed blades constructed of two plates formed around, and to, shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.

5. Inlet Screens: Grid screen of same material as housing.
6. .
7. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
8. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.
9. Piezometer Ring: Piezometer ring mounted at fan inlet cone for airflow measurement.

2.3 FORWARD-CURVED CENTRIFUGAL FANS

A. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, belt- or direct-driven centrifugal fans, consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. Factory-installed and -wired disconnect switch.

B. Housings:

1. Housing Material: Reinforced steel, Shaped fiberglass-reinforced plastic, Aluminum, Stainless steel or as specified on drawings.
2. Housing Coating: None, Thermoplastic vinyl, Epoxy, Synthetic resin, Phenolic, Hot-dip galvanized, Powder-baked enamel or as specified on drawings.
3. Housing Assembly: Sideplates continuously welded or spot welded or attached by continuous Pittsburgh lock seal or similar seal.
4. Formed panels to make curved-scroll housings with shaped cutoff.
5. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
6. Horizontally split, bolted-flange housing.
7. Spun inlet cone with flange.
8. Outlet flange.
9. Discharge Arrangement: Fan scroll housing field rotatable to discharge positions. Provide fan with discharge positioned in proper direction to minimize connected duct turns.

C. Wheels:

1. Wheel Configuration: SWSI or DWDI construction with a curved inlet flange, and a backplate fastened to shaft with setscrews.
2. Wheel and Blade Material: Steel, Aluminum, One-piece fiberglass-reinforced plastic, Stainless steel or as specified on drawings.

   a. Spark-Resistant Construction: Classified according to AMCA 99, Section 8, Type A, Type B or Type C as specified on drawings.

3. Wheel and Blade Coating: None, Thermoplastic vinyl, Epoxy, Synthetic resin, Phenolic, Hot-dip galvanized, Powder-baked enamel or as required or specified on drawings.
4. Cast-iron or cast-steel hub riveted to backplate and fastened to shaft with setscrews.
5. Forward-Curved Wheels:

a. Black-enameled or galvanized-steel construction with inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow.
b. Mechanically secured to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with setscrews.

D. Shafts:

1. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

E. Bearings:

1. Prelubricated and Sealed Shaft Bearings:

   a. Self-aligning, pillow-block-type ball or roller bearings.
   b. Ball-Bearing Rating Life: ABMA 9, L(10) at 120,000 hours.
   c. Roller-Bearing Rating Life: ABMA 11, L(10) at 120,000 hours.

2. Grease-Lubricated Shaft Bearings, Tapered Roller:

   a. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
   b. Roller-Bearing Rating Life: ABMA 11, L(10) at 120,000 hours.
   c. Extended Lubrication Lines: Extend lines to accessible location.

3. Grease-Lubricated Shaft Bearings, Ball or Roller:

   a. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
   b. Ball-Bearing Rating Life: ABMA 9, L(10) at 120,000 hours.
   c. Roller-Bearing Rating Life: ABMA 11, L(10) at 120,000 hours.
   d. Extended Lubrication Lines: Extend lines to accessible location.

F. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: 1.5.
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than 5 hp.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Comply with OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.146 inch- thick, 3/4-inch diamond-mesh wire screen, welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without

short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

7. Motor Mount: Adjustable for belt tensioning.

G. Motor Enclosure: Open, dripproof, Totally enclosed, fan cooled, Totally enclosed, air over, Explosion-proof or as specified on drawings.

H. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Scroll Drain Connection: NPS 1 steel pipe coupling welded to low point of fan scroll.
3. Companion Flanges: Rolled flanges for duct connections of same material as housing.
4. Discharge Dampers: Assembly with parallel or opposed blades constructed of two plates formed around, and to, shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.
5. Inlet Screens: Grid screen of same material as housing.
6. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
7. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
8. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.
9. Piezometer Ring: Piezometer ring mounted at fan inlet cone for airflow measurement.

2.4 SQUARE IN-LINE CENTRIFUGAL FANS

A. Description: Square in-line centrifugal fans.

B. Housing:

1. Housing Material: Reinforced steel, Aluminum, Stainless steel or as specified on drawings.
2. Housing Coating: None, Thermoplastic vinyl, Epoxy, Synthetic resin, Phenolic, Hot-dip galvanized, Powder-baked enamel or as specified on drawings.
3. Housing Construction: Side panels shall be easily removable for service. Include inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.

D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosures around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

E. Fan Wheels: Aluminum airfoil blades welded to aluminum hub.

F. Motor Enclosure: Open, dripproof, Totally enclosed, fan cooled, Totally enclosed, air over, Explosion-proof or as specified on drawings.

G. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
3. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
4. Companion Flanges: For inlet and outlet duct connections.
5. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
6. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.
7. Side Discharge: Flange connector and attachment hardware to provide right-angle discharge on side of unit.

2.5 TUBULAR IN-LINE CENTRIFUGAL FANS

A. Description: Tubular in-line centrifugal fans.

B. Housing:

1. Housing Material: Reinforced steel, Shaped fiberglass-reinforced plastic, Aluminum, Stainless steel or as specified on drawings.
2. Housing Coating: None, Thermoplastic vinyl, Epoxy, Synthetic resin, Phenolic, Hot-dip galvanized or Powder-baked enamel or as specified on drawings.
3. Housing Construction: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.

D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

E. Fan Wheels: Steel or Aluminum, airfoil blades welded to aluminum hub.

F. Motor Enclosure: Open, dripproof, Totally enclosed, fan cooled, Totally enclosed, air over, Explosion-proof or as specified on drawings.

G. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
3. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
4. Companion Flanges: For inlet and outlet duct connections.
5. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
6. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.6 PLENUM FANS

A. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, belt- or direct-driven centrifugal fans, consisting of wheel, fan shaft, bearings, motor, drive assembly, and support structure.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.

B. Wheels:

1. Wheel Configuration: SWSI construction with curved inlet flange and heavy backplate; fastened to shaft with setscrews.
2. Wheel and Blade Material: Steel, Aluminum, One-piece fiberglass-reinforced plastic, Stainless steel or as specified on drawings.

    a. Spark-Resistant Construction: Classified according to AMCA 99, Section 8, Type A, Type B or Type C as specified on drawings.

3. Wheel and Blade Coating: None, Thermoplastic vinyl, Epoxy, Synthetic resin Phenolic, Hot-dip galvanized, Powder-baked enamel or as specified on drawings.
4. Backward-Inclined Airfoil Blades: Hollow, die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.

C. Shafts:

1. Statically and dynamically balanced, and selected for continuous operation at maximum-rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

D. Bearings:

1. Prelubricated and Sealed Shaft Bearings:

    a. Self-aligning, pillow-block-type ball bearings.
    b. Ball-Bearing Rating Life: ABMA 9, L(10) at 120,000 hours.
    c. Roller-Bearing Rating Life: ABMA 11, L(10) at 120,000 hours.

2. Grease-Lubricated Shaft Bearings, Tapered Roller:

    a. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
    b. Roller-Bearing Rating Life: ABMA 11, L(10) at 120,000 hours.
    c. Extended Lubrication Lines: Extend lines to accessible location.

3. Grease-Lubricated Shaft Bearings, Ball or Roller:

a. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
b. Ball-Bearing Rating Life: ABMA 9, L(10) at 120,000 hours.
c. Roller-Bearing Rating Life: ABMA 11, L(10) at 120,000 hours.
d. Extended Lubrication Lines: Extend lines to accessible location.

E. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: 1.5.
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than 5 hp.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Comply with OSHA and fabricate to SMACNA's "HVAC Duct Construction Standards"; 0.146 inch- thick, 3/4-inch diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
7. Motor Mount: Adjustable for belt tensioning.

F. Motor Enclosure: Open, dripproof, Totally enclosed, fan cooled, Totally enclosed, air over, Explosion proof or as specified on drawings.

G. Accessories:

1. Inlet Safety Screen: Comply with OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
2. Safety Enclosure: Comply with OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
3. Belt Guard: Comply with OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
4. Inlet Companion Flange: Rolled flanges for duct connections of same material as housing.
5. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
6. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
7. Piezometer Ring: Piezometer ring mounted at fan inlet cone for airflow measurement.

2.7 PLUG FANS

A. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans, consisting of wheel, fan shaft, bearings, motor, drive assembly, and support structure.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. Factory-installed and -wired disconnect switch.

B. Wheels:

1. Wheel Configuration: SWSI construction with curved inlet flange and heavy backplate; fastened to shaft with setscrews.
2. Wheel and Blade Material: Steel, Aluminum, One-piece fiberglass-reinforced plastic Stainless steel or as specified on drawings.

    a. Spark-Resistant Construction: Classified according to AMCA 99, Section 8 Type A, Type B or Type C as specified on drawings.

3. Wheel and Blade Coating: None, Themoplastic vinyl, Epoxy, Synthetic resin, Phenolic, Hot-dip galvanized, Powder-baked enamel or as specified on drawings.
4. Backward-Inclined Airfoil Blades: Hollow, die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.

C. Shafts:

1. Statically and dynamically balanced, and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

D. Bearings:

1. Prelubricated and Sealed Shaft Bearings:

    a. Self-aligning, pillow-block-type ball bearings.
    b. Ball-Bearing Rating Life: ABMA 9, L(10) at 120,000 hours.
    c. Roller-Bearing Rating Life: ABMA 11, L(10) at 120,000 hours.

2. Grease-Lubricated Shaft Bearings, Tapered Roller:

    a. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
    b. Ball-Bearing Rating Life: ABMA 9, L(10) at 120,000 hours.
    c. Roller-Bearing Rating Life: ABMA 11, L(10) at 120,000 hours.
    d. Extended Lubrication Lines: Extend lines to accessible location.

3. Grease-Lubricated Shaft Bearings, Ball or Roller:

    a. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
    b. Ball-Bearing Rating Life: ABMA 9, L(10) at 120,000 hours.

c. Roller-Bearing Rating Life: ABMA 11, L(10) at 120,000 hours.
d. Extended Lubrication Lines: Extend lines to accessible location.

E. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: 1.5.
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with larger motors.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Comply with OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.146 inch- thick, 3/4-inch diamond-mesh wire screen, welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
7. Motor Mount: Adjustable for belt tensioning.

F. Motor Enclosure: Open, dripproof, Totally enclosed, fan cooled, Totally enclosed, air over, Explosion-proof or as specified on drawings.

G. Accessories:

1. Inlet Safety Screen: Comply with OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
2. Safety Enclosure: Comply with OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
3. Belt Guard: Comply with OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
4. Inlet Companion Flange: Rolled flanges for duct connections of same material as housing.
5. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
6. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.

2.8 UTILITY SET FANS

A. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, belt- or direct-driven centrifugal fan utility vent sets, consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.

B. Housings:

1. Housing Material: Reinforced steel, Shaped fiberglass-reinforced plastic, Aluminum, Stainless steel or as specified on drawings.
2. Housing Coating: None, Themoplastic vinyl, Epoxy, Synthetic resin, Phenolic, Hot-dip galvanized, Powder-baked enamel or as specified on drawings.
3. Formed panels to make curved-scroll housings with shaped cutoff.
4. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
5. Discharge Arrangement: Fan scroll housing field rotatable to discharge positions. Provide fan with discharge positioned in proper direction to minimize connected duct turns.

C. Wheels:

1. Wheel Configuration: SWSI, with hub keyed to shaft.
2. Wheel and Blade Materials: Steel, Aluminum, One-piece fiberglass-reinforced plastic, Stainless steel or as specified on drawings.

    a. Spark-Resistant Construction: Classified according to AMCA 99, Section 8 Type A, Type B or Type C as specified on drawings.

3. Wheel and Blade Coating: None, Thermoplastic vinyl, Epoxy, Synthetic resin, Phenolic, Hot-dip galvanized, Powder-baked enamel or as specified on drawings.
4. Backward-Inclined Airfoil Blades:

    a. Aerodynamic design.
    b. Heavy backplate.
    c. Hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.

5. Backward-Inclined Curved Blades:

    a. Curved design.
    b. Heavy backplate.
    c. Single-thickness blades continuously welded at tip flange and backplate.

6. Backward-Inclined Flat Blades:

    a. Flat design.
    b. Heavy backplate.
    c. Single-thickness blades continuously welded at tip flange and backplate.

7. Forward-Curved Blades:

    a. Curved design.
    b. Heavy backplate.
    c. Single-thickness blades continuously welded or riveted at tip flange and backplate.

D. Shafts:

1. Turned, ground, and polished steel; keyed to wheel hub. First critical speed at least 1.4 times maximum class speed.

E. Bearings:

1. Heavy-duty regreasable ball or roller type in a cast iron pillowblock housing.
2. Ball-Bearing Rating Life: ABMA 9, L(10) of 80,000 hours or as specified on drawings.
3. Roller-Bearing Rating Life: ABMA 11, L(10) of 80,000 hours or as specified on drawings.
4. Extend grease fitting to accessible location outside of unit.

F. Belt Drive:

1. Factory mounted, with final alignment and belt adjustment made after installation.
2. Service Factor Based on Fan Motor Size: 1.5.
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with motors larger than 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Comply with OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards," 0.146 inch- thick, 3/4-inch diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

G. Motor Enclosure: Open, dripproof, Totally enclosed, fan cooled, Explosion-proof or as specified on drawings.

H. Accessories:

1. Inlet and Outlet: Flanged.
2. Companion Flanges: Rolled flanges for duct connections of same material as housing.
3. Backdraft Dampers: Gravity actuated with counterweight and interlocking aluminum blades, with felt edges in steel frame installed on fan discharge.
4. Access Door: Gasketed door in scroll with latch-type handles.
5. Scroll Dampers: Single-blade damper installed at fan scroll top with adjustable linkage.
6. Inlet Screens: Removable wire mesh.
7. Outlet Screens: Removable wire mesh.
8. Belt Guard: OSHA-compliant, completely enclosed shaft and drive components.
9. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
10. Drain Connections: NPS 3/4 threaded coupling drain connection installed at lowest point of housing.
11. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.
12. Discharge Dampers: Assembly with parallel or opposed blades constructed of two plates formed around, and to, shaft, channel frame, and sealed ball bearings, with blades linked outside of airstream to single control lever of same material as housing.
13. Grease Collection Trough and Receiver: For restaurant exhaust application.
14. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

2.9 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

B. Where variable-frequency drives are indicated or scheduled, provide fan motor compatible with variable-frequency drive.

2.10 SOURCE QUALITY CONTROL

A. AMCA Certification for Fan Sound Performance Rating: Test, rate, and label in accordance with AMCA 311.

B. AMCA Certification for Fan Aerodynamic Performance Ratings: Test, rate, and label in accordance with AMCA 211.

C. AMCA Certification for Fan Energy Index (FEI): Test, rate, and label in accordance with AMCA 211.

D. Operating Limits: Classify fans in accordance with AMCA 99, Section 14.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install centrifugal fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting:

1. Install floor- or roof-mounted centrifugal fans on cast-in-place concrete equipment base(s).
2. Support duct-mounted and other hanging centrifugal fans directly from the building structure, using suitable hanging systems as specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
3. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC." or Section 230548.13 "Vibration Controls for HVAC."

E. Curb Support, Field Built-Up: Install roof curb on roof structure, level and secure, according to "The NRCA Roofing and Waterproofing Manual," detail "Equipment Support Curb," number "SPF-9" (page 1409) and detail "Equipment Support Curb," number "SPF-9S" (page 1410).

Install and secure centrifugal fans on curbs, and coordinate roof penetrations and flashing with roof construction. Secure units to curb support with anchor bolts.

F. Curb Support, Prefabricated: Rail-type wood support provided by fan manufacturer.

G. Unit Support: Install centrifugal fans level on structural curbs or pilings. Coordinate with duct connections. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

H. Isolation Curb Support: Install centrifugal fans on isolation curbs, and install flexible duct connectors and vibration-isolation and seismic-control devices.

1. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC." or 230548.13 "Vibration Controls for HVAC."

I. Install units with clearances for service and maintenance.

J. Label fans according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK AND PIPING CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to fans to allow service and maintenance.

C. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

3.5 .STARTUP SERVICE:

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
4. Verify that cleaning and adjusting are complete.
5. For direct-drive fans, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.
6. For belt-drive fans, disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
7. Adjust belt tension.
8. Adjust damper linkages for proper damper operation.
9. Verify lubrication for bearings and other moving parts.
10. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
11. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
12. Shut unit down and reconnect automatic temperature-control operators.
13. Remove and replace malfunctioning units and retest as specified above.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

D. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.7 CLEANING

A. After completing system installation and testing, adjusting, and balancing and after completing startup service, clean fans internally to remove foreign material and construction dirt and dust

3.8 FIELD QUALITY CONTROL

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

1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Fans and components will be considered defective if they do not pass tests and inspections.

B. Prepare test and inspection reports.

3.9 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 233416

SECTION 236423.13 - AIR-COOLED, SCROLL WATER CHILLERS

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 packaged, air-cooled, electric-motor-driven, scroll water chillers.

1.3 DEFINITIONS

A. BAS: Building automation system.

B. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.

C. DDC: Direct digital control.

D. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in Btu/h to the total power input given in watts at any given set of rating conditions.

E. GFI: Ground fault interrupt.

F. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit for a single chiller calculated per the method defined by AHRI 550/590 and referenced to AHRI standard rating conditions.

G. I/O: Input/output.

H. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.

I. NPLV: Nonstandard part-load value. A single number part-load efficiency figure of merit for a single chiller calculated per the method defined by AHRI 550/590 and intended for operating conditions other than the AHRI standard rating conditions.

J. SCCR: Short-circuit current rating.

K. TEAO: Totally enclosed air over.

L. TENV: Totally enclosed nonventilating.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include refrigerant, rated capacities, operating characteristics, and furnished specialties and accessories.
2. Performance at AHRI standard conditions and at conditions indicated.
3. Performance at AHRI standard unloading conditions.
4. Minimum evaporator flow rate.
5. Refrigerant capacity of water chiller.
6. Oil capacity of water chiller.
7. Fluid capacity of evaporator.
8. Characteristics of safety relief valves.
9. Force and moment capacity of each piping connection.

B. Shop Drawings: Complete set of manufacturer's prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Weight and load distribution.
3. Required clearances for maintenance and operation.
4. Size and location of piping and wiring connections.
5. Diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Certificates: For certification required in "Quality Assurance" Article.

B. Installation instructions.

C. Source quality-control reports.

D. Startup service reports.

E. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each water chiller to include in emergency, operation, and maintenance manuals.

B. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.7 QUALITY ASSURANCE

A. AHRI Certification: Certify chiller according to AHRI 590 certification program.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Ship water chillers from the factory fully charged with refrigerant and filled with oil.

B. Package water chiller for export shipping.

1.9 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Site Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.

B. AHRI Rating: Rate water chiller performance according to requirements in AHRI 550/590.

C. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration.

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.

F. Comply with NFPA 70.

G. Comply with requirements of UL 1995, "Heating and Cooling Equipment," and include label by a qualified testing agency showing compliance.

H. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought on-line.
2. See drawings for equipment served by backup power systems.
3. Provide means and methods required to satisfy requirement even if not explicitly indicated.

I. Outdoor Installations:

1. Chiller shall be suitable for outdoor installation indicated. Provide adequate weather protection to ensure reliable service life over a 25-year period with minimal degradation due to exposure to outdoor ambient conditions.
2. Chillers equipped to provide safe and stable operation while achieving performance indicated when operating at extreme outdoor temperatures encountered by the installation. Review historical weather database and provide equipment that can operate at extreme outdoor temperatures recorded over past 30-year period.

2.2 MANUFACTURERS

A. Trane

B. Daikin Applied

C. Carrier

2.3 MANUFACTURED UNITS

A. Description: Factory-assembled and run-tested water chiller complete with compressor(s), compressor motors and motor controllers, evaporator, condenser with fans, electrical power, controls, and indicated accessories.

B. Fabricate water chiller mounting base with reinforcement strong enough to resist water chiller movement during a seismic event when water chiller is anchored to field support structure.

C. Sound-reduction package shall have the following:

1. Acoustic enclosure around compressors.
2. Reduced-speed fans with acoustic treatment.
3. Designed to reduce sound level without affecting performance.

D. Security Package: Security grilles with fasteners for additional protection of compressors, evaporator, and condenser coils. Grilles shall be coated for corrosion resistance and shall be removable for service access.

2.4 CABINET

A. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.

B. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.

C. Casing: Galvanized steel.

D. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500-hour salt-spray test according to ASTM B117.

2.5 COMPRESSOR-DRIVE ASSEMBLIES

A. Compressors:

1. Description: Positive-displacement direct drive with hermetically sealed casing.
2. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.

   a. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in lieu of each compressor.

3. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
4. Capacity Control: On-off compressor cycling.

   a. Digital compressor unloading is an acceptable alternative to achieve capacity control.

5. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug or removable magnet in sump, and initial oil charge.

   a. Manufacturer's other standard methods of providing positive lubrication are acceptable in lieu of an automatic pump.

6. Vibration Isolation: Mount individual compressors on vibration isolators.

   a. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in lieu of each compressor.

B. Compressor Motors:

1. Hermetically sealed and cooled by refrigerant suction gas.
2. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.

C. Compressor Motor Controllers:

1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.

2.6 REFRIGERATION

A. Refrigerant: R-410A. Classified as Safety Group A1 according to ASHRAE 34.

B. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

C. Refrigerant Circuit: Each circuit shall include an electronic or a thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.

D. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.

1. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in each circuit in lieu of each compressor.

E. Pressure Relief Device:

1. Comply with requirements in ASHRAE 15, ASHRAE 147, and applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Select and configure pressure relief devices to protect against corrosion and inadvertent release of refrigerant.
3. ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger.

2.7 EVAPORATOR

A. Brazed-plate as indicated.

B. Brazed Plate:

1. Direct-expansion, single-pass, brazed-plate design.
2. Type 304 or 316 stainless-steel construction.
3. Code Compliance: Tested according to ASME Boiler and Pressure Vessel Code.
4. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
5. Inlet Strainer: Factory-furnished, 20 or 40-mesh strainer for field installation in supply piping to evaporator. Manufacturer has option to factory install strainer.

C. Flow Switch: Factory-furnished and -installed, thermal-type flow switch wired to chiller operating controls.

D. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F.

2.8 AIR-COOLED CONDENSER

A. Coil(s) with integral subcooling on each circuit.

B. Copper Tube with Plate Fin Coils:

1. Construct coils of copper tubes mechanically bonded to aluminum fins.

C. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.

D. Fan Motors: TENV or TEAO enclosure, with sealed and permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.

1. Overcurrent- and thermal-overload protection not integral to motor is acceptable if provided with chiller electrical power package.

E. Fan Guards: Removable steel safety guards with corrosion-resistant PVC coating.

2.9 INSULATION

A. Closed-cell, flexible, elastomeric thermal insulation complying with ASTM C534/C534M, Type I for tubular materials and Type II for sheet materials.

1. Thickness: 3/4 inch.

B. Adhesive: As recommended by insulation manufacturer.

C. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.

1. Apply adhesive to 100 percent of insulation contact surface.
2. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
3. Seal seams and joints to provide a vapor barrier.
4. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
5. Manufacturer has option to factory or field insulate chiller components to reduce potential for damage during installation.
6. Field-Applied Insulation:

   a. Components that are not factory insulated shall be field insulated to comply with requirements indicated.
   b. Manufacturer shall be responsible for chiller insulation whether factory or field installed to ensure that manufacturer is the single point of responsibility for chillers.
   c. Manufacturer's factory-authorized service representative shall instruct and supervise installation of field-applied insulation.
   d. After field-applied insulation is complete, paint insulation to match factory-applied finish.

2.10 ELECTRICAL

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.

C. House in a unit-mounted, NEMA 250, Type 3R enclosure with hinged access door with lock and key or padlock and key.

D. Wiring shall be numbered and color-coded to match wiring diagram.

E. Factory wiring shall be located outside of an enclosure in a metal raceway. Terminal connections shall be made with not more than a 24-inch length of liquidtight or flexible metallic conduit.

F. Field power interface shall be to wire lugs NEMA KS 1, heavy-duty, nonfused disconnect switch. Minimum SCCR according to UL 508 shall be as required by electrical power distribution system, but not less than 42,000 A.

G. Each motor shall have branch power circuit and controls with one of the following disconnecting means having SCCR to match main disconnecting means:

1. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
2. NEMA KS 1, heavy-duty, nonfusible switch.
3. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

H. Each motor shall have overcurrent protection.

I. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.

J. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.

K. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.

L. Control Relays: Auxiliary and adjustable time-delay relays, or an integral to water chiller microprocessor.

M. Service Receptacle:

1. Unit-mounted, 120-V GFI duplex receptacle.
2. Power receptacle from chiller internal electrical power wiring.

2.11 CONTROLS

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Standalone, microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.

C. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.

D. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, digital display.

E. BAS or DDC System Interface: Factory-install hardware and software to enable system to monitor, control, and display chiller status and alarms.

1. Hardwired I/O Points:

a. Monitoring: On/off status, common trouble alarm electrical power demand (kilowatts) electrical power consumption (kilowatt hours).
b. Control: On/off operation, chilled-water discharge temperature set-point adjustment electrical power demand limit.

F. Factory-installed wiring outside of enclosures shall be in NFPA 70-complaint raceway. Make terminal connections with liquidtight or flexible metallic conduit.

2.12 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209.

2.13 SOURCE QUALITY CONTROL

A. Perform functional test of water chillers before shipping.

B. Factory performance test water chillers, before shipping, according to AHRI 550/590.

1. Test the following conditions:

a. Design conditions indicated.
b. AHRI 550/590 part-load points.

C. Factory test and inspect evaporator and water-cooled condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.

D. For water chillers located outdoors, rate sound power level according to AHRI 370 procedure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before water chiller installation, examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, controls, and electrical connections to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.

1. Water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping, controls, and electrical connections.

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

3.2 WATER CHILLER INSTALLATION

A. Coordinate sizes and locations of bases with actual equipment provided. Cast anchor-bolt inserts into concrete bases.

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures with actual equipment provided.

C. Install water chillers on support structure indicated.

D. Equipment Mounting:

1. Install water chillers on cast-in-place concrete equipment bases.
2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Maintain manufacturer's recommended clearances for service and maintenance.

F. Maintain clearances required by governing code.

G. Chiller manufacturer's factory-trained service personnel shall charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.

H. Install separate devices furnished by manufacturer and not factory installed.

1. Chillers shipped in multiple major assemblies shall be field assembled by chiller manufacturer's factory-trained service personnel.

3.3 PIPING CONNECTIONS

A. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements in Section 232300 "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

C. Where installing piping adjacent to chillers, allow space for service and maintenance.

D. Evaporator Fluid Connections:

1. Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage.
2. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
3. Make connections to water chiller with a union, flange or mechanical coupling.

E. Connect each drain connection with a drain valve, full size of drain connection. Connect drain pipe to drain valve with union and extend drain pipe to terminate over floor drain.

F. Connect each chiller vent connection with an automatic or a manual vent, full size of vent connection.

3.4 ELECTRICAL POWER CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Provide nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch high. Locate nameplate where easily visible.

3.5 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between chillers and other equipment to interlock operation as required to provide a complete and functioning system.

C. Connect control wiring between chiller control interface and DDC system for remote monitoring and control of chillers. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

D. Provide nameplate on face of chiller control panel indicating control equipment designation serving chiller and the I/O point designation for each control connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch high.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
2. Verify that pumps are installed and functional.
3. Verify that thermometers and gages are installed.
4. Operate water chiller for run-in period.
5. Check bearing lubrication and oil levels.
6. Verify that refrigerant pressure relief device for chillers installed indoors is vented outside.
7. Verify proper motor rotation.
8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
9. Verify and record performance of chilled-water flow and low-temperature interlocks.
10. Verify and record performance of water chiller protection devices.
11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

D. Visually inspect chiller for damage before starting. Repair or replace damaged components, including insulation. Do not start chiller until damage that is detrimental to operation has been corrected.

E. Prepare a written startup report that records results of tests and inspections.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water chillers.

1. Instructor shall be factory trained and certified.
2. Provide not less than eight hours of training.
3. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
4. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
5. Obtain Owner sign-off that training is complete.
6. Owner training shall be held at Project site.

END OF SECTION 236423.13

SECTION 237313.16 - INDOOR, SEMI-CUSTOM AIR-HANDLING 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.

1.2 SUMMARY

A. Section includes insulated, double-wall-casing, indoor, semi-custom air-handling units that are factory assembled using multiple section components, including the following:

1. Casings.
2. Fans, drives, and motors.
3. Coils.
4. Air filtration.
5. Dampers.
6. Air-to-air energy recovery.
7. Diffuser.

1.3 ACTION SUBMITTALS

A. Product Data: For each air-handling unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:

    a. Include certified fan-performance curves with system operating conditions indicated.
    b. Include certified fan-sound power ratings.
    c. Include fan construction and accessories.
    d. Include motor ratings, electrical characteristics, and motor accessories.

6. Include certified coil-performance ratings with system operating conditions indicated.
7. Include filters with performance characteristics.
8. Include dampers, including housings, linkages, and operators.

B. Shop Drawings: For each type and configuration of indoor, semi-custom air handling unit.

1. Include plans, elevations, sections, mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of indoor, semi-custom air-handling units, as well as procedures and diagrams.
4. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Seismic Qualification Data: Certificates for air-handling units, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Restraint of internal components.

C. Source quality-control reports.

D. Startup service reports.

E. Field quality-control reports.

F. Sample Warranty: For manufacturer's warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Filters: One set(s) for each air-handling unit.
2. Gaskets: One set(s) for each access door.
3. Fan Belts: One set(s) for each air-handling unit fan.

1.7 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of indoor, semi-custom air-handling units that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Manufacturers standard year(s) from date of Substantial Completion or as required by project.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

F. Structural Performance: Casing panels shall be self-supporting and capable of withstanding positive/negative 8-inch wg of internal static pressure, without exceeding a midpoint deflection of 0.0042 inch/inch of panel span.

G. Casing Leakage Performance: ASHRAE 111, Class 6 leakage or better at plus or minus 8 inch wg.

H. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0.

2.2 MANUFACTURERS

A. Trane

B. Daiken Applied

C. York

2.3 UNIT CASINGS

A. Frame: Modular and providing overall structural integrity without reliance on casing panels for structural support.

B. Base Rail:

1. Material: Galvanized steel or Welded structural steel.
2. Height: 6 inches.

C. Casing Joints: Hermetically sealed at each corner and around entire perimeter.

D. Double-Wall Construction:

1. Outside Casing Wall:

a. Material, Galvanized Steel: Minimum 16 gauge or 14 gauge thick.
b. Material, Aluminum: Minimum 14 gauge or 12 gauge thick.
c. Material, Stainless Steel: Minimum 16 gauge or 14 gauge thick.
d. Factory Finish: Provide manufacturer's standard finish.

2. Inside Casing Wall:

a. Material, Galvanized Steel: Solid or Perforated, minimum 16 gauge thick.
b. Material, Aluminum: Solid or Perforated, minimum 14 gauge thick.
c. Material, Stainless Steel: Solid or Perforated, minimum 16 gauge thick.
d. Antimicrobial Coating: Applied during the manufacturing process. EPA approved, NSF approved or FDA listed.

E. Floor Plate:

1. Material, Galvanized Steel: Treadplate, minimum 14 gauge or 12 gauge thick.
2. Material, Aluminum: Treadplate, minimum 12 gauge thick.
3. Material, Stainless Steel: Treadplate, minimum 14 gauge or 12 gauge thick.
4. Antimicrobial Coating: Applied during the manufacturing process. EPA approved, NSF approved or FDA listed.

F. Casing Insulation:

1. Materials: Glass-fiber blanket or board insulation, Type I or Type II ASTM C1071 ,Injected polyurethane foam insulation or Glass-fiber insulation layered over injected foam in perforated interior casing sections to meet specified acoustic requirements.
2. Casing Panel R-Value: Minimum R-13.
3. Insulation Thickness: 2 inches.

4. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.

G. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

H. Static-Pressure Classifications:

1. For Unit Sections Upstream of Fans: Minus 3-inch wg or 4-inch wg as required.
2. For Unit Sections Downstream and Including Fans: 3-inch wg or 4-inch wg as required.

I. Panels, Doors, and Windows:

1. Panels:

a. Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against airflow
c. Gasket: Neoprene, applied around entire perimeters of panel frames.
d. Size: Large enough to allow unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 18 inches wide by full height of unit casing up to a maximum height of 72 inches.

2. Doors:

a. Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
b. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
c. Gasket: Neoprene, applied around entire perimeters of panel frames.
d. Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 24 inches wide by full height of unit casing up to a maximum height of 72 inches.

3. Windows:

a. Construction: Fabricate windows in access panels and doors of double-glazed, safety glass with an airspace between panes and sealed with interior and exterior rubber seals.
b. Size: Minimum 6 inches, square or round.

4. Locations and Applications:

a. Fan Section: Doors or Panels.
b. Coil Section: Panels.
c. Access Section: Doors or Panels.

d. Access Sections Immediately Upstream and Downstream of Coil Sections: Doors or Panels.
e. Damper Section: Doors or Panels.
f. Filter Section: Doors or Panels large enough to allow periodic removal and installation of filters.
g. Access Sections Immediately Upstream and Downstream of Filter Sections: Doors or Panels.
h. Mixing Section: Doors or Panels.
i. Humidifier Section: Doors or Panels.

5. Service Lights: LED vaporproof luminaire with individual switched junction box located, adjacent to access.

a. Locations: Fan section.

6. Convenience Outlets: One 20-A duplex GFCI receptacle with junction box located on outside casing wall.

a. Locations: Fan section.

J. Condensate Drain Pans:

1. Construction:

a. Single-wall, galvanized-steel, noncorrosive polymer or stainless-steel sheet.
b. Double-wall, galvanized-steel, noncorrosive polymer or stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.

2. Drain Connection:

a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end both ends of pan.
b. Minimum Connection Size: NPS 1.

3. Slope: Minimum 0.125-in./ft. slope, to comply with ASHRAE 62.1, in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
4. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1.
5. Width: Entire width of water producing device.
6. Depth: A minimum of 2 inches deep.
7. Formed sections or Integral part of floor plating.
8. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.
9. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

2.4 FAN, DRIVE, AND MOTOR SECTION

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

B. Fans: Centrifugal, galvanized steel; mounted on solid-steel shaft.

1. Shafts: With field-adjustable alignment.

   a. Turned, ground, and polished hot-rolled steel with keyway.

2. Shaft Bearings:

   a. Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with an L-50 rated life of 200,000 hours according to ABMA 9.
   b. Grease-Lubricated, Tapered-Roller Bearings: Self-aligning, pillow-block type with double-locking collars and two-piece, cast-iron housing with grease lines extended to outside unit and an L-50 rated life of 200,000 hours according to ABMA 11.
   c. Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing with grease lines extended to outside unit and an L-50 rated life of 200,000.

3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

   a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.

4. Housings, Plenum Fans: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.
5. Plenum Fan Arrays: Contained or Uncontained as defined in AHRI 430. Steel or aluminum frame with inlet cone and structural framing around each fan built into an array of multiple fans. Provide backdraft or motorized dampers at each fan to prevent short circuiting of flow if one fan is not operating.
6. Backward-Inclined, Centrifugal Fan Wheels: Construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; steel or aluminum hub riveted to backplate and fastened to shaft with setscrews.
7. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; steel or aluminum hub swaged to backplate and fastened to shaft with setscrews.
8. Airfoil, Centrifugal Fan Wheels (Plenum Fan Wheels): Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; steel hub riveted to backplate and fastened to shaft with setscrews.
9. Mounting: For internal vibration isolation and seismic control. Factory-mount fans with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 1 inch.
10. Shaft Lubrication Lines: Extended to a location outside the casing.

11. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch-wide by 0.028-inch- thick, galvanized-steel sheet or 0.032-inch- thick, aluminum sheets.

    a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

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

C. Drive, Direct: Factory-mounted, direct drive.

D. Drive, Belt: Factory-mounted, V-belt drive, with adjustable alignment and belt tensioning, and with 1.5 1.25 service factor based on fan motor.

1. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
2. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.
3. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.146-inch- thick, 3/4-inch diamond-mesh wire screen, welded to steel angle frame; prime coated

E. Motors:

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
3. Enclosure Type: Open, dripproof or Totally enclosed, fan cooled.
4. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

F. Variable-Frequency Motor Controller: Serving each fan individually or all fans combined in fan array.

1. Manufactured Units: Pulse-width modulated; constant torque and variable torque for Design A and Design B inverter-duty motors.
2. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range or 66 Hz, with torque constant as speed changes; maximum voltage equals input voltage.
3. Unit Operating Requirements:

    a. Internal Adjustability:

1) Minimum Speed: 5 to 25 percent of maximum rpm.
2) Maximum Speed: 80 to 100 percent of maximum rpm.
3) Acceleration: 0.1 to 999.9 seconds.
4) Deceleration: 0.1 to 999.9 seconds.
5) Current Limit: 30 to minimum of 150 percent of maximum rating.

b. Self-Protection and Reliability Features:

1) Surge suppression.
2) Loss of input signal protection.
3) Under- and overvoltage trips.
4) Variable-frequency motor controller and motor-overload/overtemperature protection.
5) Critical frequency rejection.
6) Loss-of-phase protection.
7) Reverse-phase protection.
8) Motor-overtemperature fault.

c. Bidirectional autospeed search.
d. Torque boost.
e. Motor temperature compensation at slow speeds.

1) Panel-mounted operator station.
2) Historical logging information and displays.
3) Digital indicating devices.

f. Control Signal Interface: Electric.
g. Proportional Integral Directive (PID) control interface.
h. DDC system for HVAC Protocols for Network Communications: ASHRAE 135.

4. Line Conditioning:

a. Input line conditioning.
b. Output filtering.
c. EMI/RFI filtering.

5. Bypass Systems:

a. Bypass Mode: Field-selectable automatic or manual.
b. Bypass Controller, Two-Contactor Style: With bypass and output isolating contactors and isolating switch.
c. Bypass Controller, Three-Contactor Style: With bypass and input and output isolating contactors and isolating switch.
d. Bypass Contactor Configuration: Full-voltage (across the line) or Reduced-voltage (autotransformer) type.

2.5 COIL SECTION

A. General Requirements for Coil Section:

1. Comply with AHRI 410.
2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. For multizone units, provide air deflectors and air baffles to balance airflow across coils.
4. Coils shall not act as structural component of unit.

B. Preheat Coils:

1. Electrical Coils, Controls, and Accessories: Comply with UL 1995.

    a. Casing Assembly: Slip-in or Flanged type with galvanized-steel frame.
    b. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
    c. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
    d. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
    e. Control Panel: Unit or Remote mounted with disconnecting means and overcurrent protection.

        1) Magnetic or Mercury contactor.
        2) Solid-state, stepless pulse controller.
        3) Toggle switches, one per step.
        4) Step controller.
        5) Time-delay relay.
        6) Pilot lights, one per step.
        7) Airflow proving switch.

2. Hot-Water Coils: Continuous circuit, Self-draining, Cleanable.

    a. Piping Connections: Threaded or Flanged, same end of coil.
    b. Tube Material: Copper.
    c. Fin Type: Plate.
    d. Fin Material: Aluminum.
    e. Fin Spacing: Maximum 12 fins per inch.
    f. Fin and Tube Joint: Mechanical bond or Silver brazed.
    g. Headers:

        1) Cast iron with cleaning plugs and drain and air vent tappings extended to exterior of unit.
        2) Seamless copper tube with brazed joints, prime coated.
        3) Fabricated steel, with brazed joints, prime coated.
        4) Provide insulated cover to conceal exposed outside casings of headers.

    h. Frames: Channel frame, 0.0625-inch- thick, galvanized steel or 0.0625-inch- thick, stainless steel.
    i. Coil Working-Pressure Ratings: 200 psig, 325 deg F.

j. Coating: None Corrosion-resistant coating.
k. Integral Face-and-Bypass Dampers: Horizontal or Vertical, opposed-blade, galvanized-steel, aluminum or extruded-aluminum dampers with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel, aluminum or extruded-aluminum frame, with operating rods connected with a common linkage. Meeting edges of blades shall have gaskets and edge seals, and blades shall be mechanically fastened.

3. Steam Coils: Distributed Single tube.

a. Piping Connections: Threaded or Flanged, same end of coil.
b. Tube Material: Copper.
c. Fin Type: Plate.
d. Fin Material: Aluminum.
e. Fin Spacing: Maximum 12 fins per inch.
f. Fin and Tube Joint: Mechanical bond or Silver brazed.
g. Headers:

1) Cast iron with cleaning plugs and drain and air vent tappings extended to exterior of unit.
2) Seamless copper tube with brazed joints, prime coated.
3) Fabricated steel, with brazed joints, prime coated.
4) Provide insulated cover to conceal exposed outside casings of headers.

h. Frames: Channel frame, 0.0625-inch- thick, galvanized steel or 0.0625-inch- thick, stainless steel.
i. Coil Working-Pressure Ratings: 200 psig, 325 deg F.
j. Coating: None or Corrosion-resistant coating as required.
k. Integral Face-and-Bypass Dampers: Horizontal or Vertical, opposed-blade, galvanized-steel, aluminum or extruded-aluminum dampers with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel, aluminum or extruded-aluminum frame, with operating rods connected with a common linkage. Meeting edges of blades shall have gaskets and edge seals, and blades shall be mechanically fastened.

C. Heating Coils:

1. Electrical Coils, Controls, and Accessories: Comply with UL 1995.

a. Casing Assembly: Slip-in or Flanged type with galvanized-steel frame.
b. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
c. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
d. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.

e. Control Panel: Unit or Remote mounted with disconnecting means and overcurrent protection.

1) Magnetic or Mercury contactor.
2) Solid-state, stepless pulse controller.
3) Toggle switches, one per step.
4) Step controller.
5) Time-delay relay.
6) Pilot lights, one per step.
7) Airflow proving switch.

2. Hot-Water Coils: Continuous circuit, Self-draining, Cleanable.

a. Piping Connections: Threaded or Flanged, same end of coil.
b. Tube Material: Copper.
c. Fin Type: Plate.
d. Fin Material: Aluminum.
e. Fin Spacing: Maximum 12 fins per inch.
f. Fin and Tube Joint: Mechanical bond or Silver brazed.
g. Headers:

1) Cast iron with cleaning plugs and drain and air vent tappings extended to exterior of unit.
2) Seamless copper tube with brazed joints, prime coated.
3) Fabricated steel, with brazed joints, prime coated.
4) Provide insulated cover to conceal exposed outside casings of headers.

h. Frames: Channel frame, 0.0625-inch- thick, galvanized steel or 0.0625-inch- thick, stainless steel.
i. Coil Working-Pressure Ratings: 200 psig, 325 deg F.
j. Coating: None Corrosion-resistant coating.

3. Steam Coils: Distributed or Single tube.

a. Piping Connections: Threaded or Flanged, same end of coil.
b. Tube Material: Copper.
c. Fin Type: Plate.
d. Fin Material: Aluminum.
e. Fin Spacing: Maximum 12 fins per inch.
f. Fin and Tube Joint: Mechanical bond or Silver brazed.
g. Headers:

1) Cast iron with cleaning plugs and drain and air vent tappings extended to exterior of unit.
2) Seamless copper tube with brazed joints, prime coated.
3) Fabricated steel, with brazed joints, prime coated.
4) Provide insulated cover to conceal exposed outside casings of headers.

h. Frames: Channel frame, 0.0625-inch- thick, galvanized steel or 0.0625-inch- thick, stainless steel.
i. Coil Working-Pressure Ratings: 200 psig, 325 deg F.
j. Coating: None Corrosion-resistant coating.

D. Cooling Coils:

1. Chilled-Water Coil: Continuous circuit, Self-draining, Cleanable.

a. Piping Connections: Threaded or Flanged, same end of coil.
b. Tube Material: Copper.
c. Fin Type: Plate.
d. Fin Material: Aluminum.
e. Fin Spacing: Maximum 12 fins per inch.
f. Fin and Tube Joint: Mechanical bond or Silver brazed.
g. Headers:

1) Cast iron with cleaning plugs and drain and air vent tappings extended to exterior of unit.
2) Seamless copper tube with brazed joints, prime coated.
3) Fabricated steel, with brazed joints, prime coated.
4) Provide insulated cover to conceal exposed outside casings of headers.

h. Frames: Channel frame, 0.0625-inch- thick, galvanized steel or 0.0625-inch- thick, stainless steel.
i. Coatings: None or Corrosion-resistant coating as required.
j. Working-Pressure Ratings: 200 psig, 325 deg F.

2. Refrigerant Coil:

a. Tubes: Copper.
b. Fins:

1) Material: Aluminum.
2) Fin Spacing: Maximum 12 fins per inch.

c. Fin and Tube Joints: Mechanical bond.
d. Headers: Seamless-copper headers with brazed connections.
e. Frames: Galvanized steel or Stainless steel.
f. Coatings: None Corrosion-resistant coating.
g. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

1) Working Pressure: Minimum 300 psig.

2.6 AIR FILTRATION SECTION

A. Panel Filters:

1. Description: Pleated factory-fabricated, self-supported, disposable air filters with holding frames.
2. Filter Unit Class: UL 900.
3. Media: Interlaced glass, synthetic or cotton fibers coated with nonflammable adhesive.
4. Filter-Media Frame: Beverage board with perforated metal retainer, or metal grid, on outlet side.

B. Bag Filters:

1. Description: Factory-fabricated, dry, extended-surface, self-supporting filters with holding frames in steel, basket-type retainers.
2. Filter Unit Class: UL 900.
3. Media: Fibrous material, coated with antimicrobial agent, constructed so individual pockets are maintained in tapered form by flexible internal supports under rated-airflow conditions.
4. Filter-Media Frame: Galvanized steel.

C. Cartridge Filters:

1. Description: Factory-fabricated, adhesive-coated disposable, packaged air filters with media perpendicular to airflow, and with holding frames.
2. Filter Unit Class: UL 900.
3. Media: Fibrous material, coated with antimicrobial agent, constructed so individual pleats are maintained in pleated form under rater-airflow conditions by corrugated aluminum separators.
4. Filter Media Frame: Galvanized steel.

D. Adhesive, Sustainability Projects: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.

E. Front- or Back-Access Filter Mounting Frames:

1. Particulate Air Filter Frames: 4” thick Galvanized-steel or Aluminum framing members with access for filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.

   a. Prefilters: Incorporate a separate 2-inch- thick track with spring clips, with same access as primary filter.
   b. Sealing: Full periphery foam gaskets.

2. HEPA Filter Frames: Aluminum or Stainless-steel framing members, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation operation. Bolted filter-sealing mechanism shall mount and continuously seal each individual filter.

   a. Prefilters: Incorporate a separate 4-inch- thick track with spring clips with same access as primary filter.

b. Sealing: Gasketed or gel, hand-crank locking mechanism to provide positive-sealing for each filter to ensure seal between filter elements to prevent bypass of unfiltered air.

3. Gas-Phase Air Filter Frames: Galvanized-steel or Aluminum framing members with access for filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.

   a. Prefilters: Incorporate a separate 2-inch- thick track with spring clips.
   b. Sealing: Full periphery foam gaskets or Positive-sealing-device for each row of filters to ensure seal between gasketed filter elements to prevent bypass of unfiltered air.

F. Side-Access Filter Mounting Frames:

1. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. 4” thick Galvanized steel or Aluminum track.

   a. Prefilters: Incorporate an integral 2-inch- thick track with same access as primary filter.
   b. Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2. HEPA Filter Frames:

   a. Frames: Match inner casing and outer casing material, and insulation thickness. Aluminum or Stainless steel track.
   b. Prefilters: Incorporate an integral 4-inch- thick track,
   c. Sealing: Incorporate positive-sealing clamping device on each filter between gasket or gel seal on all sides of filter cartridge frames to prevent bypass of unfiltered air.

3. Gas-Phase Air Filter Frames:

   a. Frames: Matching inner casing and outer casing material, and insulation thickness. Galvanized-steel or Aluminum track.
   b. Prefilters: Incorporate an integral 2-inch- thick track.
   c. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2.7 DAMPERS

A. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel, aluminum or extruded-aluminum dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed or parallel-blade arrangement with zinc-plated steel operating rods rotating in stainless steel sleeve, sintered bronze or nylon bearings mounted in a single galvanized-steel, aluminum or extruded-aluminum frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg , tested, rated, and labeled in accordance with AMCA 511.

B. Face-and-Bypass Dampers: Opposed-blade, galvanized-steel, aluminum or extruded-aluminum dampers with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel, aluminum or extruded-aluminum frame and with operating rods connected with a common linkage. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.

C. Zone Dampers: Two single-blade, galvanized-steel, aluminum or extruded-aluminum dampers offset 90 degrees from each other on zinc-plated steel operating rod rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel, aluminum orextruded-aluminum frame. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.

D. Electronic Damper Operators:

1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
2. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
3. Operator Motors:

    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements.
    b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
    c. 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.

4. 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.
5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
6. Size dampers 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.

7. Coupling: V-bolt and V-shaped, toothed cradle.
8. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
9. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.

10. Power Requirements (Two-Position Spring Return): 24 V dc, 120 V ac, 230 V ac as required.
11. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
12. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
13. Temperature Rating: Minus 22 to plus 122 deg F.

E. Mixing Section: Multiple-blade, air-mixer assembly located immediately downstream of mixing section.

2.8 AIR-TO-AIR ENERGY RECOVERY UNITS

A. Heat Wheels:

1. Casing:

a. Galvanized steel, stainless steel, or aluminum with manufacturer's standard finish.
b. Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg differential pressure.
c. Casing seals on periphery of rotor, on duct divider, and on purge section.
d. Support rotor on grease-lubricated ball bearings with extended grease fittings. Mount horizontal wheels on tapered roller bearing.

2. Rotor, Aluminum or Polymer: Segmented wheel, strengthened with radial spokes, with nontoxic, noncorrosive, silica-gel desiccant coating.
3. Rotor - Aluminum, Metallic, or Polymer: Segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, 3-angstrom molecular-sieve desiccant coating.
4. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable-frequency controller. Permanently lubricated wheel bearings with an L-10 bearing life 400,000 hours.
5. Controls:

a. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
b. Variable-frequency controller, factory mounted and wired, permitting input of field connected 4- to 20-mA or 1- to 10-V control signal.
c. Variable-frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.
d. Variable-frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain exhaust temperature above freezing and air differential temperature above set point. Provide maximum rotor speed when exhaust-air temperature is less than outdoor-air temperature.
e. Pilot-Light Indicator: Display rotor rotation and speed.
f. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.

B. Fixed-Plate Sensible Heat Exchangers:

1. Casing: Aluminum or Galvanized steel.
2. Plates: Evenly spaced and sealed and arranged for counter 0r cross airflow.
3. Plate Material: Embossed aluminum, Stainless steel or High-density plastic.
4. Plate Coating: Epoxy.
5. Bypass: Plenum within casing, with gasketed face-and-bypass dampers that have operating rods extended outside casing.
6. Heat-Exchanger Prefilters: 2 inches thick, disposable MERV 6.

2.9 DIFFUSERS

A. Description: Velocity profile equalizer device for providing equalized airflow profile downstream of Type DWDI fans.

B. Material: Galvanized steel or Aluminum.

2.10 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B 09.

E. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a 3000-hour salt-spray test according to ASTM B117.

1. Standards:

   a. ASTM B117 for salt spray.
   b. ASTM D2794 for minimum impact resistance of 100 in-lb.
   c. ASTM B3359 for cross hatch adhesion of 5B.

2. Application: Immersion or Spray.
3. Thickness: 1 mil.
4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.11 SOURCE QUALITY CONTROL

A. AHRI 430 Certification: Test, rate, and label air-handling units and their components in accordance with AHRI 430.

B. AHRI 1060 Certification: Test, rate, and label air-handling units that include air-to-air energy recovery devices in accordance with AHRI 1060.

C. AHRI 260 or AMCA 311 Sound Performance Rating Certification: Test, rate, and label in accordance with AHRI 260 or AMCA 311.

D. Fan Aerodynamic Performance Rating: Factory test and rate fan performance for airflow, pressure, power, air density, rotation speed, and efficiency in accordance with AMCA 210.

E. Fan Energy Index (FEI): Test in accordance with AMCA 210 and rate in accordance with AMCA 99, AMCA 207, and AMCA 208.

F. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.

G. Water Coils: Factory tested to 300 psig according to AHRI 410 and ASHRAE 33.

H. Steam Coils: Factory tested to 300 and 200 psig underwater according to AHRI 410 and ASHRAE 33.

I. Refrigerant Coils: Factory tested to minimum 450-psig internal pressure and to minimum 300-psig internal pressure while underwater, according to AHRI 410 and ASHRAE 33.

J. Witnessed Casing Leakage Tests:

1. Pay for all expenses, for one representative designated by Owner, to travel to the factory to witness cabinet air-leakage testing on the specific assembled unit(s) prior to release for delivery to Project site.
2. If the unit(s) does not meet specified leakage requirements, perform factory modifications and retest. Do not release unit for shipment until tested leakage is measured to be within specified leakage and leakage testing report has been accepted by Owner's designated representative.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

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

3.2 INSTALLATION, GENERAL

A. Equipment Mounting:

1. Install air-handling units on cast-in-place concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers.

C. Arrange installation of units to provide access space around air-handling units for service and maintenance.

D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

E. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

F. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

3.3 PIPING CONNECTIONS

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

B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4, ASTM B88, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

F. Steam and Condensate Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install shutoff valve at steam supply connections, float and thermostatic trap, and union or flange at each coil return connection. Install gate valve and inlet strainer at supply connection of dry steam humidifiers, and inverted bucket steam trap to condensate return connection.

G. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
6. Verify that zone dampers fully open and close for each zone.
7. Verify that face-and-bypass dampers provide full face flow.
8. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
9. Comb coil fins for parallel orientation.

10. Verify that proper thermal-overload protection is installed for electric coils.
11. Install new, clean filters.
12. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.7 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

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

3.8 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.9 FIELD QUALITY CONTROL

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

1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
2. Charge refrigerant coils with refrigerant and test for leaks.
3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. HEPA Filters: Pressurize housing to a minimum of 3-inch wg or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.

5. HEPA Filters, Critical Applications: Pressurize housing to a minimum of 3-inch wg or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter for air leaks according to ASME AG-1, pressure-decay method.
6. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 237313.16

SECTION 237416.11 - PACKAGED, SMALL-CAPACITY, ROOFTOP AIR-CONDITIONING 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.

1.2 SUMMARY

A. Section includes packaged, small-capacity, rooftop air-conditioning units (RTUs) with the following components:

1. Casings.
2. Fans, drives, and motors.
3. Coils.
4. Refrigerant circuit components.
5. Air filtration.
6. Dampers.
7. Electrical power connections.
8. Controls.
9. Roof curbs.
10. Accessories.

1.3 DEFINITIONS

A. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, small-capacity, rooftop air-conditioning units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

1.4 ACTION SUBMITTALS

A. Product Data: For each RTU.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, dimensions, required clearances, characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:
    a. Include certified fan-performance curves with system operating conditions indicated.
    b. Include certified fan-sound power ratings.

c. Include fan construction and accessories.
d. Include motor ratings, electrical characteristics, and motor accessories.

6. Include certified coil-performance ratings with system operating conditions indicated.
7. Include filters with performance characteristics.
8. Include gas furnaces with performance characteristics.
9. Include dampers, including housings, linkages, and operators.

B. Shop Drawings: For each packaged, small-capacity, rooftop air-conditioning unit.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Include design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Sample Warranty: For manufacturer's warranty.

C. Source quality-control reports.

D. System startup reports.

E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Filters: One set of filters for each unit.

2. Gaskets: One set(s) for each access door.
3. Fan Belts: One set(s) for each belt-driven fan.
4. Filters: One set(s) of filters for each unit.

1.8 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of outdoor, semi-custom, air-handling unit that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 1 year(s) from date of Substantial Completion.
2. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of RTUs and components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE 15 Compliance: For refrigeration system safety.

E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. UL Compliance: Comply with UL 1995.

G. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design mounting and restraints for RTUs, including comprehensive engineering analysis.

2.2 MANUFACTURERS

A. <u>TRANE</u>

B. <u>CARRIER</u>

C. DAIKIN APPLIED

2.3 UNIT CASINGS

A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

B. Double-Wall Construction:

1. Outside Casing Wall: Galvanized steel, minimum 18 gauge thick with manufacturer's standard finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
2. Inside Casing Wall: G90 -coated galvanized steel, 0.034 inch thick.
3. Floor Plate: G90 galvanized steel thick.
4. Casing Insulation:

a. Materials: Injected polyurethane foam insulation.
b. Insulation Thickness: 1 inch.
c. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.

C. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

D. Static-Pressure Classifications:

1. For Unit Sections Upstream of Fans: Minus 2-inch wg.
2. For Unit Sections Downstream and Including Fans: 2-inch wg.

E. Panels and Doors:

1. Panels:

a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
c. Gasket: Neoprene, applied around entire perimeters of panel frames.
d. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.

2. Access Doors:

a. Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
b. Gasket: Neoprene, applied around entire perimeters of panel frames.
c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.

3. Locations and Applications:

a. Fan Section: Inspection and access panels.
b. Access Section: Doors.
c. Coil Section: Inspection and access panels.
d. Damper Section: Inspection and access panels.
e. Filter Section: Inspection and access panels large enough to allow periodic removal and installation of filters.
f. Mixing Section: Doors.

F. Condensate Drain Pans:

1. Location: Each type of cooling coil.
2. Construction:

a. Single-wall, galvanized-steel or noncorrosive polymer sheet.

3. Drain Connection:

a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
b. Minimum Connection Size: NPS 1.

4. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.
5. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

2.4 FANS, DRIVES, AND MOTORS

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

B. Supply-Air Fans: Centrifugal, rated according to AMCA 210; galvanized or painted steel; mounted on solid-steel shaft.

1. Shafts: With field-adjustable alignment.

a. Turned, ground, and polished hot-rolled steel with keyway.

2. Shaft Bearings:

a. Heavy-duty, self-aligning, pillow-block type with an L-50 rated life of minimum 100,000 hours according to ABMA 9.

3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.

4. Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; steel or aluminum hub swaged to backplate and fastened to shaft with setscrews.
5. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 1 inch.
6. Shaft Lubrication Lines: Extended to a location outside the casing.
7. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch-wide by 0.028-inch-thick, galvanized-steel sheet.

   a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

C. Drives, Direct: Factory-mounted, direct drive.

D. Condenser-Coil Fan: Variable-speed propeller, mounted on shaft of permanently lubricated ECM motors.

E. Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Enclosure Type: Open, dripproof.

2.5 COILS

A. General Requirements for Coils:

1. Comply with AHRI 410.
2. Fabricate coils section to allow for removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. Coils shall not act as structural component of unit.

B. Supply-Air Refrigerant Coil:

1. Tubes: Copper.
2. Fins:

   a. Material: Aluminum.

3. Fin and Tube Joints: Mechanical bond.
4. Headers: Seamless-copper headers with brazed connections.
5. Frames: Galvanized steel.
6. Coatings: None.
7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

   a. Working Pressure: Minimum 300 psig.

2.6 REFRIGERANT CIRCUIT COMPONENTS

A. Compressor: Hermetic, variable-speed scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief.

B. Refrigeration Specialties:

1. Refrigerant: R-410A.
2. Expansion valve with replaceable thermostatic element.
3. Refrigerant filter/dryer.
4. Manual-reset high-pressure safety switch.
5. Automatic-reset low-pressure safety switch.
6. Minimum off-time relay.
7. Automatic-reset compressor motor thermal overload.
8. Brass service valves installed in compressor suction and liquid lines.

2.7 AIR FILTRATION

A. Panel Filters:

1. Description: Pleated factory-fabricated, self-supported, disposable air filters with holding frames.
2. Filter Unit Class: UL 900.
3. Media: Interlaced glass, synthetic or cotton fibers coated with nonflammable adhesive and antimicrobial coating.

2.8 DAMPERS

A. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade arrangement with Zinc-plated steel operating rods rotating in bearings mounted in a single frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg.

B. Barometric relief dampers.

C. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."

D. Electronic Damper Operators:

1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
2. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
3. Operator Motors:

    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
c. 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.

4. Size dampers 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.

5. Coupling: V-bolt and V-shaped, toothed cradle.
6. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
7. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
8. Power Requirements (Two-Position Spring Return): 120 V ac.
9. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
10. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
11. Temperature Rating: 40 to 104 deg F.
12. Run Time: 30 seconds.

2.9 ELECTRICAL POWER CONNECTIONS

A. RTU shall have a single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

2.10 CONTROLS

A. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

B. Basic Unit Controls:

1. Control-voltage transformer.
2. Wall-mounted thermostat or sensor with the following features:

   a. Heat-cool-off switch.
   b. Fan on-auto switch.
   c. Fan-speed switch.
   d. Automatic changeover.
   e. Adjustable deadband.
   f. Degree F indication.
   g. Unoccupied-period-override push button.
   h. Data entry and access port to input temperature and humidity set points, occupied and unoccupied periods, and output room temperature and humidity, supply-air temperature, operating mode, and status.

3. Wall-mounted humidistat or sensor with the following features:

   a. Exposed set point.
   b. Exposed indication.

4. Unit-Mounted Annunciator Panel for Each Unit:

   a. Lights to indicate power on, cooling, heating, fan running, filter dirty, and unit alarm or failure.
   b. DDC controller or programmable timer and interface with HVAC instrumentation and control system.
   c. Digital display of outdoor-air temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.

C. DDC Controller:

1. Controller shall have volatile-memory backup.
2. Safety Control Operation:

   a. Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire-alarm control panel.
   b. Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply-air temperature is less than 40 deg F.
   c. Defrost Control for Condenser Coil: Pressure differential switch to initiate defrost sequence.

3. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
4. Unoccupied Period:

   a. Heating Setback: 10 deg F.
   b. Cooling Setback: System off.
   c. Override Operation: Two hours.

5. Supply Fan Operation:

   a. Occupied Periods: Run fan continuously.
   b. Unoccupied Periods: Cycle fan to maintain setback temperature.

6. Refrigerant Circuit Operation:

   a. Occupied Periods: Cycle or stage compressors to match compressor output to cooling load to maintain room temperature and humidity. Cycle condenser fans to maintain maximum hot-gas pressure. Operate low-ambient control kit to maintain minimum hot-gas pressure.
   b. Unoccupied Periods: Cycle compressors and condenser fans for heating to maintain setback temperature.
   c. Switch reversing valve for heating or cooling mode on air-to-air heat pump.

7. Terminal-Unit Relays:

a. Provide heating- and cooling-mode changeover relays compatible with terminal control system required in Section 233600 "Air Terminal Units" and Section 230923 "Direct Digital Control (DDC) System for HVAC."

D. Interface Requirements for HVAC Instrumentation and Control System:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
3. Provide BACnet compatible interface for central HVAC control workstation for the following:

a. Adjusting set points.
b. Monitoring supply fan start, stop, and operation.
c. Inquiring data to include outdoor-air damper position, supply- and room-air temperature and humidity.
d. Monitoring occupied and unoccupied operations.
e. Monitoring constant and variable motor loads.
f. Monitoring variable-frequency drive operation.
g. Monitoring cooling load.
h. Monitoring economizer cycles.
i. Monitoring air-distribution static pressure and ventilation air volume.

2.11 ROOF CURBS

A. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

a. Materials: ASTM C1071, Type I or II.
b. Thickness: 1 inch.

2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.

a. Liner Adhesive: Comply with ASTM C916, Type I.
b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
c. Liner materials applied in this location shall have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
d. Liner Adhesive: Comply with ASTM C916, Type I.

B. Curb Dimensions: Height of 14 inches.

2.12 ACCESSORIES

A. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.

B. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.

C. Remote potentiometer to adjust minimum economizer damper position.

D. Return-air bypass damper.

E. Factory- or field-installed, demand-controlled ventilation.

F. Coil guards of painted, galvanized-steel wire.

G. Door switches to disable heating or reset set point when open.

H. Oil separator.

2.13 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209.

2.14 SOURCE QUALITY CONTROL

A. AHRI Compliance:

1. Comply with AHRI 210/240 for testing and rating energy efficiencies for RTUs.
2. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.
3. Comply with AHRI 270 for testing and rating sound performance for RTUs.
4. Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.

B. AMCA Compliance:

1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.

2. Damper leakage tested according to AMCA 500-D.
3. Operating Limits: Classify according to AMCA 99.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.

B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.

C. Examine roofs for suitable conditions where RTUs will be installed.

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

3.2 INSTALLATION

A. Roof Curb: Install on roof structure or concrete base, level and secure. Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.

B. Unit Support: Install unit level on structural steel supports. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.

C. Equipment Mounting:
1. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.3 PIPING CONNECTIONS

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

B. Where installing piping adjacent to RTU, allow space for service and maintenance.

C. Connect piping to unit mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4, ASTM B88, Type M copper tubing. Extend to nearest equipment or roof drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

3.4 DUCT CONNECTIONS

A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination at top of roof curb.
2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
4. Install return-air duct continuously through roof structure.

3.5 ELECTRICAL CONNECTIONS

A. Connect electrical wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs as specified in Section 260553 "Identification for Electrical Systems."
2. Locate nameplate where easily visible.

3.6 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.7 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B.

C. Tests and Inspections:

1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. RTU will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.8 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Inspect for visible damage to unit casing.
3. Inspect for visible damage to furnace combustion chamber.
4. Inspect for visible damage to compressor, coils, and fans.
5. Inspect internal insulation.
6. Verify that labels are clearly visible.
7. Verify that clearances have been provided for servicing.
8. Verify that controls are connected and operable.
9. Verify that filters are installed.
10. Clean condenser coil and inspect for construction debris.
11. Remove packing from vibration isolators.
12. Inspect operation of barometric relief dampers.
13. Verify lubrication on fan and motor bearings.
14. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
15. Adjust fan belts to proper alignment and tension.
16. Start unit according to manufacturer's written instructions.

    a. Start refrigeration system.
    b. Do not operate below recommended low-ambient temperature.
    c. Complete startup sheets and attach copy with Contractor's startup report.

17. Inspect and record performance of interlocks and protective devices; verify sequences.
18. Operate unit for an initial period as recommended or required by manufacturer.

19. Calibrate thermostats.
20. Adjust and inspect high-temperature limits.
21. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
22. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F (8 deg C) above return-air temperature:

    a. Coil leaving-air, dry- and wet-bulb temperatures.
    b. Coil entering-air, dry- and wet-bulb temperatures.
    c. Outdoor-air, dry-bulb temperature.
    d. Outdoor-air-coil, discharge-air, dry-bulb temperature.

23. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
24. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.

    a. Supply-air volume.
    b. Return-air volume.
    c. Relief-air volume.
    d. Outdoor-air intake volume.

25. Simulate maximum cooling demand and inspect the following:

    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.

26. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:

    a. High-temperature limit on gas-fired heat exchanger.
    b. Low-temperature safety operation.
    c. Filter high-pressure differential alarm.
    d. Economizer to minimum outdoor-air changeover.
    e. Relief-air fan operation.
    f. Smoke and firestat alarms.

27. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.9 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

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

3.10 CLEANING

A. After completing system installation and testing, adjusting, and balancing RTUs and air-distribution systems, clean RTUs internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.11 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Tests and Inspections:

1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. RTU will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.12 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain RTUs.

END OF SECTION 237416.11

SECTION 238216.11 - HYDRONIC AIR COILS

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. Hydronic air coils.
2. Integral face-and-bypass hot-water coils.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

1.6 FIELD CONDITIONS

A. Altitude above Mean Sea Level: 49 feet.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. ASHRAE 62.1 Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment," and Section 7, "Construction and Startup."

B. Performance Ratings: Tested and rated in accordance with AHRI 410 and ASHRAE 33.

C. Minimum Working-Pressure/Temperature Ratings: 200 psig /300 deg F.

D. Select cooling coils for no moisture carryover at design conditions. Provide moisture eliminators on discharge face of cooling coil if necessary to eliminate moisture carryover.

2.2 HYDRONIC AIR COILS

A. Source Limitations: Obtain hydronic coils from single source from single manufacturer.

B. Description: Coils constructed of staggered tubes mechanically expanded into continuous collars that are die-formed into the coil fins; self-venting; counterflow design of air to fluid.

C. Tubes:

1. Material: Copper.
2. Nominal Diameter: Minimum, selected to provide performance indicated.
3. Nominal Wall Thickness: As required by performance.
4. Return Bends: 180-degree bends; material, wall thickness, and nominal diameter to match tubes.
5. Fluid Velocity at Design Flow Rate:

    a. Maximum: 6 fps.
    b. Minimum: 3 fps.

6. Features: Cleanable, Individually drainable.

D. Fins:

1. Type: Plate.
2. Materials:

    a. Aluminum: 0.0060 inch thick.
    b. Copper: 0.0060 inch thick.
    c. 90/10 Cupronickel: 0.0060 inch thick.

3. Spacing: Maximum 12 fins per inch.
4. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
5. Configuration: Fin type as required by performance requirements.

6. Fin and Tube Joint: Mechanical bond or silver brazed.

E. Headers:

1. Material: Carbon steel.
2. Tube-to-Header Connections: Tube-to-header holes to intrude inward, so landed surface area is 3 times the core tube thickness, to provide enhanced-header-to-tube joint integrity. Evenly extend tubes within the ID of the header no more than 0.12 inch (3 mm).
3. Header Top and Bottom Caps: End caps to be die-formed and installed on the ID of header, such that the landed surface area is 3 times the header wall thickness.
4. Drains: Include low point of supply header with a NPS 1/2 drain connection.
5. Vents: Include high point of return header with a NPS 1/2 vent connection.
6. Supply and Return Connections: Copper pipe; threaded or flanged.
7. Protect opening of supply, return, vent, and drain connections with a threaded cap to prevent entry of dirt into coil.
8. Fluid Velocity at Design Flow Rate: Maximum of 6 fps.

F. Casings and Tube Sheets:

1. Depth: Extend coil casing and tube sheets a minimum of 1/2 inch beyond face of fins on both entering and leaving sides.
2. Materials:

   a. Stainless steel, Type 304, No. 2D finish, ASTM A240/A240M.
   b. Galvanized steel, ASTM A653/A653M, G90 coating.
   c. Copper, ASTM B152/B152M.

G. Top and Bottom Casings:

1. Flange face minimum of 1-1/2 inches; double-flange edge for rigidity and ease of removal with secondary flange face minimum of 1/2 inch.
2. Thickness:

   a. Coils with Fin Length of Up to 72 Inches: Minimum of 16 gauge thick.
   b. Coils with Fin Length Exceeding 72 Inches: Minimum of 14 gauge thick.

H. End Tube Sheets:

1. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
2. Flange face minimum of 1-1/2 inches.
3. Thickness: Minimum of 16 gauge thick.

I. Intermediate Tube Sheets:

1. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
2. Space intermediate tube sheets a maximum of 48 inches o.c. and locate to provide equal spacing between tube sheet across coil tube length.
3. Flange face minimum of 1/2 inch.

4. Thickness: Minimum of 16 gauge thick.

J. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.

K. Hardware: Use hex-head bolts, nuts, and washers constructed of Type 304 or Type 316 stainless steel.

L. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:

1. Manufacturer name and address.
2. Manufacturer model number.
3. Serial number.
4. Manufacturing date.
5. Coil identification (indicated on Drawings).

2.3 MATERIALS

A. Aluminum: ASTM B209.

B. Copper Tube: ASTM B75/ASTM 75M annealed temper or ASTM B280 drawn temper.

C. Copper Sheet: ASTM B152.

D. 90/10 Cupronickel Alloy: ASTM B122/ASTM B122M.

E. Steel:

1. Pipe Connections: ASTM A53/A53M.

2.4 SOURCE QUALITY CONTROL

A. Hydronic Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than 300-psig internal pressure.

B. Coils to display a tag with inspector's identification as proof of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.

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

3.2 INSTALLATION

A. Install coils level and plumb.

B. Install coils in metal ducts and casings constructed in accordance with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. Install galvanized-steel or stainless steel drain pan under each cooling coil.

1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
3. Extend drain pan upstream and downstream from coil face.
4. Extend drain pan under coil headers and exposed supply piping.

D. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.

E. Straighten bent fins on air coils.

F. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 PIPING CONNECTIONS

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

B. Install piping adjacent to coils to allow service and maintenance.

C. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Control valves are specified in Section 230923.11 "Control Valves," and other piping specialties are specified in Section 232116 "Hydronic Piping Specialties."

END OF SECTION 238216.11

SECTION 238216.12 - STEAM AIR COILS

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. Steam air coils.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

1.6 FIELD CONDITIONS

A. Altitude above Mean Sea Level: 49 feet.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. ASHRAE 62.1 Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment," and Section 7, "Construction and Startup."

B. Performance Ratings: Tested and rated in accordance with AHRI 410 and ASHRAE 33.

C. Minimum Working-Pressure/Temperature Ratings: 100 psig /400 deg F.

2.2 STEAM AIR COILS

A. Source Limitations: Obtain steam air coils from single source from single manufacturer.

B. Description: Plate fin coils constructed of tubes mechanically expanded into continuous collars that are die-formed into plate fins and specially designed for thermal expansion and contraction of the tubes during coil operation.

1. Distributing-type steam coils of a tube-in-tube design for uniform steam distribution along the entire length of each tube, to ensure a consistent temperature rise across the full coil face and accelerate condensate removal.
2. Non-distributing-type steam coils of a single tube design for uniform steam distribution across the entire header and each tube

C. Tubes:

1. Material: Copper.
2. Nominal Diameter: Minimum, selected to provide performance indicated.
3. Nominal Wall Thickness: As required by performance.
4. Features: Individually drainable, distributing-type steam coils.

D. Fins:

1. Type: Plate.
2. Materials:

    a. Aluminum: 0.0060 inch thick.

3. Spacing: Maximum 12 fins per inch.
4. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
5. Configuration: Fin type as required by performance requirements.
6. Fin and Tube Joint: Mechanical bond or silver brazed.

E. Headers:

1. Material: Carbon steel.

2. Tube-to-Header Connections: Tube-to-header holes to intrude inward, so landed surface area is 3 times the core tube thickness, to provide enhanced header-to-tube joint integrity. Evenly extend tubes within the ID of the header no more than 0.12 inch (3 mm).
3. Header Top and Bottom Caps: End caps to be die-formed and installed on the ID of header, such that the landed surface area is 3 times the header wall thickness.
4. Drains: Include low point of supply header with a NPS 1/2 drain connection.
5. Vents: Include high point of return header with a NPS 1/2 vent connection.
6. Supply and Condensate Return Connections: Copper pipe; threaded or flanged.
7. Protect opening of supply, return, vent, and drain connections with a threaded cap to prevent entry of dirt into coil.

F. Casings and Tube Sheets:

1. Depth: Extend coil casing and tube sheets a minimum of 1/2 inch beyond face of fins on both entering and leaving sides.
2. Materials:

a. Stainless steel, Type 304, No. 2D finish.
b. Galvanized steel, G90 coating.
c. Copper.

G. Top and Bottom Casings:

1. Flange face minimum of 1-1/2 inches; double-flange edge for rigidity and ease of removal with secondary flange face minimum of 1/2 inch.
2. Thickness:

a. Coils with Fin Length of Up to 72 Inches: Minimum of 16 gauge thick.
b. Coils with Fin Length Exceeding 72 Inches: Minimum of 14 gauge thick.

H. End Tube Sheets:

1. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
2. Flange face minimum of 1-1/2 inches.
3. Thickness: Minimum of 16 gauge thick.

I. Intermediate Tube Sheets:

1. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
2. Space intermediate tube sheets a maximum of 48 inches o.c. and locate to provide equal spacing between tube sheet across coil tube length.
3. Flange face minimum of 1/2 inch.
4. Thickness: Minimum of 16 gauge thick.

J. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.

K. Hardware: Use hex-head bolts, nuts, and washers constructed of Type 304 or Type 316 stainless steel.

L. Nameplate: Aluminum or stainless steel nameplate for each coil, with the following data engraved or embossed:

1. Manufacturer name website address.
2. Manufacturer model number.
3. Serial number.
4. Manufacturing date.
5. Coil identification (indicated on Drawings).

2.3 MATERIALS

A. Aluminum: ASTM B209.

B. Copper Tube: ASTM B75/B75M annealed temper or ASTM B280 drawn temper.

C. Copper Sheet: ASTM B152.

D. Galvanized Steel: ASTM A653/A653M.

E. 90/10 Cupronickel Alloy: ASTM B122/B122M.

F. Stainless Steel: ASTM A240/A240M.

G. Steel:

1. Pipe Connections: ASTM A53/A53M.

2.4 SOURCE QUALITY CONTROL

A. Steam Coils: Factory tested to 300 psig.

B. Coils to display a tag with inspector's identification as proof of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.

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

3.2 INSTALLATION

A. Install coils level and plumb.

B. Install coils in metal ducts and casings constructed in accordance with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. Straighten bent fins on air coils.

D. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 PIPING CONNECTIONS

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

B. Install piping adjacent to coils to allow service and maintenance.

C. Connect steam piping with gate valve and union and steam condensate piping with union, strainer, trap, and gate valve to allow coils to be disconnected without draining piping. Control valves are specified in Section 230923.11 "Control Valves," and other piping specialties are specified in Section 232213 "Steam and Condensate Heating Piping."

END OF SECTION 238216.12

SECTION 238216.13 - REFRIGERANT AIR COILS

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. Refrigerant air coils.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

1.6 FIELD CONDITIONS

A. Altitude above Mean Sea Level: 49 feet.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. ASHRAE 62.1 Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment," and Section 7, "Construction and Startup."

B. Performance Ratings: Tested and rated in accordance with AHRI 410 and ASHRAE 33.

C. Minimum Working-Pressure/Temperature Ratings: 200 psig/300 deg F.

D. Select cooling coils for no moisture carryover at design conditions. Provide moisture eliminators on discharge face of cooling coil if necessary to eliminate moisture carryover.

2.2 REFRIGERANT AIR COILS

A. Source Limitations: Obtain refrigerant coils from single source from single manufacturer.

B. Description: Plate fin coils constructed of staggered tubes mechanically expanded into continuous collars that are die-formed into plate fins. Coils are to be counterflow circuited and equipped with pressure-type distributors, and distributor tubes are to be of equal length, to ensure equal distribution of refrigerant to each circuit.

C. Tubes:

1. Material: Copper.
2. Nominal Diameter: Selected for performance indicated.
3. Nominal Wall Thickness: As required by performance.
4. Return Bends: 180-degree bends; material, wall thickness, and nominal diameter to match tubes.
5. Brazing: High-temperature brazing alloy with not less than 5 percent silver.

D. Fins:

1. Type: Plate.
2. Materials:

   a. Aluminum: Minimum 0.0060 inch thick, as required by performance.

3. Spacing: Maximum 12 fins per inch.
4. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
5. Configuration:Fin type as required by performance requirements.
6. Fin and Tube Joint: Silver brazed.

E. Headers:

1. Material: Seamless copper.

2. Tube-to-Header Connections: Tube-to-header holes to intrude inward, so landed surface area is 3 times the core tube thickness, to provide enhanced header-to-tube joint integrity. Evenly extend tubes within the ID of the header no more than 0.12 inch (3 mm).
3. Header Top and Bottom Caps: End caps to be die-formed and installed on the ID of header, such that the landed surface area is 3 times the header wall thickness.
4. Protect openings to prevent entry of dirt into coil.

F. Casings and Tube Sheets:

1. Depth: Extend coil casing and tube sheets a minimum of 1/2 inch beyond face of fins on both entering and leaving sides.
2. Materials:
    a. Galvanized steel, G90 coating.

3. Top and Bottom Casings:

    a. Flange face minimum of 1-1/2 inches; double-flange edge for rigidity and ease of removal with secondary flange face minimum of 1/2 inch.
    b. Thickness: Minimum of 16 gauge thick, or as required by application.

4. End Tube Sheets:

    a. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
    b. Flange face minimum of 1-1/2 inches.
    c. Thickness: Minimum of 16 gauge thick, or as required by application.

5. Intermediate Tube Sheets:

    a. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
    b. Space intermediate tube sheets a maximum of 48 inches o.c. and locate to provide equal spacing between tube sheet across coil tube length.
    c. Flange face minimum of 1/2 inch.
    d. Thickness: Minimum of 16 gauge thick.

G. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.

H. Hardware: Use hex-head bolts, nuts, and washers constructed of Type 304 or Type 316 stainless steel.

I. Nameplate: Aluminum or stainless steel nameplate for each coil, with the following data engraved or embossed:

1. Manufacturer name and address.
2. Manufacturer model number.
3. Serial number.
4. Manufacturing date.
5. Coil identification (indicated on Drawings).

2.3 MATERIALS

A. Aluminum: ASTM B209.

B. Copper Sheet: ASTM B152.

C. Copper Tube: ASTM B75/75M annealed temper or ASTM B280 drawn temper.

D. Galvanized Steel: ASTM A653/A653M.

E. Stainless Steel: ASTM A240/A240M.

F. Steel: ASTM A53/A53M.

2.4 SOURCE QUALITY CONTROL

A. Refrigerant Coils: Factory tested using dry nitrogen while coil is completely submerged underwater to design pressure indicated, but not less than 400-psig internal pressure.

B. Coils to display a tag with inspector's identification as proof of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.

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

3.2 INSTALLATION

A. Install coils level and plumb.

B. Install coils in metal ducts and casings constructed in accordance with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. Install galvanized-steel or stainless steel drain pan under each cooling coil.

1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
3. Extend drain pan upstream and downstream from coil face.

4. Extend drain pan under coil headers and exposed supply piping.

D. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.

E. Straighten bent fins on air coils.

F. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 PIPING CONNECTIONS

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

B. Install piping adjacent to coils to allow service and maintenance.

C. Connect refrigerant piping according to Section 232300 "Refrigerant Piping."

END OF SECTION 238216.13

SECTION 238216.14 - ELECTRIC-RESISTANCE AIR COILS

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. Electric-resistance air coils.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

1.6 FIELD CONDITIONS

A. Altitude above Mean Sea Level: 49 feet.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Coil Assembly: Comply with UL 1995.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

C. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

D. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment," and Section 7, "Construction and Startup."

E. Equally balance heater electrical load for each step across all electrical phases.

F. Part-Load Operation: Provide arrangement with operation staged for uninterrupted operation over the full range of airflow down to the minimum airflow indicated.

2.2 ELECTRIC-RESISTANCE AIR COILS

A. Source Limitations: Obtain electric-resistance air coils from single source from single manufacturer.

B. Heating Elements:

1. Open Elements:

    a. Open-coil resistance wire of 80 percent nickel and 20 percent chromium; supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in a frame.
    b. Safety Screens: Install safety screens to protect operators from accidentally coming into direct connect with elements.

2. Finned Tubular Elements:

    a. Coiled resistance wire of 80 percent nickel and 20 percent chromium; center-mounted and surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
    b. Finish finned tubular elements with a baked-on aluminum paint, and mount in a frame.
    c. Each element individually removable from terminal box.
    d. Use threaded stainless steel element terminals and hardware.

C. Frame: Galvanized, stainless or aluminized steel; minimum 0.052 inch thick for slip-in or flanged mounting. Include intermediate element support brackets equally spaced at a maximum of 36 inches o.c. across electric-resistance air coil.

D. Terminal Box/Control Panel: Unit or remote mounting arrangement indicated on Drawings; with disconnection means and overcurrent protection.

1. Enclosure: NEMA 250, Type 1 or Type 12 enclosure complying with UL 50.
2. Full-face-hinged door with lock and key latching device(s).
3. Factory insulate terminal box to prevent condensation from occurring within box.
4. Install a laminated elementary wiring diagram on inside face of heater control panel door or in another protected location than visible be service personnel. Wiring diagram to match installation.

E. Controls:

1. Safety Controls: Each heater is to be provided with the following factory-mounted safety controls:

    a. Disk-type thermal cutout switch with automatic reset.
    b. Primary linear thermal limit cutout switch with automatic reset.
    c. Secondary linear thermal limit cutout switch with local manual reset.
    d. Airflow Proving Switch: Pressure differential type; with pressure range selected to ensure reliable operation throughout full range of air-handling unit airflow down to minimum airflow indicated.

2. Staging Control: Magnetic contactors for switching stages of heat.
3. Remote Monitoring and Control: Include control devices necessary to interface with remote-control signals, including the following:

    a. Heater on/off control.
    b. Monitoring heater on/off status.
    c. High-temperature alarm.
    d. Low-airflow alarm.
    e. Heater capacity control.

F. Electrical:

1. Single-Point Field Power Connection: Install and wire the heater to accommodate a single field electrical connection for electrical power.
2. Disconnecting Means: Provide each heater with a main electrical power connection, door mounted and interlocking, and disconnecting means to prevent access into panel, unless switched to the off position.

    a. Fused disconnect switch with lockable handle.
    b. Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than 42,000 A.

3. Factory install and wire branch circuit fusing or circuit breakers in accordance with NFPA 70.
4. Pilot Lights: Include labeled pilot lights on face of control panel for the following:

    a. Power on.
    b. Low-airflow alarm.

c. High-temperature alarm.
d. One for each stage on.

5. Terminations: Wire terminations and field interface terminations to labeled terminal strips.
6. Control Transformer: Size control circuit transformer for load.
7. Labeling: Label each electrical device with a laminated phenolic tag.
8. Use only NRTL-labeled electrical components.

G. Nameplate: Include the following data:

1. Manufacturer name, address, telephone number, and website address.
2. Manufacturer model number.
3. Serial number.
4. Manufacturing date.
5. Coil identification (indicated on Drawings).

H. See Section 230923.27 "Temperature Instruments" for thermostat.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

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

3.2 INSTALLATION

A. Install coils level and plumb.

B. Install coils in metal ducts and casings constructed in accordance with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
   1. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.

3.5 FIELD QUALITY CONTROL

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

B. Tests and Inspections:

   1. Operational Test: After electrical circuitry has been energized, operate electric coils to confirm proper unit operation.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Prepare test and inspection reports.

END OF SECTION 238216.14

SECTION 260500 – COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 REFERENCES

A. Refer to the GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS and applicable parts of DIVISION 1 for other general requirements. These requirements may be repeated in this Division for emphasis or for inclusion of more stringent/additional related requirements. Such repetition shall NOT be construed to reduce the requirements of those Divisions NOR to eliminate other requirements under those Divisions.

B. The requirements of this Section apply to ALL work specified in this Division, unless modified to be of higher quality or more stringent in another Section.

C. THIS PROJECT WILL BE COMMISSIONED. REFER TO COMMISSIONING SPECIFICATION SECTIONS FOR COMMISSIONING INFORMATION AND RESPONSIBILITIES. THE COMMISSIONING PROCESS WILL REQUIRE ADDITIONAL LABOR, MATERIAL AND/OR OTHER COSTS WHICH MUST BE PROVIDED BY THE CONTRACTOR AS PART OF THIS PROJECT.

1.2 INTENT

A. The CONTRACT DOCUMENTS are inclusive of all Drawings and Specifications, both those specifically covering the work of this Division and those covering other subjects of work.

B. It is the intent of the Contract Documents to require finished work, tested and ready for operation.

C. It is not intended that Contract Documents show every pipe, wire, conduit, fitting and appurtenance; however, such parts as may be necessary to complete the systems in accordance with best trade practice and Code requirements and to Engineer's satisfaction shall be deemed to be included.

D. Drawings are diagrammatic and indicate the general arrangement of systems and work included in the Contract. DO NOT SCALE THE DRAWINGS.

1.3 EXAMINATION OF SITE AND CONTRACT DOCUMENTS

A. Before submitting prices or beginning work, thoroughly examine the site and the Contract Documents.

B. No claim for extra compensation will be recognized if difficulties are encountered which would have been revealed by examination of site conditions and Contract Documents prior to executing Contract.

C. Where discrepancies occur within Contract Documents, notify Engineer, in writing, of discrepancy and request clarification. Until notified of Engineer's decision, include item or arrangement of better quality, greater quantity or higher cost in Contract price.

D. For material, device and equipment identified on Contract Drawings by manufacturer and/or model: Coordinate with Specification for ancillary requirements and include with furnished item.

E. Notify Engineer, in writing, of materials and apparatus believed to be omitted, inadequate or unsuitable, or in violation of laws, ordinances, rules or regulations of authorities having jurisdiction. In absence of such written notice, it is mutually agreed that bid price for work under each Section has included the cost of items required for acceptable satisfactory functioning of entire system.

1.4 DEFINITIONS

A. Where more than one material, item, or grade is listed in same paragraph, first one named is preferred choice.

B. The following terms are used in this Division and are defined as follows:

1. "Indicated", "shown", "noted", "scheduled", "specified": These terms are a cross-reference to graphics, notes or schedules on the Drawings, to other paragraphs or schedules in the Specifications, and to similar means of recording requirements in Contract Documents. NO limitation of location is intended except as specifically noted.
2. "Directed", "requested", "authorized", "selected", "required", "permitted": Where not otherwise explained, these terms mean "directed by the Engineer", "requested by the Engineer", etc. However, NO such implied meaning will be interpreted to extend the Engineer's responsibility into Contractor's area of construction supervision or means and methods.
3. "Provide": To furnish and install, ready for safe and regular operation the item, material or service indicated.
4. "Furnish": To purchase, acquire and deliver to the site, complete with related accessories.
5. "Install": To erect, mount and connect completely, by acceptable methods.
6. "Work": Labor, materials, equipment, apparatus, controls and accessories required for proper and complete installation.
7. “Finished Spaces”: Spaces other than the following:

    a. Mechanical and electrical equipment rooms.
    b. Furred spaces.
    c. Pipe and duct shafts.
    d. Unheated spaces immediately below roof.
    e. Spaces above ceilings.
    f. Unexcavated spaces.
    g. Crawl spaces.
    h. Tunnels.

8. “Exposed”, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical or electrical equipment rooms.
9. “Exposed”, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
10. “Concealed”, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in shafts.
11. “Concealed”, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated structures.
12. "Acceptable equivalent" or "Equal": Of weight, size, design, capacity and efficiency to meet requirements specified and shown, and of acceptable manufacture, as determined in the opinion of the Engineer.
13. "Acceptable": Acceptable, as determined in the opinion of the Engineer.
14. "Contractor": General Contractor, Trade Contractor, sub-Contractor, or Construction Manager.
15. "Named" Product: Manufacturer's name for product, as recorded in published documents of latest issue as of date of Contract Documents. Obtain Engineer's permission before using products of later or earlier model.

1.5 STANDARDS

A. Standards, specifications and tests of following technical societies, organizations and governmental bodies, as referenced in Contract Documents, are hereby made part of Contract Documents.

1. ANSI: American National Standards Institute
2. ASTM: American Society for Testing and Materials
3. EPA: Environmental Protection Agency
4. FSSC: Federal Specification
5. IRI: Industrial Risk Insurers
6. ISO: Insurance Services Office
7. NBS: National Bureau of Standards
8. NEC: National Electrical Code.
9. NEMA: National Electrical Manufacturers Association
10. NFPA: National Fire Protection Association
11. NSC: National Safety Council
12. OSHA: Occupational Safety and Health Administration
13. UL: Underwriters Laboratories
14. ASHRAE: American Society of Heating Refrigeration and Air Conditioning Engineers
15. ICC: International Code Council
16. IES/IESNA: Illuminating Engineering Society of North America
17. IEEE: The Institute of Electrical & Electronics Engineering
18. BICSI: Building Industry Consulting Services International
19. INETA/NETA: InterNational Electrical Testing Association
20. NECA: National Electrical Contractors Association
21. CODE: Codes and regulations of the Federal, State and local governments and of utility companies having jurisdiction, as appropriate.

B. Use of singular or plural reference form in the Contract Documents shall not be construed to limit number of units required. Specifications are intended to define quality and performance characteristics; quantity of units supplied shall be as needed to meet requirements as specified and at a minimum, as shown on Contract Documents.

1.6 PERMITS, LAWS, ORDINANCES AND CODES

A. Contractor shall obtain and pay for permits, inspections, licenses and certificates required for work under this Division.

B. Complete Utility connections as indicated or needed, extension to Project, metering as required, and connection to building systems, including:

1. Apply for all services and pay for all fees, assessments and charges of the Utility for each connection, all in a timely manner and according to the Project Schedule.
2. Provide and install all metering equipment and accessories as required by Utility. Install entire service in accordance with the Utility's requirements or other applicable regulation.
3. Coordinate with Utility to determine scope of work provided by Utility and the part provided by Contractor so that a complete Utility connection is made.
4. Schedule all work required by utility companies in order to maintain project schedule.

C. Contractor shall pay utility company charges associated with work of this Division.

D. Contractor shall comply with laws, ordinances, rules and regulations of Local, State and Federal authorities having jurisdiction; and shall comply with rules and regulations of National Board of Fire Underwriters, National Electrical Code and local utility companies.

E. Contract Documents shall govern whenever they are more stringent than Code requirements.

1.7 COORDINATION DRAWINGS

A. Before materials are purchased or work is begun, prepare coordination drawings showing relationship of work among all trades.

B. Submit completed and signed coordination drawings to the Engineer for review.

C. Coordination drawings are for use by Contractors and Engineer during construction and are not replacements for shop, as built, or record drawings required elsewhere in the Contract Documents

1.8 SHOP DRAWING SUBMITTALS

A. General

1. Prior to submission of specific shop drawings, submit for review a preliminary list of intended or proposed manufacturers for all items for which shop drawings are required.

2. Submit through contractual channels for review.

B. Shop Drawings

1. Shop drawings shall include the following information:

a. Descriptive and product data necessary to verify compliance with Contract Documents.
b. Manufacturer’s specifications including materials of construction, metal gauge, thickness, and finish.
c. Certified dimensional drawings including clearances required for maintenance or access.
d. Performance data, ratings, operating characteristics, and operating limits.
e. Operating points on curves.
f. Electrical ratings and characteristics.
g. Wiring and control diagrams, where applicable.
h. Certifications requested, including UL label or listing.
i. List of accessories which are required but are NOT being furnished by the product manufacturer or are NOT being provided by this Section. Identify the Section(s) by which the accessories are being furnished or provided.

2. Clearly mark submittals with the following:

a. Where equipment is specified, as follows:

1) Specifications: Section and paragraph.
2) Drawings: Drawing number, schedule, note, and detail, as required.

b. Equipment or fixture identification corresponding to that used in Contract Documents.
c. Accessories and special or non-standard features and materials, which are being provided.

3. The selection and intention to use a product specified by name shall NOT excuse the need for timely submission of shop drawings for that product.
4. For samples submitted in lieu of shop drawings, submit as follows:

a. Submit samples in duplicate.
b. Clearly identify the samples.
c. All samples that are not accepted will be returned.
d. For samples that are approved, one sample will be returned and one sample will be kept by the Engineer.

5. Upon completion of shop drawing review, shop drawings will be returned, marked with one of the following notations: Furnish as Submitted, Furnish as Corrected, Revise and Resubmit, Rejected, or Submit Specified Item. Use only products whose shop drawings are marked Furnish as Submitted or Furnish as Corrected.

C. Other Submittals

1. Refer to Sections of this Division for additional submittal requirements relating to specific equipment or systems.

D. Submission of shop drawings of an unnamed manufacture or shop drawings at variance with the Contract Documents is NOT a proper request for substitution.

E. Repeat submission of products without addressing all comments from prior review will be returned to the Contractor without review for correction. Note:

1. Contractor may be liable for additional efforts expended by the Engineer
2. Contractor WILL be liable for impact to project schedule.

F. Test reports are to be submitted to Engineer for review prior to acceptance of equipment or systems for beneficial use.

1.9 PRODUCT SELECTION

A. Options for selecting products are limited by Contract Document requirements and governing regulations and are NOT controlled by industry traditions or procedures experienced by Contractor on previous construction projects. Required procedures include, but are NOT necessarily limited to, following specifying methods in Contract Documents:

1. Single Product Manufacturer Named: Provide product indicated.
2. Two or More Manufacturers' Products Named: Provide one of the named products, at Contractor's option, but excluding products which do NOT comply with requirements.
3. "Acceptable equivalent" or "Or Equal": Where named products are accompanied by this term or words of similar effect, provide one of named products or propose substitute product according to paragraph 1.10, SUBSTITUTIONS.
4. Standards, Codes and Regulations: Where specification requires only compliance with a standard, code or regulation, Contractor may select any product which complies with requirements of that standard, code or regulation.
5. Performance Requirements: Provide products which comply with specific performances indicated and which are recommended by manufacturer (in published product literature or by individual certification) for application intended. Overall performance of product is implied where product is specified with only certain specific performance requirements.
6. Prescriptive Requirements: Provide products which have been produced in accordance with prescriptive requirements using specified materials and components, and complying with specified requirements for fabricating, finishing, testing and other manufacturing processes.
7. Visual Matching: Where matching with an established material is required, Engineer's judgment of whether proposed product matches established material shall be final.
8. "Color as Selected by Architect": Unless otherwise noted, where specified product requirements include "color as selected by Architect" or words of similar effect, the selection of manufacturer and basic product complying with Contract Documents is Contractor's option and subsequent selection of color is Architect's option.

B. Inclusion by name, of more than one manufacturer or fabricator, does NOT necessarily imply acceptability of standard products of those named. All manufacturers, named or proposed, shall conform, with modification by manufacturer as necessary, to criteria established by Contract Documents for performance, efficiency, materials and special accessories.

1.10 SUBSTITUTIONS

A. Contractor's request for substitution may be submitted only after award of Contract. Requests shall be in writing and presented through appropriate contractual channels.

B. Substitution Request to include the following:

1. Detailed comparison of significant differences in quality, construction, performance, features, options, and appearance between specified item and proposed substitution. Citation, where applicable, to where a specified requirement is located in the Contract Documents is to be provided.
2. Statement of effect on construction time, coordination with other affected work, and cost of work.
3. Contractor's statement to the effect that proposed substitution will result in overall work equal to, or better than, work originally intended.

C. Substitution requests will be considered based on all of the following:

1. If extensive revisions to Contract Documents are NOT required
2. If changes are in keeping with general intent of Contract Documents
3. If submitted in timely and proper manner, fully documented
4. If one or more of following conditions is satisfied; all as judged by Engineer:

   a. Where request is directly related to "acceptable equivalent" clause, "or equal" clause or words of similar effect in Contract Documents.
   b. Where specified product, material or method CANNOT be provided within Contract Time; but NOT as a result of Contractor's failure to pursue the work promptly or properly coordinate Contractor's efforts.
   c. Where substantial advantage is offered Owner; in terms of cost, time, energy conservation or other valuable considerations; after deducting offsetting responsibilities that Owner may be required to bear, including additional compensation to Engineer for redesign and evaluation services, increased cost of other work by Owner or separate contractors, and similar considerations.

D. The burden is upon the Contractor, supplier and manufacturer to satisfy Engineer that:

1. Proposed substitute is equal to, or superior to, the item specified.
2. Intent of the Contract Documents, including required performance, capacity, efficiency, quality, durability, safety, function, appearance, space clearances and delivery date, will be equaled or bettered.

E. Submission of shop drawings of unspecified manufacture or shop drawings at variance with the Contract Documents is NOT a proper request for substitution.

F. Changes in work of other trades, such as structural supports, which are required as a result of substitution and the associated costs for such changes shall be the complete responsibility of Contractor proposing substitution. Except as noted in subparagraph 1.10.C.4 (a) above, there shall be NO additional expense to the Owner.

G. Substitution requests that require the Engineer to expend additional efforts for review, investigation, verification, or similar activities, will require the Contractor to compensate the Engineer at the rate of $135/hr if:

1. Engineer is not familiar with the proposed manufacturer or the proposed product from that manufacturer
2. Engineer needs to investigate proposed product, attend presentations, confer with other professionals, contact references, or similar activities that would not otherwise have been required if one of the named products was proposed.
3. Engineer must travel to the manufacturer's facilities or a representative installation of the proposed product to review, confirm, or assess product characteristics or directly communicate with manufacturer's representatives on technical or product support subjects.

1.11 SAMPLES

A. Submit samples where required or referenced elsewhere in this Division of work.

B. Where in the opinion of the Engineer, a sample is required to clarify the acceptable characteristics of a material or product, additional samples may be required.

1.12 RECORD DRAWINGS

A. Furnish and keep on the job at all times, a minimum of one complete and separate set of Contract Documents for the purpose of tracking installation of the work.

B. As work progresses, record changes, revisions and additions to the work clearly, neatly, accurately and promptly. Items to be indicated include but are not limited to:

1. Dimensional change of equipment or material
2. Revision to Drawing Detail
3. Actual routing of distribution systems
4. Revision to power or control wire circuiting/source
5. Actual equipment location
6. Location of concealed distribution work such a pipes, conduits, ducts, etc
7. Location of concealed work and access panels, where access for maintenance or service is required.
8. Changes made by Change Order
9. Details not on original Contract Drawing, but used for installation of the work.
10. Information on concealed elements which would be difficult to identify or measure later

C. Indicate daily progress on these prints by coloring in the various lines, fixtures, apparatus and associated appurtenances as they are erected.

D. Approval of requisition for payment for work installed will NOT be given unless supported by record prints as required above.

E. At the conclusion of work, prepare final record drawings reflecting all field recorded data, neatly transferred from documents used in the field to a clean paper set of the Original Contract Documents. Submit record drawings for review by Engineer. After review and acceptance, the Contractor will be furnished with an electronic set of the original contract documents to be edited to reflect modifications and field data as reported on record drawings. Electronic copy of final "as-built" contract documents to be provided to the Owner in a format agreed upon at the commencement of work.

F. Coordination Drawings are to be updated, reflecting installation of work that differs from that presented on the Coordination Drawings which were signed off at the start of work. All trades will review and sign off on these documents as accurate. Electronic copy of final "as-built" coordination drawings to be provided to the Owner in a format agreed upon at the commencement of work.

G. Refer to DIVISION 1, GENERAL CONDITIONS and SUPPLEMENTARY CONDITIONS for further requirements.

1.13 OPERATING AND MAINTENANCE MANUALS

A. Submit for review operating and maintenance (O&M) manuals for each system or piece of equipment. Applicable content, as generated, is to be collected continuously during the construction process and maintained in a DRAFT manual format for review by the Engineer at any time.

B. Completed manual will be reviewed by the Engineer and modifications made as identified, before distribution or use. Acceptance will be required prior to scheduling of Owner Training and Instructions.

C. Required modifications identified during Training and Instruction activities are to be made before final Manual is delivered to the Owner.

D. Refer to DIVISION 1 for additional requirements and procedures relating to O&M manuals.

E. Operating and maintenance manual(s) will be organized with the following fundamental content:

1. Table of Contents and Index

2. Project Information

a. Contractor name, address, contact information, and primary contact individual specific to this project

b. Sub-contractor names, responsibility, address, contact information, and primary contact individual specific to this project.
c. Summary description of project scope and period of time work was executed.

3. Guarantees and Warrantees

a. Documentation describing covered work/materials, effective coverage dates, and terms/conditions
b. Contact information for initiating a claim and responsible party

4. Each Major Building System

a. Supplier information including

1) Technical Support contact
2) Source of parts / replacement units
3) Chain of purchase (Supply house, manufacturer's sales vendor, sub-contractor, etc), including Original order number/identification for tracking purposes

b. Operating Instructions

1) Prepared specific for this project

a) System Description
b) Operating parameters
c) Adjustable settings and purpose
d) Warnings and cautions
e) Sequence of Operations and Control Diagrams

2) Description of training and instruction provided to Owner including:

a) Date(s) of instruction/training
b) Agenda
c) Attendee list

c. Maintenance Instructions

1) Prepared specific for this project

a) Preventative maintenance schedule
b) Summary of consumable materials / regularly replaced elements
c) Recommended stocking materials and specialized tools or equipment necessary to perform regular and preventative maintenance
d) Maintenance contracts secured under this project, or separately contracted for through this provider.

d. Commissioning and Test Reports

1) Documentation of all inspection and testing activities performed with associated reports and corrective measures undertaken (if applicable).
2) Factory test reports
3) Certification letters for equipment manufacturers attesting to the complete and satisfactory installation and operation of systems/products.
4) Seismic inspection and certification
5) Special inspections
6) Sign off by Authorities Having Jurisdiction

e. Parts / Material List

1) Bill of materials for each system or piece of equipment

f. Product Literature

1) Copy of shop drawings reflecting final acceptance by Engineer, with modifications made reflecting changes to the installed work which is not represented accurately.

g. Manufacturer’s Operation & Maintenance Literature

1) Materials provided with equipment/products shipped for use on project
2) Supplementary materials which are required to provide the Owner with a complete representation of manufacturer’s instructions and recommendations.

F. In addition to the above, the following Content is to be included in the Operation & Maintenance Manual(s)

1. Copy of All Panelboard, Power Panel, Distribution Panel, and Switchboard Directory
2. Copy of all electrical testing reports for cables, breakers, distribution system equipment, generation equipment, control and transfer equipment when such is included in project scope.
3. Other data, as required under pertinent Sections of these Specifications.

1.14 GUARANTEE

A. Furnish standard manufacturers' guarantees for work under this Division. Such guarantees shall be in addition to, and NOT in lieu of, other liabilities under the law or by other provisions of the Contract Documents.

B. Materials, equipment and workmanship shall carry the standard warranty against defects in material and workmanship. Failure which may develop due to defective or improper material, equipment, workmanship or design shall be made good, forthwith, by and at the expense of the Contractor, including damage done to areas, materials and other systems resulting from this failure.

C. Guarantee that all elements of the systems are of sufficient capacity to meet the specified performance requirements as set forth in Contract Documents.

D. Upon receipt of notice from Owner of a failure of system(s) or component(s) during the guarantee period, replace affected components within reasonable time period at no additional cost.

E. Guarantee period shall extend for one year from Date of Substantial Completion.

F. Before final request for payment, furnish written guarantee covering above requirements.

PART 2 - PRODUCTS

2.1 GENERAL PRODUCT REQUIREMENTS

A. Products shall be undamaged and unused at time of installation and shall be complete with accessories, trim, finish, safety guards and other devices and details needed for complete installation and for intended use.

B. Where available, products shall be standard products of types which have been produced and used previously and successfully on other projects and in similar applications.

C. Labels and Stamps

1. Locate labels and stamps required to be observed after installation on accessible surfaces. In occupied spaces, select locations that are not conspicuous.
2. Locate labels and stamps not required to be observed after installation on concealed surfaces.

PART 3 - EXECUTION

3.1 ARRANGEMENT OF WORK

A. Consult Architectural Contract Drawings and Details for exact locations of fixtures and equipment. If exact location is not given, obtain information from Engineer. Verify measurements in field. Base measurements on Engineer's established benchmarks.

B. Install work as closely as possible to layouts shown on Contract Drawings. Modify work as necessary to:

1. Provide maximum possible headroom and space clearance on each side.
2. Provide adequate clearance and ready access to all parts of the work, for inspection, operation, safe maintenance and repair, and code conformance.
3. Coordinate and arrange work to avoid conflicts with work of other trades, to avoid unnecessary cutting and patching, and as needed for satisfactory space conditions shown on coordination drawing submittals.

4. Where space appears inadequate, consult Engineer before proceeding with installation.

C. Coordinate installation of required supporting devices.

D. Set sleeves in cast-in-place concrete for services that will need to pass through concrete. Coring of installed concrete is not intended and the Contractor will be responsible for determining the impact on structural integrity, certifying that there will be no impact, and any remedial work required to accommodate impact from coring.

E. Work shall present a neat coordinated appearance.

3.2 COORDINATION

A. Examine Contract Documents and coordinate with Contractor and other trades as necessary to facilitate the progress of the work.

B. Each trade shall keep Contractor and other trades fully informed as to shape, size, and locations of openings, chases, equipment, panels, access doors, sleeves, inserts and anchor bolts required; whether temporary or permanent. Coordinate sizes, depths, fill and bedding requirements with excavation trades. Give sufficient advance notice so that coordination may be completed in advance. If information is not furnished in proper and timely fashion, the trade involved shall do own cutting and patching or have same done by Contractor, without additional cost to Owner.

C. Coordinate size and location of concrete bases with DIVISION 3 and the following:

1. Floor Drains and underslab utilities
2. Dimensional requirements for embedded anchors as necessary for support, vibration isolation, and seismic restraint.
3. Access and walkway requirements
4. Work of other trades

D. Particular emphasis is placed on timely installation of major apparatus and furnishing of other trades and Contractor with relevant information.

E. Do NOT install a system until critical components of system and related systems have been coordinated and applicable shop drawings have been accepted.

3.3 WORKMANSHIP

A. Work covered under this Division shall be constructed and finished in every respect in a workmanlike and substantial manner.

B. Equipment and materials shall be new, of first quality, selected and arranged to fit properly into spaces indicated.

C. Obtain detailed information from manufacturer as to proper methods for installation and connections. This includes such tests as equipment manufacturer recommends. Where documentation regarding installation is NOT obtainable, work shall be installed in accordance with best trade practice.

1. Unless specifically indicated otherwise on Contract Documents, equipment and materials shall be installed in accordance with manufacturer's recommendations.
2. Notify Engineer of conflicts between manufacturer's recommendations and Contract Documents requirements, and request clarification before proceeding with installation.

D. Where equipment, piping, ductwork, conduit, etc. is exposed, color of finish or paint shall be as selected by Engineer.

3.4 OPERATION OF SERVICES AND UTILITIES

A. During the construction period and until finally inspected, tested and accepted, maintain new services and utilities.

B. Shutdown of existing services and utilities shall, without exception, be coordinated with the proper utility and with the Owner as to date, time of day, and duration.

1. Notify Engineer and Owner of estimated duration of shutdown period at least ten days in advance of date when shutdown is proposed. Approval of shutdown shall be obtained from proper utility and Owner, before any service is interrupted.
2. Work during shutdown period shall be arranged for continuous performance, including overtime if required, to ensure that existing operating services will be shut down only for time actually necessary to complete connections.

3.5 PROTECTION

A. Contractor shall be responsible for work and equipment until fully inspected, tested and accepted. Carefully store materials and equipment which are 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 or damaging water.

B. Equipment shall be protected against damage while in storage either on or off the construction site. The equipment shall be stored in a dry environment with temperature and controlled to within ranges specified by the manufacturer. Space heaters shall be installed and energized when required to control humidity. Store light sensitive materials where not subjected to direct sunlight.

C. Protect work and material of other trades from damage that might be caused by work of this and other Divisions and correct damage thus caused.

D. Maintain protective measures used for transport of equipment or materials to project site until ready to set and connect utilities and related work. If protective covers need to be removed for inspection or coordination of work, repair or replace to equivalent.

3.6 IDENTIFICATION

A. Distribution systems such as pipes, tubing, conduits, sheetmetal, insulation, etc shall have following information clearly printed on the material: manufacturer's name, material grade, gauge, thickness, type, and data to identify required methods of attachment; as applicable. Unmarked material shall NOT be used.

B. Permanent nameplates shall be provided on each piece of service-connected, power-operated, or distribution equipment, on easily accessible surface. Nameplate shall include product name, model number, serial number, capacity, speed, ratings, and similar essential operating data.

1. Manufacturer's nameplate, name, trademark and address shall be attached permanently to equipment and material furnished. Nameplate showing distributor or Contractor will NOT be permitted.
2. Unless otherwise specified or requested, letters and numbers shall be 1/2O high.
3. Attach nameplates with screws or rivets. Wherever covers of adjacent units are interchangeable, attach nameplates to wall or backboard rather than covers.

C. Unless specified elsewhere in this Section, labels shall be provided to indicate equipment according to designations used in Contract Documents. Label shall be plastic nameplate with letters and numbers 1-1/2O high. Furnish directory indicating number, location and use of each item. After finish painting is completed, apply identification label where it will be readily visible from normal operating position on floor.

3.7 LUBRICATION

A. Equipment shall be furnished and installed so that lubrication points are conveniently and readily accessible for maintenance. Make these provisions by whatever means is appropriate: extended fittings, access doors, equipment location, etc.

B. No equipment shall be operated for temporary service or for testing purposes without proper lubrication. Items requiring lubrication shall be left freshly and fully lubricated at time of substantial completion.

C. Prior to substantial completion, deliver to Owner, along with itemized list: one complete new set of special lubrication devices required for servicing, such as grease guns, fittings and adapters.

3.8 ATTACHMENT OF SUPPORTS TO BUILDING STRUCTURE

A. Equipment shall be securely attached to building structure in acceptable manner. Attachments shall be of strong and durable nature as determined by Engineer.

B. Attachment of supports to roof decking is NOT permitted. Pipes, ducts, conduits, boxes, etc. must be supported from building structural framing (bar joist, beams, columns) or by supplementary members installed by the Contractor, spanning structural framing in a method acceptable to the structural engineer.

C. Cut, Fit and place miscellaneous metal supports for installation of work.

D. Field Welding: Comply with AWS D1.1 or other applicable standards

E. Refer to DIVISION 5 for material specification of supplemental members to be installed.

3.9 ACCESSIBILITY, ACCESS PANELS AND ACCESS DOORS

A. Locate equipment which must be serviced, including motor starters, switches, panels and junction boxes, in accessible locations if at all possible. For other locations, furnish access panels as described under DIVISION 1.

B. Access doors shall be located to conveniently serve intended purpose and shall be installed so that adjacent piping, equipment and structures do NOT render doors unusable.

C. Access doors are not required in removable panel ceilings if suitable identifying markers are provided to indicate access locations.

D. During project closeout, Contractor shall perform walk-through identifying and demonstrating access to equipment for service and/or replacement. Walk-through shall be arranged at times convenient for Engineer and Owner to attend.

1. Equipment with insufficient access shall be relocated or provided with additional access panels at no additional cost to Owner.
2. Trade responsible for access problem shall be responsible for costs of access modifications. In general, this shall be understood to be the trade installing the equipment. If access problem was caused by architectural layout changes which occurred subsequent to equipment installation, cost of access modifications shall be borne by trade responsible for architectural changes.

3.10 WATERPROOFING

A. Where work pierces waterproofing, including waterproof concrete and floor of a wet area, submit method of installation for review by the Engineer before work is done.

B. Provide necessary sleeves, caulking and flashing required to make openings waterproof. See DIVISION 7 on WATERPROOFING.

3.11 GROUTING

A. Mix and install grout for equipment base bearing surfaces, base plates, and anchors

3.12 BASES AND SUPPORTS

A. Unless noted otherwise, provide necessary supports, rails, framing, bases and piers required for equipment furnished or installed under this Division.

B. Unless otherwise indicated: floor-mounted equipment shall be mounted on concrete pads. Concrete and associated reinforcing materials shall be as specified in DIVISION 3, CONCRETE.

1. Pads shall be three-inch thick minimum. Pads for seismically supported equipment shall extend at least 6 inches beyond equipment footprint. Coordinate final extension requirements with approved seismic shop drawing calculations and details. All other pads shall NOT extend more than one inch beyond equipment footprint. Top edge of pads shall be chamfered.
2. Furnish dimensional and load information so that shop drawings for pads may be submitted and reviewed prior to pad installation.
3. Equipment shall be firmly grouted into concrete pads and anchor bolted.

C. Where mounted on the floor: Foundations, supports, pads, bases and piers shall be of the same finish quality as the adjacent flooring material.

D. Equipment supports shall be designed and constructed so that equipment will be capable of resisting both vertical and horizontal movement. Refer to Section “VIBRATION AND SEISMIC CONTROLS” In this Division.

3.13 PAINTING

A. Unless otherwise specified, materials furnished under this Division shall have prime coat and standard manufacturer's finish.

B. Finish painting of exposed work and equipment is covered under DIVISION 9.

C. Paint equipment and appurtenances in concealed and unfinished areas with one coat of rust-inhibiting paint or with an appropriate bitumastic protective product designed for the intended application. Asphalt paint is NOT acceptable. Items to be painted shall include, but not be limited to: non-insulated hangers, supports, piping, conduit, tanks and other ferrous metal work, which are concealed or inaccessible but not galvanized.

D. Special care shall be taken to avoid painting or spattering equipment nameplates.

E. Cooperate in identifying systems for painters. Refer to paragraph, IDENTIFICATION.

3.14 TESTS - GENERAL

A. Make final adjustments to equipment before testing. Manufacturer's authorized representative shall verify proper installation and adjustment prior to startup of major equipment; refer to paragraph, OPERATING AND MAINTENANCE MANUALS.

B. Furnish labor, materials, instruments, supplies and services necessary for testing required under this Division. Correct defects appearing during tests, and repeat tests until no defects are disclosed. Final tests shall be made in Engineer's presence.

C. Use true RMS ammeter to measure current, for equipment which may have harmonic (non-linear) load component.

D. Notify Owner, Architect and Engineer of testing schedule at least 48 hours in advance of tests.

E. Perform specified tests and tests required by legal authorities and by agencies having jurisdiction over this Work. Tests shall be performed to the satisfaction of legal authorities, agencies having jurisdiction, and Owner.

F. Each piece of equipment, including motors and controls, shall be operated continuously for minimum test period of one hour.

G. If manufacturer's startup services are specified under other Sections in this Division, furnish services of factory-trained service engineering representative to provide following. If manufacturer's startup services are not required, Contractor shall furnish following services.

1. Inspection of equipment/system installation.
2. Assistance in initial startup and adjustment of equipment; including necessary time to achieve proper installation and adjustments.
3. Instruction of Owner's staff; see paragraph, INSTRUCTIONS.

H. Upon completion of tests, demonstrate the following:

1. Equipment and systems are installed and operating in accordance with manufacturer's specifications and instructions and with Contract Documents.
2. Proper adjustment of equipment and systems.
3. Systems are properly cleaned and free of contaminants.
4. Systems are properly phase balanced.
5. Circuits and motorized equipment are equipped with proper overload protection and are not operating under overload.
6. Instruments are recording properly.

I. Refer to testing requirements in other Sections of this Division for addition work.

3.15 INSTRUCTIONS

A. Arrange for each installer of work requiring continuing maintenance or operation, to meet with Owner's personnel at project site and instruct them in the operation and maintenance. Include instruction by manufacturer's representatives where installers are not expert in the required procedures. Instruction periods for all trades shall be minimum of 8 hours total; refer to individual SECTIONS for further requirements.

B. Instructions include, but are not limited to, the following:

1. Review of Operation and Maintenance manuals, record documentation, tools, spare parts and materials, lubricants, fuels, identification system, control sequences, hazards, cleaning, and similar procedures and facilities.
2. Demonstration of the following:

a. Start up procedures
b. Shutdown procedures
c. Emergency operations
d. Noise/vibration control adjustments
e. Safety concerns and protective equipment
f. Economy/efficiency adjustments
g. Cleaning
h. Similar operations

3. Review of applicable guarantees and warranties.
4. Demonstration of procedures for routine maintenance, at the equipment involved, to ensure proper accessibility to components involved.

3.16 QUIET OPERATION

A. Equipment and material provided as part of the Work shall NOT produce sound level greater than 55 decibels (or level required by Code, if more stringent) in adjacent occupied areas. Sound level shall be as measured on A-weighting scale of sound level meter or sound survey meter.

B. Methods described in ASHRAE guide and data books may be used to determine sound level of equipment when total of background sound and equipment sound exceeds the required minimum.

C. Contractor shall ensure that equipment and materials provided as part of the Work do NOT produce excessive noise/vibration and do NOT transmit excessive noise/vibration to occupied spaces. If objectionable noise/vibration occurs, Contractor shall provide systems, devices, and equipment necessary to eliminate objectionable noise/vibration at no additional cost to Owner.

D. Refer to VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS for further requirements.

3.17 FINAL CLEANING

A. Clean each surface of each unit of work, to normal "clean" condition expected for a first-class building cleaning and maintenance program. Comply with manufacturer's instructions for cleaning operations. The following are examples, but not limitations, of cleaning required:

1. Remove labels which are not required as permanent labels.
2. Clean transparent materials, removing substances which are noticeable as vision-obscuring.
3. Clean exposed hard-surfaced finishes, until free of dust, stains, films and similar noticeable substances.
4. Wipe surfaces of mechanical and electrical equipment clean, remove excess lubrication and other substances.
5. Remove debris and surface dust from limited-access spaces such as plenums, shafts, and ceiling spaces.

6. Clean lighting fixtures and lamps; removing dust, smudge marks and protective wraps; so as to function with full efficiency.

3.18 DEMOLITION, RENOVATION, IMPACT TO EXISTING

A. Demolition:

1. In areas where demolition of systems of this Division are indicated, the following requirements apply:

   a. Disconnect and remove from the project site, and dispose of in a legal manner, all materials not otherwise identified to be handled otherwise.
   b. Investigate impact to areas outside the designated area for demolition and identify any impact that demolition may have on those areas.
   c. Building structure, partitions, floors, and walls to remain shall not be impacted by demolition work.

B. Selective Demolition

1. Major changes to existing building spaces and systems have been shown on Contract Drawings; minor changes have NOT been shown. Contractor shall anticipate that there will be numerous minor changes including:

   a. Removal and/or relocation of pipes, conduits, wiring, etc
   b. Removal and/or relocation of wall and ceiling mounted devices due to architectural revisions or phasing
   c. Temporary relocation of existing devices or distribution equipment to permit installation of new work.
   d. Temporary work and modifications to existing systems to maintain Owner’s use and operations in areas outside the boundaries of the work.
   e. Work related to phased demolition of existing systems
   f. Work related to phased installation of new work

2. Remove, store, clean and relocate equipment designated to be relocated and reused.

3. Material which is removed and is not designated for reuse shall, at the Owner's option, either:

   a. Be delivered to Owner's storage location
      OR
   b. Become Contractor's property and be removed from the site and disposed of properly

END OF SECTION 260500

SECTION 260515 - BASIC MATERIALS & METHODS - ELECTRICAL

PART 1 - GENERAL

1.1 REFERENCES

A. This Section covers the specification of basic materials and methods for electrical work. Refer to GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS and applicable parts of DIVISION 1 for other general requirements.

B. Refer to Section, “COMMON WORK RESULTS”.

1.2 SCOPE

A. Provide labor, materials, services, equipment and transportation necessary for complete and operational electrical systems as indicated on Contract Drawings and specified herein.

B. Interface with work of Mechanical Trades (Divisions 23):

1. Division 26 is responsible to supply disconnects, starters and motor controls NOT supplied integral to equipment provided under other divisions, unless otherwise noted.
2. Variable Frequency Drives (VFD) for control of motors which are integral to packaged equipment supplied under other Divisions will be supplied by that Division.
3. Division 26 is responsible for all power wiring to and from Disconnect Switches, Motor Starters (including VFD’s), and Motors, unless otherwise noted.
4. A source of power to feed mechanical control panels for Building Management (BMS, DDC, etc) systems is to be made available by Division 26. Line voltage wiring from power source (breaker in panel) to control panels is to be provided by Mechanical Trade where wiring/homerun has not been indicated elsewhere on Contract Drawings. Coordinate with Division 23 Section CONTROL AND INSTRUMENTATION.

C. This section includes but is not limited to the following:

1. Conduit, cable and fittings
2. Pull boxes and junction boxes
3. Outlet boxes
4. Conduit hangers and supports
5. Wires and cables
6. Splices
7. Wall plates
8. Safety switches and fuses
9. Motor starters
10. Emergency fan shutdown system
11. Labeling and identification

1.3 SUBMITTALS

A. Submit, for review, list of manufacturers and grade or type of material proposed, including wire, wiring devices, terminating systems, connectors, conduit, wireway and fittings. Submit samples if requested.

B. Submit for review shop drawings for all equipment and materials specified under this Section.

C. Prior to final inspection, submit test reports to Engineer for review.

D. Upon completion of job, furnish reproducible copies of wiring and interconnection diagrams required for clear and permanent record of interconnected equipment, such as alarms and annunciator panels.

E. Refer to Section COMMON WORK RESULTS in this Division.

1.4 COORDINATION DRAWINGS

A. Refer to Section 260510, PROJECT COORDINATION AND COORDINATION DRAWINGS.

1.5 STANDARDS

A. All work shall conform to following standards:

1. NEMA Standards.
2. ANSI Standard CI: National Electrical Code (NFPA 70).
3. ANSI Standard C50: Rotating Electrical Machinery.
4. ANSI Standard C501-1: Construction and guide for selection, installation and use of electric motors.
5. ANSI Standard C52.1: Motors and generators (NEMA MG1).
6. ADA: Americans with Disabilities Act
7. Refer to Section COMMON WORK RESULTS for additional requirements

1.6 UNDERWRITERS LABORATORIES LABELS

A. Equipment, materials and components, for which there are listings in UL Product Directories, shall bear UL labels.

PART 2 - PRODUCTS

2.1 CONDUIT AND FITTINGS

A. The generic term “Conduit” when reference is made to method of installation and fittings, includes all types of conduit and EMT.

B. Rigid conduit (RMC) shall be UL listed, hot dipped galvanized steel with full cut hot dipped galvanized NPT threads. RMC shall be chromated on all surfaces for corrosion and abrasion protection. Connectors and couplings shall be galvanized steel threaded type listed for RMC use.

C. Intermediate metal conduit (IMC) shall be UL listed, hot galvanized steel with full cut hot galvanized NPT threads and factory-applied interior coating or lining for ease in pulling wires. Connectors and couplings shall be galvanized steel threaded type listed for IMC use.

D. Electric metallic tubing (EMT) shall be UL listed, hot galvanized steel with factory-applied interior coating or lining for ease in pulling wires. Connectors and couplings shall be galvanized steel, either compression type or heavy-duty set screw-type, listed for EMT use. Indent or crimp-type connectors are NOT allowed.

E. Non-metallic conduit (NMC) shall be rigid PVC, heavy-wall Schedule 40, UL rated, acceptable equivalent to Carlon "Type 40". Where non-metallic conduit is installed below paved areas, conduit shall be rigid PVC, heavy wall Schedule 80, UL rated and of same manufacturer as the Schedule 40 conduit.

F. Flexible metal conduit (FMC) shall be UL listed, single strip, spirally wound, corrosion-resistant, galvanized steel acceptable equivalent to Liquatite "Type BR". Use galvanized steel fittings and clamps listed for FMC use.

G. Liquid tight flexible metal conduit (LFMC) shall be UL listed, with a flexible core of single spiral wound strip of hot dipped galvanized steel and a liquid-tight jacket of flame-retardant, sun/oil/acid-resistant flexible PVC: Acceptable equivalent to Liquatite "Type LA". Connectors and couplings shall be zinc-plated malleable iron or steel, with engagement inspection window, locknut and sealing ring; liquid-, oil-, and rain-tight; suitable for wet locations; listed for LFMC use: acceptable equivalent to O-Z/Gedney "Type 4Q".

1. Blue Type LA liquid-tight flexible metal conduit (LFMC) shall be used for all wiring beneath raised floor.
2. Grey/Tan Type LA liquid-tight flexible metal conduit (LFMC) shall be used for final connections to vibrating equipment and to partition furniture systems.

H. Minimum Conduit and EMT size: 3/4”

I. Minimum Flexible Metal Conduit Size: 1/2”

J. Special Fittings

1. Where conduit penetrates air handling unit walls or plenums locations: provide sealing fittings acceptable equivalent to Crouse-Hinds "EYS Series".

2. Where conduit penetrates waterproof foundation, floor or roof: provide through-wall seals acceptable equivalent to O.Z./Gedney "Type CSMI" on each side of existing walls and O.Z./Gedney "Type FSK" on new walls.

3. Where conduit from underground distribution system enters building, provide cable terminators acceptable equivalent to O.Z./Gedney "Type CSB".

4. Where conduit is exposed at building expansion joint: provide expansion fittings acceptable equivalent to O.Z./Gedney "Type EX" or "Type EXE".

K. Where conduit is in concrete at building expansion or seismic joint and where conduit is exposed at seismic joint: provide expansion/deflection fittings acceptable equivalent to O.Z./Gedney "Type DX".

2.2 WIREWAYS AND SURFACE RACEWAYS

A. Wireways shall be steel, UL listed, with hinged or screwed covers by Lee Products, Keystone or acceptable equivalent.

1. Minimum Wireway Size: 4” x 4”

B. Surface raceways shall be UL labeled, steel with standard buff finish, acceptable equivalent to Wiremold. Sizes and types shall be as shown on Contract Drawings or as required by Engineer.

2.3 CABLE ASSEMBLIES

A. Type MC cable shall be UL listed, 600 V, 90°C rated, flexible metal encased multi-conductor assembly; with cable sheath of interlocked galvanized steel strip, copper conductors with Code gauge THHN insulation, and internal green insulated ground: acceptable equivalent to AFC "Type MC Tuff". Connectors and fittings shall be galvanized steel, listed for MC cable use. Cable sheath of interlocked aluminum is NOT acceptable. Type MC cable shall NOT be used for homeruns.

2.4 PENETRATION OF FIRE RATED CONSTRUCTION

A. Where single cable/conduit must penetrate fire-rated walls, ceilings or floors: seal with Dow-Corning #3-6548-RTV silicon foam, according to manufacturer's instructions; or

1. For conduits in cored holes: provide fire seals acceptable equivalent to O.Z./Gedney "Type CFS".
2. For cables in cored holes: provide O.Z./Gedney "Type CAFS".

B. Where multiple cables/conduits must penetrate fire-rated walls, ceilings or floors: seal with Dow-Corning #3-6548-RTV silicone foam according to manufacturer's instructions; or provide through-wall sealing fittings acceptable equivalent to Crouse-Hinds "TW Series Thru-Wall Barrier", with following provisions:

1. Assemblies shall be complete with Crouse-Hinds TWF mounting frames, Crouse-Hinds TWB sealing block assemblies, Crouse-Hinds TWP plugs, Crouse-Hinds TWR reducers, Crouse-Hinds TWK anchors, and Crouse-Hinds TWL lubricant.

2.5 APPLICATIONS – CONDUIT, CABLES, RACEWAYS

A. RMC: buried in floor slabs, in concrete walls, concealed in exterior masonry walls, wiring in fire pump rooms, hazardous locations, applications above 600 V.

B. IMC: where noted on drawings.

C. EMT: unless otherwise noted:

1. Feeders
2. Power wiring in mechanical rooms
3. Wiring for fire alarm systems
4. Branch circuits
5. Control wiring, including work done under Division 23
6. Wiring above non-accessible ceilings

D. LFMC: final connections to motors and equipment-mounted controls from minimum of 18” to maximum of 6 feet lengths.

E. FMC: light fixture whips above accessible ceilings, except not in damp or wet locations and limited to maximum lengths of 6 feet.

F. NMC: sleeves through interior walls, below slab-on-grade, electrical ductbanks, and below grade unless otherwise noted.

G. MC Cable: Galvanized steel cable only, aluminum clad will not be accepted.

1. MC cable in interior walls constructed of metal studs and gypsum wall board.
2. Where MC cable is allowed, EMT shall be installed from electrical panels to a collector box and from the collector box to the first device in each circuit.
3. Provide with a separate dedicated insulated ground wire, AFC Type MC/IG or equal where an isolated, redundant, or dedicated ground is required.

H. Wiremold, cable tray: as shown on Contract Drawings.

I. EMT is NOT permitted as a substitute for rigid conduit; MC is NOT permitted as a substitute for flexible metal conduit.

J. AC (BX) cable shall NOT be used.

2.6 PULL BOXES AND JUNCTION BOXES

A. Boxes shall be heavy, stamped steel with covers attached by screws. Provide locknuts for conduit size to which boxes are connected. In finished areas, boxes shall have neatly mitered frame and flush steel cover screwed to the frame.

B. Boxes shall be sized according to NEC.

C. Boxes shall be flush mounted where installed with concealed conduit, and surface mounted elsewhere.

2.7 CONDUIT HANGERS AND SUPPORTS

A. Hangers, clips and accessories supporting conduit shall be UL listed.

B. Individual large conduits shall be supported by means of adjustable, malleable hangers of acceptable design placed on maximum 8’-0” centers. Individual small conduits may be held in place by one hole malleable clips.

C. MC cable shall be supported by hangers of acceptable design placed on maximum 4’-0” centers. MC cable shall be supported within 12” of each fitting.

2.8 WIRES AND CABLES

A. Secondary conductors shall be new copper with 600 V code gauge insulation, conforming to NEC requirements, and shall be Type THWN or THHN, except as follows:

1. Type XF or SFF 150°C shall be used for fixture wiring.
2. Ground wires shall be as specified under SECTION 260526, ELECTRICAL GROUNDING, and in accordance with NEC.
3. Type XHHW shall be used for conductors #3 AWG and larger.

B. When wire sizes are not shown on Contract Drawings, sizes shall be in accordance with NEC but no smaller than following:

1. Power wiring: #12 AWG.
2. Control wiring: #14 AWG.
3. Wiring and cable for alarm and signal systems: as recommended by equipment manufacturer.

C. All multi-purpose feeders and circuits shall include a full size neutral and separate insulated ground conductor.

1. All 277/120 VAC circuits shall include separate full sized neutral and insulated ground conductors. Shared neutrals or ground conductors are not permitted.

D. Provide cable supports per NEC ARTICLE 300.19, acceptable equivalent to O.Z./Gedney "Type R" for large cables and Kellems "Grips" for bundles of smaller wires.

2.9 SPLICES

A. Splices for #10 or smaller wires shall be made with UL approved solderless connectors: spring type acceptable equivalent to Minnesota Mining and Manufacturing Company "Scotchlock"; or crimp-type acceptable equivalent to Thomas & Betts "Sta-Kon".

B. Splices, cable taps and terminals for #8 and larger shall be made with UL approved compression connectors: compression taps acceptable equivalent to Thomas & Betts "Colored Keyed" "C" taps applied with special tools according to manufacturer's recommendations; or bolted pressure connectors, bronze or copper construction, by Thomas & Betts, Burndy or acceptable equivalent.

2.10 WALL PLATES

A. Plates on exposed conduit boxes shall be galvanized zinc-coated with rounded edges.

B. Plates for special receptacles, other than 120 V, shall be engraved to indicate the voltage. Cover on three phase switches shall read "3 PHASE".

C. Wherever switches are grouped, they shall be ganged and provided with one-piece gang plates to suit installation.

2.11 SAFETY SWITCHES AND FUSES

A. Work of this Division shall include:

1. Furnishing and installing an appropriate fusible safety switch for each motor, unless otherwise noted.
2. Installation of safety switches furnished under DIVISION 23, MECHANICAL WORK.
3. Fuses for safety switches.
4. Power wiring to and from safety switches.

B. Disconnect Switches for Motor Starters

1. Provide disconnect switch ahead of each magnetic motor starter. The disconnect switch shall be located in sight of the controller location and not more than 50' apart.
2. Where more than one motor is connected to single branch feeder, provide fused disconnect switch for each motor, even if within sight of feeder branch breaker.
3. Motors requiring disconnecting means remote from the starter shall have a fused switch as close as possible to motor.

C. Safety switches shall have rejection clips for RK fuses and NEMA 1 enclosure, unless otherwise noted. Safety switches shall be NEMA Type HD (heavy-duty), manufacturer's specification grade switches by Square D, General Electric, or Westinghouse, acceptable equivalent to following:

1. Switches for use on 120/208 V system: rated for 240 V.

2. Switches for use on 480 V system: rated for 600 V.
3. Fused disconnect 2-pole and 3-pole: Square D "Type H".
4. Switches that are used in conjunction with variable frequency drives (VFDs) shall have auxiliary contacts that open before switch blades to interrupt control circuits. Auxiliary contacts shall be 120 VAC; 5 Ampere rated.
5. Switches for use with 6 lead motors: 600 VAC, NEMA 4X enclosure.

   a. Fused: Square “D” Type H

D. Fuses for safety switches shall be non-renewable dual element cartridge type, Class RK5, UL listed. Fuses shall be Bussmann #FRN for 208 V usage, and Bussmann #FRS for 460 V usage; or acceptable equivalent by Shawmut or Littelfuse. Install fuse so that size is readily visible. Special types and classes are indicated on Contract Drawings.

E. Provide one spare set of fuses for each type and size used with switches and other equipment.

F. Pedestals for roof mount disconnect switches shall be stainless steel with an integrally welded deck flange. Pedestals shall extend 36" above roof line and 12" below roof line and shall include pedestal mounted NEMA 3R safety switch and GFCI receptacle. Pedestals shall be equal to MAPA #MPD-30.

2.12 MOTOR STARTERS

A. Unless otherwise noted, provide an appropriate motor starter for each motor. Installation of, and power wiring to and from, the starters furnished under DIVISION 23, MECHANICAL WORK, shall be done as part of the work of this Division. Unless otherwise noted, control wiring shall be provided as specified under SECTION "CONTROL TRADE WORK".

B. Motor starters shall meet NEC, NEMA, UL, CSA and ANSI and shall be suitable for required load, duty, voltage, phase, frequency, service and location.

C. Starters shall be by Allen-Bradley, Cutler-Hammer/Westinghouse, Square D, or General Electric, acceptable equivalent to following:

1. Manual motor starters for 115 V or 200 V, single-phase motors less than 1/2 HP: Square D "Class 2510" Type FG-5P or Type FG-6P. Provide with handle guard/lock-off to prevent accidental operation and to allow starter to be locked in the ON or OFF position.
2. Manual motor starters for three-phase motors: Square D "Class 2510" Type KG-6. Provide with handle guard/lock-off to prevent accidental operation and to allow starter to be locked in the ON or OFF position.
3. Magnetic across-the-line starters, for single-phase motors 1/2 HP and larger and for three-phase motors: Square D "Class 8536".
4. Combination motor starters, with fused disconnect switch (fuse class RK-5): Square D "Class 8538".
5. Combination motor starters, with thermal-magnetic circuit breaker (with interrupting rating as specified elsewhere): Square D "Class 8539".
6. Magnetic starters for two-speed, single winding, consequent pole motors: Square D "Class 8810".

7. Combination motor starters with fused disconnect switch (fuse class RK-5) or with thermal-magnetic circuit breakers; for two-speed, two winding motors: Square D "Class 8810".

Reduced voltage starters, solid-state: Square D "Class 8660".

D. For 208V systems, provide 120 V control power by tapping one power phase leg with single-pole fuse in fuse clip and running one #12 AWG neutral to starter.

E. For 208V or 277/480 VAC systems, provide integral 120 VAC fused control power transformer in each starter, unless otherwise noted.

F. Unless otherwise noted, motor starter shall have NEMA 1 enclosure.

G. Magnetic starters shall have the following features:

1. Two extra N.O. and two extra N.C. auxiliary contacts, for each speed.
2. "HAND-OFF-AUTOMATIC" switch mounted in cover.
3. Red "ON" pilot light equipped with neon lamp and mounted in starter cover.
4. Red and yellow "ON" pilot lights for high and low speeds, on two-speed motors.
5. Terminal strip for field wiring connections to control circuits.
6. Cover-mounted reset button.
7. Three thermal overload relays, with appropriate heaters to provide protection on all motor phase legs. Relays shall be bimetallic or melting alloy type.
8. High-Low selector switch which is functional only in "HAND" position on two-speed motors.
9. Reverse phase and phase failure relay, for motors 100 HP and larger.
10. Other features specified in motor starter schedule.

H. For control of HVAC starters, refer to DIVISION 23, MECHANICAL WORK.

2.13 EMERGENCY FAN SHUTDOWN SYSTEM

A. Provide following system to shut down fans upon signal from Fire Alarm System or upon the actuation of a manual fan shutdown switch.

1. Provide relay within three feet of each temperature control panel. Relay shall have 120 V, 60 Hz coil and shall have one N.O. and one N.C. contact for use with controls under SECTION "CONTROL TRADE WORK", to shut down fans upon deactivation of relay.
2. Dry contacts in shutdown switches and Fire Alarm System shall be connected in series to energize all relays under normal conditions. Any alarm shall cause relays to de-energize.

B. Relays shall be acceptable equivalent to Square D "Type X" control relay with one N.O. and one N.C. 10 A contact and continuous duty rated coil. Provide NEMA 1 enclosure, acceptable equivalent to Square D "Class 9991 Type UE7".

C. Wiring shall be #12 AWG in 1/2” EMT.

D. Provide 120 V control power from 20 A, single pole circuit breaker provided with handle lock. (Where available, this shall be an emergency circuit.)

2.14 LABELING AND IDENTIFICATION

A. Refer to PART 3 – EXECUTION.

PART 3 - EXECUTION

3.1 SUPERVISION

A. Furnish services of experienced electrical Superintendent who shall be constantly in charge of electrical work, together with skilled laborers required to unload, transfer, erect, connect, adjust, start, operate and test each system.

B. Particular emphasis is placed on timely installation of major apparatus and furnishing of other trades and Contractor with relevant information.

3.2 MOTOR AND CONTROL CIRCUIT WIRING

A. Provide wiring required for electrical equipment furnished under other Divisions of this Specification. Provide disconnects, starting switches and motor protection ahead of each piece of equipment, unless specified otherwise.

B. Check all protective and control equipment furnished or installed under this Division. Ensure that such equipment is properly sized for motor or other electrical equipment that it serves. Replace any material or equipment damaged due to improperly-sized protective control mechanisms.

C. Electrical controls and starters integral with or specialized for mechanical equipment may be specified with equipment in other DIVISIONS. Disconnects and other controls and starters are specified in this Division.

D. Output power wiring from variable frequency drive (VFD) to motor shall be run in metallic conduit; other wiring shall NOT be run in this conduit. VFD shall have separate equipment conductor back to ground bus of source panel or switchboard and shall NOT depend on metallic conduit for grounding. Power shall NOT be applied to VFD until VFD manufacturer has checked and approved VFD installation.

3.3 IDENTIFICATION

A. Provide nameplates and general identification as required under SECTION 260500, COMMON WORK RESULTS FOR ELECTRICAL, and under DIVISION 1, and as follows:

1. Nameplates on panelboards, distribution panels and service switches: minimum of 1-1/2” by 2-1/2” size with letters not less than 3/8” high.
2. Nameplates on starters and other switches and devices: minimum of 3/4” by 2-1/2” size with letters not less than 1/4” high.

B. Wall plates provided for flush-mounted control switches in finished areas shall be engraved, stainless steel with black-filled letters.

C. Conductors size #6 and smaller shall have solid color insulation for identification.

D. Conductors size #4 and larger shall have color identification, six inches minimum length near termination and in splice boxes, junction boxes, panels and manholes. Identification shall be by solid color insulation, tape or paint.

E. Phase rotation shall be indicated by following color code:

Phase	**208Y/120V**	**480Y/277V**
A	Black	Brown
B	Red	Orange
C	Blue	Yellow
Neutral	White	White with purple stripe or natural gray
Ground	Green	Green

F. 480 V wiring shall have orange adhesive tape strips with continuous pre-printed legend "480 Volts" affixed near terminations and in pull boxes and wireways. Preprinted tape shall be by Seton Nameplate, W.H.Brady or acceptable equivalent.

G. Where wall plates are provided for control switches flush mounted in finished areas, plates shall be engraved, stainless steel with black-filled letters.

3.4 INSTALLATION OF CONDUIT, BOXES AND FITTINGS

A. Ends of conduits shall be reamed before assembly, and bushings and locknuts shall be provided where conduits connect to boxes.

B. Boxes shall be set plumb and square with building lines. Exposed conduit shall run parallel to building lines, unless noted otherwise, and shall NOT block ceiling inserts.

C. Maintain conduit and outlet boxes in position during construction of concrete floors, masonry walls, etc.

D. Wiring device boxes shall NOT be installed back-to-back in walls.

E. Conduit shall run to avoid low pockets which might collect water, and, during installation, open ends shall be capped.

F. RMC or IMC buried in grade or in ductbanks shall have couplings made up tight. Thread to coupling joint shall be coated heavily with bitumastic paint, ensuring watertightness.

G. Parallel groups of conduit shall be supported from below, either by horizontal angle irons or channel systems such as "Unistrut", with vertical hanger rods at appropriate intervals.

H. Supports for conduit on concrete walls shall be attached to wall with all metal expansion shields.

I. Conduits in slabs or in grade shall be swabbed internally prior to pulling wire or cable.

J. Final connections to motors, control devices mounted on equipment, vibrating equipment and vibration isolated equipment shall be made through liquid-tight flexible metal conduit.

K. Use standard radius bends on concealed conduit; on exposed work, use either standard bends or "L" type fittings acceptable equivalent to Crouse-Hinds.

L. Wherever MC cable is used, leave sufficient slack for future removal or withdrawal of boxes or fixtures from finished ceiling or partitions. All cables shall be rigidly supported from the building structure at least 4' O.C. and within 12" from every fitting and shall run in lines parallel or perpendicular to building structural members. Cable shall not rest on the ceiling structure.

M. Exposed wiring shall be kept as close as possible to underside of roof and floor slabs or bottom of beams, unless noted otherwise. Space above hung ceilings is extremely critical and coordination with mechanical trades is essential.

N. Conduit and wiring shall NOT be run in roof fill and shall NOT pierce roof deck, unless specifically noted to on Contract Drawings.

O. Galvanized electrical conduit of 1/2” nominal diameter may be embedded within 4-1/2” overall thickness suspended concrete slabs over permanent metal floor forms; galvanized electrical conduit of 1” nominal diameter may be embedded within slabs of 6” thickness overall.

P. Conduits concealed in or beneath slab on grade: Conduits larger than 3/4” nominal diameter shall be completely buried below vapor barrier within the porous fill layer, such that surface of vapor barrier is smooth and level within ±1/4” tolerance. Conduits 3/4” and smaller may be:

1. Completely buried below the vapor barrier within the porous fill, or
2. Placed above the vapor barrier, within the slab, at mid-height of slab, or
3. If within the slab, spaced minimum of 3 diameters away from parallel conduits.

Q. Field cut IMC and RGS conduits shall be field threaded. Field threads to be cold galvanized by brush or spray. Cold galvanize to be minimum 95% zinc and shall cure before attaching to threaded fitting. Set screw and compression fittings shall not be acceptable.

R. Conduit shall not be run directly above generator set exhaust system including piping, silencer, emission control equipment, heat recovery exchangers or any other equipment that contains hot exhaust gases.

S. Seal all conduits at the last structure prior to conduits entering a building and where conduits enter a building with Carlon “MAT” or “MAQ” series duct plug for conduits with wires and Carlon “MAE” series for spare conduits or equal. All spare conduits shall have nylon pull string and footage tape.

3.5 INSTALLATION OF CABLES

A. Parallel groups of cables shall be supported from below, either by horizontal angle irons or channel systems such as “Unistrut”, with vertical hanger rods at maximum of three-foot intervals.

B. Supports for cables on concrete walls shall be attached to wall with all metal expansion shields.

END OF SECTION 260515

SECTION 260526 - ELECTRICAL GROUNDING

PART 1 - GENERAL

1.1 REFERENCES

A. This Section covers the specification of grounding for electrical equipment and systems. Refer to SECTION 260500 – COMMON WORK RESULTS FOR ELECTRICAL WORK, GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS, applicable Sections of DIVISION 1, and all other project instructions for other requirements.

1.2 SCOPE

A. Provide labor, materials, services, equipment and transportation necessary for complete and operational grounding systems as indicated on Contract Drawings and specified herein, including but not limited to following:

1. Equipment grounds

1.3 SHOP DRAWING SUBMITTALS

A. Submit for review shop drawings for the following:

1. Ground rods
2. Bus
3. Bushings and pressure lugs
4. Pipe clamps
5. Circuit breakers
6. Grounding conductors
7. Receptacles
8. Plug-in tester unit

PART 2 - PRODUCTS

2.1 EQUIPMENT GROUNDS

A. Provide green THW insulated copper equipment grounding conductor between the ground bus of the source distribution panel or switchboard and each load being served. Conductor shall be sized according to NEC Table 250.122. Provide separate grounding conductor for each branch circuit, unless otherwise indicated on Contract Drawings.

2.2 MATERIALS

A. Ground rods shall be 3/4" x 10'-0" copper-clad steel, by Carolina or acceptable equivalent.

B. Below-grade and concealed connections shall be Thermweld, Cadweld or acceptable equivalent. Above-grade and exposed connections shall be Burndy or acceptable equivalent.

C. Wire shall be stranded bare copper or insulated copper, as indicated on Contract Drawings.

D. Bus shall be copper bar, as indicated on Contract Drawings.

E. Bushings and Pressure Lugs shall be by T&B, O.Z./Gedney or acceptable equivalent.

F. Pipe Clamps shall be by O.Z./Gedney or acceptable equivalent.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

A. Refer to SECTION 260500, BASIC MATERIALS & METHODS - ELECTRICAL.

B. Grounding shall be installed and tested in accordance with NEC (NFPA 70) and to satisfaction of local electrical inspector and Architect.

3.2 EQUIPMENT GROUNDS

A. Equipment grounds shall be continuous from ground bus to electrical equipment and devices.

B. Provide equipment grounds for electrical equipment furnished or installed as part of this Contract.

C. Grounded service conductor (neutral) of 480Y/277 V distribution system shall be grounded at only one point: neutral connection to the ground bus. Under no circumstances shall system neutral be grounded at any other point. As part of final inspection procedures, demonstrate purity of system neutral.

D. Regardless of rating or length, circuits run in FMC shall carry grounding conductor for that portion of circuit in FMC; bond conductor at each end.

E. Current return conductors (neutrals), which are grounded at the source, shall NOT be used for equipment grounding.

F. Grounding conductor shall be secured to equipment enclosure at power source (usually to a ground bus) and at apparatus being served by AC supply. Grounding conductors shall be insulated and shall be large enough to carry ground fault current safely.

G. Maintain electrical continuity of raceways by the following means:

1. Threaded fittings with joints made up wrench-tight where threaded rigid conduit is used.

2. Threadless fittings made up tight.
3. Metal bushing inside and locknut outside of metal boxes and cabinets when threaded conduit is used. If outside locknut is inaccessible for tightening after installation, provide additional locknut inside. If bushing is composed entirely of insulating material, use locknuts inside and outside.
4. Bonding jumper across joints of wireways, cable trays, expansion or deflection fittings, etc.
5. Devices listed for the purpose by UL.

H. NOTE: Addition of equipment grounding conductor to AC circuits run in metallic enclosures does NOT lessen the requirement for conductor enclosure continuity, since part of total ground fault current will flow through the raceway and enclosure system. Therefore, the continuity of this system shall be maintained.

I. Neutrals of each 208Y/120 V distribution transformer to ground so as to be separately delivered system and shall be grounded locally to building steel. If building steel does not exist (i.e., concrete structures), the transformer shall be grounded to main service ground bus. Transformer ground shall also be bonded to nearest available local metal water pipe. The primary feeder ground is supplemental and shall be sized for primary feeder protection. Refer to contract drawings for additional bonding requirements.

END OF SECTION 260526

SECTION 260560 - ELECTRICAL TESTING

PART 1 - GENERAL

1.1 REFERENCES

A. Refer to the GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS and applicable parts of DIVISION 1 for other general requirements. These requirements may be repeated in this Division for emphasis or for inclusion of more stringent/additional related requirements. Such repetition shall NOT be construed to reduce the requirements of those Divisions NOR to eliminate other requirements under those Divisions.

1.2 SUMMARY

A. This Section includes general requirements for electrical field testing and inspecting. Additional detailed requirements are specified in each Section containing components that require testing.

B. General requirements include the following:

1. Qualifications of testing agencies and their personnel.
2. Suitability of test equipment.
3. Calibration of test instruments.
4. Coordination requirements for testing and inspecting.
5. Reporting requirements for testing and inspecting.

C. A qualified Testing Agency is to be engaged to perform the required testing.

D. All corrections, replacements, repairs so that final testing report describes all equipment “as-left” as acceptable is to be provided.

1.3 QUALITY ASSURANCE

A. Testing Agency Basic Qualifications: Each Section containing electrical testing may include additional requirements from that specified below.

B. Acceptance Testing of Electrical Systems: Minimum Standard – Compliance with latest Edition of NETA “Acceptance Testing Specifications.”

PART 2 - NOT USED

PART 3 - EXECUTION

3.1 GENERAL TESTS AND INSPECTIONS

A. If a group of tests are specified to be performed by an independent testing agency, prepare systems, equipment, and components for tests and inspections, and perform preliminary tests to ensure that systems, equipment, and components are ready for independent agency testing. Include the following minimum preparations as appropriate:

1. Perform insulation-resistance tests.
2. Perform continuity tests.
3. Perform rotation test (for motors to be tested).
4. Provide a stable source of single-phase, 208/120-V electrical power for test instrumentation at each test location.

B. General Wiring Tests

1. Prior to final inspection and tests: wiring and connections shall be completed, devices and equipment shall be properly operating, power circuit and control wiring shall be clearly identified with acceptable tags, ready for acceptance.

2. Before devices or equipment is energized, test each wiring system for the following:

a. System is free from short circuits.
b. System is free from ground faults.
c. System is at or below 600 V shall have a minimum installation resistance of 100 megohms when tested with 1000 VDC potential between conductors and between conductors and ground, for a minimum of one minute at 70°F ambient air temperature and dry atmosphere (below 55% RH).
d. Grounding paths have been visually confirmed and acceptable maximum resistance to earth tested.

C. Overcurrent Protective Device Setting

1. Manufacturer's Field Service: Engage a factory-authorized service representative, of electrical distribution equipment to perform or supervise the adjustment of settings on overcurrent protective devices within equipment.
2. Testing: Perform the following device setting and prepare reports:

a. After installing overcurrent protective devices and during energizing process of electrical distribution system, perform the following:

1) Verify that overcurrent protective devices meet parameters used in studies.
2) Adjust devices to values listed in study results.

3. Adjust devices according to recommendations in Chapter 7, "Inspection and Test Procedures," and Tables 10.7 and 10.8 in NETA ATS.

D. Motor Tests

1. After systems are balanced and ready to be turned over to the Owner, test and report motor performance data for motors.
2. Include the following information in the test report:

    a. Equipment name and/or number.
    b. Manufacturer’s nameplate data, including RPM, horsepower, Volts, full-load amperes per phase, service factor, power factor, manufacturer’s name, motor type and model number.
    c. Motor test data, including amperes for each phase, average amperes and phase-to-phase voltage at motor, starter or disconnect switch terminals.
    d. Percentage of: (average load test amperes) divided by (nameplate full-load amperes).
    e. Size, number and ampere rating of overload heaters. Manufacturer’s motor starter heater table.
    f. Breaker and disconnect switch data, including size and manufacturer of switches and fuses and branch circuit wiring.

E. Operational Tests

1. Each piece of electrical equipment, including lighting fixtures, motors and controls shall be operated continuously for minimum test period of one hour.
2. Demonstrate by operating equipment that circuits and devices are in good operating condition. Each item of control equipment shall be operated minimum of five times. Demonstration shall be performed after wiring tests.

F. Mechanical System Adjustment and Testing

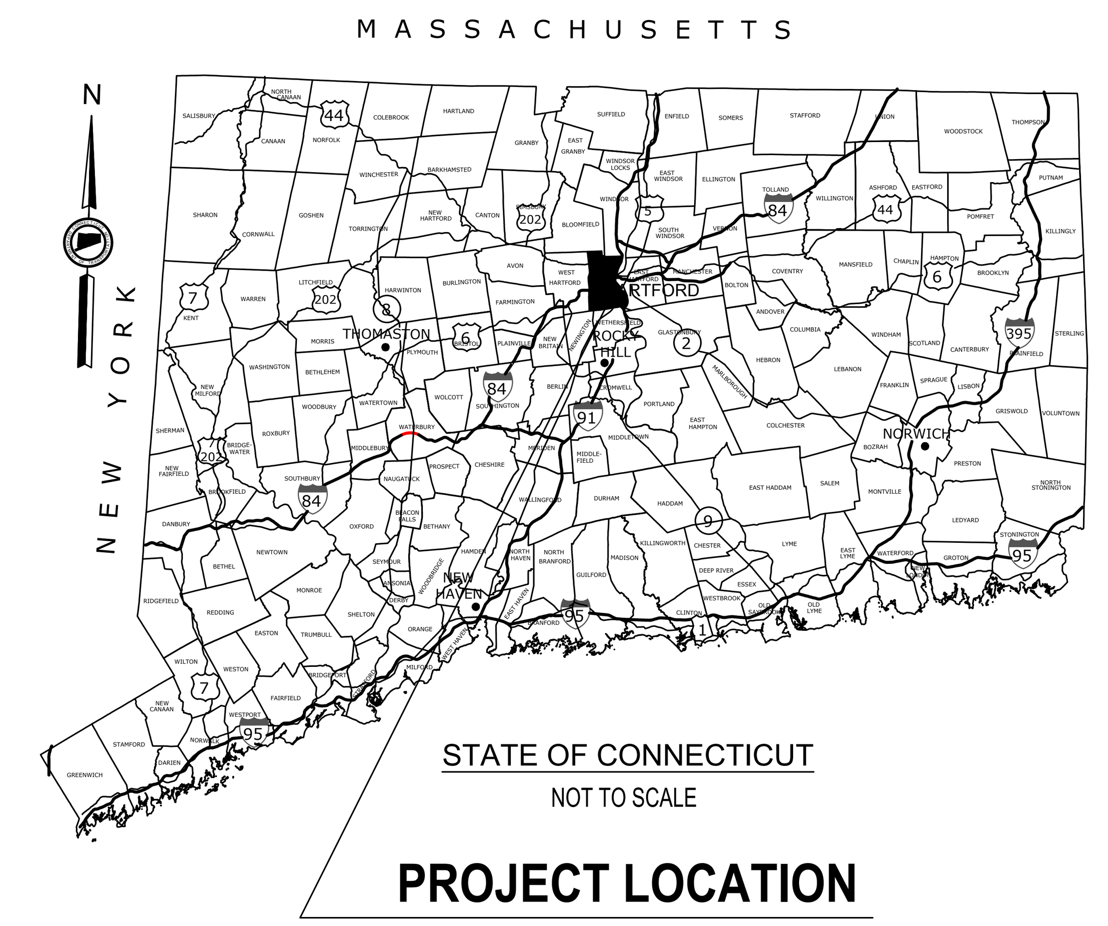
1. Be present during adjustment period and final testing of mechanical systems. Take readings necessary to ensure that electrical systems are operating properly. Tests for mechanical work are detailed under DIVISION 23, MECHANICAL WORK.
2. Take ampere readings at each electrical component, such as motor and heating coil, to determine proper operation.
3. Record readings and submit them in triplicate to Engineer for review.

G. Test and Inspection Reports: In addition to requirements specified elsewhere, report the following:

1. Manufacturer's written testing and inspecting instructions.
2. Calibration and adjustment settings of adjustable and interchangeable devices involved in tests.
3. Tabulation of expected measurement results made before measurements.
4. Tabulation of "as-found" and "as-left" measurement and observation results.

END OF SECTION 260560

GREATER HARTFORD TRANSIT DISTRICT
UNION STATION HVAC UPGRADES
1 UNION PLACE
CITY OF HARTFORD, CT 06103



100% BID DOCUMENTS

NOVEMBER 1, 2023

Greater Hartford
Transit District

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Boston, MA Cranston, RI Richmond, VA
Exton, PA

GENERAL MECHANICAL SYMBOLS

1	REVISION NUMBER - SHOWN ON PLANS
	POINT WHERE E.T.R CONNECTS TO DEMOLITION
	POINT WHERE NEW CONNECTS TO EXISTING
	NUMBER OF DETAIL ON SHEET
	NUMBER OF SHEET WHERE DETAIL APPEARS
1	KEYNOTE
	CONTINUATION SYMBOL
Room 5	ROOM NAME AND NUMBER
	ITEM TO BE DEMOLISHED
	AREA NOT IN CONTRACT
2"	PIPE SIZE TAG (DIAMETER)
	ABOVE GROUND PIPING
1/8" / 12" SLOPE	PIPE SLOPE TAG
	BELOW GROUND PIPING
INVERT: -105' - 1"	PIPE INVERT ELEVATION TAG
(E)	EXISTING PIPE TAG
	PIPING BEING DEMOLISHED

ABBREVIATIONS

Ø	ROUND	LVR	LOUVER
ABV	ABOVE	LWT	LEAVING WATER TEMPERATURE
AC	AIR CONDITIONING	M/A	MIXED AIR
AD	AREA DRAIN	MAX	MAXIMUM
ADD	ADDENDUM	MBH	ONE THOUSAND BTU PER HOUR
AFF	ABOVE FINISHED FLOOR	MCF	ONE THOUSAND CUBIC FEET
AFUE	ANNUAL FUEL UTILIZATION EFFICIENCY	MD	MOTORIZED DAMPER
ALT	ALTERNATE	MECH	MECHANICAL
AP	ACCESS PANEL	MFR	MANUFACTURER
ARCH	ARCHITECT/ARCHITECTURAL	MIN	MINIMUM
BFF	BELOW FINISHED FLOOR	MISC	MISCELLANEOUS
BLW	BELOW	MTR	MOTOR
BTU	BRITISH THERMAL UNITS	MU/A	MAKE-UP/AIR
BTUH	BRITISH THERMAL UNITS PER HOUR	NC	NOISE CRITERIA
CAP	CAPACITY	NC	NORMALLY CLOSED
CB	CATCH BASIN	NIC	NOT IN CONTRACT
CFM	CUBIC FEET PER MINUTE	NO	NUMBER
CLG	CEILING	NO	NORMALLY OPEN
CO	CLEAN OUT	NTS	NOT TO SCALE
CW	COLD WATER	O	OXYGEN
D	DEGREE	O/A	OUTSIDE AIR
DB	DRY BULB	ORD	OVERFLOW ROOF DRAIN
DIA	DIAMETER	PD	PRESSURE DROP
DN	DOWN	PIV	POST INDICATOR VALVE
DW	DISTILLED WATER	PLBG	PLUMBING
EA	EACH	PRESS	PRESSURE
EAT	ENTERING AIR TEMPERATURE	PRV	PRESSURE REDUCING VALVE
ELEC	ELECTRICAL	PSI	POUNDS PER SQUARE INCH
EQUIP	EQUIPMENT	PSIG	POUNDS PER SQUARE INCH GAUGE
EWC	ELECTRIC WATER COOLER	PWR	POWER
EWT	ENTERING WATER TEMPERATURE	R	DUCT RISER
E/A	EXHAUST AIR	R/A	RETURN AIR
EXIST	EXISTING	RCP	RADIANT CEILING PANEL
F	DEGREES FAHRENHEIT	RD	ROOF DRAIN
FCO	FLOOR CLEAN OUT	REC	RECESSED
FD	FLOOR DRAIN	RED	REDUCER
FDC	FIRE DEPARTMENT CONNECTION	RH	RELATIVE HUMIDITY
FL	FLOOR	RL/A	RELIEF AIR
FO	FUEL OIL	RM	ROOM
FOV	FUEL OIL VENT	RPM	REVOLUTIONS PER MINUTE
FOR	FUEL OIL RETURN	RW	RAIN WATER
FOS	FUEL OIL SUPPLY	SF	SQUARE FOOT
FPM	FEET PER MINUTE	S/A	SUPPLY AIR
FS	FLOOR SINK	SAN	SANITARY
FT	FOOT/FEET	SF	SQUARE FOOT
FTR	FIN TUBE RADIATION	SD	SMOKE DAMPER
GAL	GALLON	SM	SURFACE MOUNT
GF	GAS-FIRED	SP	STANDPIPE
GC	GENERAL CONTRACTOR	SP	STATIC PRESSURE
GPM	GALLONS PER MINUTE	STM	STEAM
GW	GREASE WASTE	T	THERMOSTAT
HB	HOSE BIB	TD	TEMPERATURE DROP
HP	HORSE POWER	TDR	TRENCH DRAIN
HTG	HEATING	TEMP	TEMPERATURE
HTR	HEATER	TYP	TYPICAL
HW	HOT WATER	UG	UNDERGROUND
HYD	HYDRANT	VAC	VACUUM
ID	INDIRECT	V	VENT
IN	INCH	VAV	VARIABLE AIR VOLUME
INV	INVERT	VENT	VENTILATION
LB	POUND	VTR	VENT THROUGH ROOF
LB/HR	POUNDS PER HOUR	W	WASTE
LAT	LEAVING AIR TEMPERATURE	WB	WET BULB
LP	LOW PRESSURE	WCO	WALL CLEAN OUT
LPG	LIQUEFIED PETROLEUM GAS	WH	WALL HYDRANT

EQUIPMENT ABBREVIATIONS

AC	AIR CONDITIONING UNIT	ET	EXPANSION TANK
ACCU	AIR COOLING CONDENSING UNIT	EWH	ELECTRIC WATER HEATER
AHU	AIR HANDLING UNIT	FCU	FAN COIL UNIT
AS	AIR SEPARATOR	FP	FIRE PUMP
B	BOILER	GI	GREASE INTERCEPTOR
CH	CHILLER	GRV	GRAVITY ROOF VENTILATOR
CT	COOLING TOWER	HWP	HEATING WATER PUMP
CUH	CABINET UNIT HEATER	HRU	HEAT RECOVERY UNIT
CHWP	CHILLED WATER PUMP	PRV	POWER ROOF VENTILATOR
DBP	DOMESTIC WATER BOOSTER PUMP	RE	RETURN/EXHAUST FAN
DC	DUCT MOUNTED COIL	RTU	ROOFTOP UNIT
DCP	DOMESTIC WATER CIRCULATING PUMP	SP	SUMP PUMP
EF	EXHAUST FAN	UH	UNIT HEATER
EDC	ELECTRIC DUCT COIL	WH	WATER HEATER

* NOTE *
ALL OF GENERAL NOTES ON THIS SHEET ARE TO BE APPLIED TO ALL OTHER DRAWINGS IN THIS SET. THE SYMBOLS AND ABBREVIATIONS SHOWN ON THIS SHEET MAY OR MAY NOT BE USED IN THIS SET OF DRAWINGS.

HVAC SYMBOLS

18"x12"	SQUARE DUCT SIZE TAG (WIDTH x HEIGHT)
18"/12"	OVAL DUCT SIZE TAG (WIDTH / HEIGHT)
18"Ø	ROUND DUCT SIZE TAG (DIAMETER)
(E)	EXISTING DUCT TAG
	DUCT BEING DEMOLISHED
18"x18" S/A	SUPPLY AIR
18"x18" S-O/A	CONDITIONED OUTSIDE AIR
18"x18" O/A	OUTSIDE AIR
18"x18" R/A	RETURN AIR
18"x18" T/A	TRANSFER AIR
18"x18" E/A	EXHAUST AIR
18"x18" L/A	RELIEF AIR
18"x18" GE/A	GREASE EXHAUST AIR
18"x18" CE/A	CONDENSATE EXHAUST AIR
18"x18" SE/A	SMOKE EXHAUST AIR
6"Ø FLUE	EXHAUST GAS FLUE
6"Ø C/A	COMBUSTION AIR
DROP	RECTANGULAR SUPPLY/OUTSIDE AIR DUCT RISE
DROP	ROUND SUPPLY/OUTSIDE AIR DUCT RISE
DROP	RECTANGULAR RETURN/TRANSFER AIR DUCT RISE
DROP	ROUND RETURN/TRANSFER AIR DUCT RISE
DROP	RECTANGULAR EXHAUST/RELIEF AIR DUCT RISE
DROP	ROUND EXHAUST/RELIEF AIR DUCT RISE

GRILLES, REGISTERS & DIFFUSERS TAG

TYPE (SEE SCHEDULE)
3-CONE DIFFUSER — SD1 400 / 10" / 24x24 / 22 H-5/7/14 — CFM; NECK SIZE / MODULE SIZE; THROW-150FPM/ 100FPM/ 50FPM; THROW PATTERN; MAX NC RATING
PERFORATED DIFFUSER WITH DEFLECTORS — SD3 300 / 10" / 24x24
RG2 500 / 12"x10" / 24x24 / 18 — EGGCRATE RETURN GRILLE
ROUND DIFFUSER WITH ADJUSTABLE PATTERNS — SD9 400 / 12" / ---
LOUVERED DOUBLE DEFLECTION GRILLE — SG5 500 / 12"x10"
RG11 500 / 12"x10" / 24x12 — LOUVERED GRILLE
LINEAR BAR GRILLE — SLB3 400 / 48"x2 1/2"

LINEAR DIFFUSER TAG

TYPE (SEE SCHEDULE) — LSD1 200 / 1 / 4' - 0" / 8" / 8' - 0"AFF — CFM; NUMBER OF SLOTS / ACTIVE SLOT LENGTH (PLENUM LENGTH) / NECK SIZE; ELEVATION (CENTER OF FACE); SECTION TOTAL TRACK LENGTH
LSD1 200 / 1 / 4' - 0" / 8"
6' - 0"
LINEAR SLOT DIFFUSER
LSD1 200 / 1 / 4' - 0" / 8"

MECHANICAL EQUIPMENT TAGS

HEATING COIL FLOW — VAV-XX / Htg: 3.7 GPM / VAV BOX
OPERATING WEIGHT NOT INCLUDING CURB — RTU-XX / 590 lb
BOTTOM OF EQUIPMENT ELEVATION — VAV-XX / 10' - 0"
RTU-XX / 4.0 ton — NOMINAL COOLING CAPACITY
ROOFTOP UNIT
EXISTING EQUIPMENT TO REMAIN — (E)VAV-XX
EXISTING RELOCATED EQUIPMENT — (R)VAV-XX
FUEL INPUT GAS PIPE FLOW — RTU-XX / 115000 Btu/h / 115 CFH
EQUIPMENT BY OTHERS (REFER TO OTHER DISCIPLINE FOR ADDITIONAL INFORMATION) — VAV-XX

DATA DEVICE TAGS

EQUIPMENT ID — RTU-XX — SYMBOL

TEMPERATURE SENSOR	TS	C3H3	C3H3 DETECTOR
HUMIDITY SENSOR	HS	CH4	CH4 DETECTOR
TEMPERATURE & CO2 SENSOR	TC	CO2	CO2 DETECTOR
TEMPERATURE & HUMIDITY SENSOR	TH	CO	CO DETECTOR
THERMOSTAT	T	H2	H2 DETECTOR
HUMIDISTAT	H	H2S	H2S DETECTOR
O2 DETECTOR	O2	HZG	HAZARDOUS GAS DETECTOR
PANEL NAME BMS CONTROL PANEL	HVAC-CP-X	NO2	NO2 DETECTOR

DAMPER TAGS

COMB. FIRE/SMOKE DAMPER — MANUAL BALANCING DAMPER
FIRE DAMPER — MOTORIZED DAMPER
SMOKE DAMPER — BACKDRAFT DAMPER
12"x12" S/A — 12"x12" S/A

PIPING SYMBOLS

CHWR	CHILLED WATER RETURN
CHWS	CHILLED WATER SUPPLY
CD	CONDENSATE DRAINAGE
CWR	CONDENSER WATER RETURN
CWS	CONDENSER WATER SUPPLY
GWR	GEOTHERMAL WATER RETURN
GWS	GEOTHERMAL WATER SUPPLY
HWR	HEATING WATER RETURN
HWS	HEATING WATER SUPPLY
G	NATURAL GAS
PG	PROPANE GAS
REF-L	REFRIGERANT-LIQUID
REF-S	REFRIGERANT-SUCTION
REF-HG	REFRIGERANT-HOT GAS
STM	STEAM
CDR	CONDENSATE RETURN
	PIPING TO BE DEMOLISHED

PIPE DROP
PIPE RISE
PIPE TEE
CAP
2"
4"
4"
PLUG
REDUCING 45 DEGREE TEE
45 DEGREE TEE

PIPE ACCESSORY TAGS

2" SHUTOFF BALL VALVE	2" LOCKED LOCK SHIELD VALVE
2" BALANCING BALANCING VALVE	2" PRV PRESS REDUCING
2" BUTTERFLY BUTTERFLY VALVE	2" QUICK QUICK OPENING
2" CHECK CHECK VALVE	2" STRAINER
(ALTERNATE CHECK VALVE SYMBOL)	1" GAS-CNTRL EMERG. GAS SHUTOFF
2" CIRC CIRCUIT SETTER	1" PLUG PLUG VALVE
2" GATE GATE VALVE	1" GAS COCK GAS SHUTOFF COCK
2" GLOBE GLOBE VALVE	1" REG PRESS REGULATOR
2" M-CNTRL ELEC. CONTROL	4" 3-WAY CNTRL 3-WAY ELEC. CONTROL

CONTROLS SYMBOLS

DS	DUCT SMOKE DETECTOR
AO	ANALOG OUTPUT
AI	ANALOG INPUT
BO	BINARY OUTPUT
BI	BINARY INPUT
PS	STATIC PRESSURE SENSOR

BASE BID

SHALL INCLUDE REPLACEMENT OF THE FOLLOWING EQUIPMENT AND CONTROLS:

1. FOUR AIR HANDLER UNITS: AHU-9A,11A,9B & 11B.
2. THREE PACKAGE UNITS: PK1, PK2 & PK3.
3. FIVE AIR HANDLERS UNITS SERVING PROPARK (SOUTH WING), AND
4. ONE MAKEUP AIR UNIT IN THE TRANSPORTATION CENTER.

ADD ALTERNATE #1

SHALL INCLUDE REPLACEMENT OF THE FOLLOWING EQUIPMENT AND CONTROLS:

1. SEVEN AIR HANDLER UNITS LOCATED IN THE ATTIC: AHU-2,3,4,5,6,7 & 8.
2. SEVEN EXHAUST FANS EX-2, EX-3, EX-4, EX-5, EX-6, EX-7 & EX-8 LOCATED IN THE ATTIC.
3. A NEW BUILDING MANAGEMENT SYSTEM TO REPLACE THE EXISTING SYSTEM IN PLACE. THE NEW SYSTEM SHALL BE PROVIDED AS DETAILED IN SPECIFICATION 230923. THE EQUIPMENT TO BE INTEGRATED INTO THE NEW SYSTEM SHALL INLCUDE AT MINIMUM:
   - ALL HVAC EQUIPMENT (INCLUDING EXISTING AIR HANDLING EQUIPMENT NOT PART OF PROJECT)
   - ALL CHILLERS
   - ALL PUMPS
   - ALL BOILERS

THE BMS SHALL HAVE IN ADDITION TO THE STATUS OF EQUIPMENT A MINIMUM OF 20 ADDITIONAL POINTS TO BE DEFINED BY THE OWNER AT NO COST. THE BMS SHALL BE EXPANDABLE TO ALLOW FOR FUTURE EXPANSION. THE PRICE SHALL INCLUDE COST FOR ALL EQUIPMENT, PROGRAMMING, WIRING, DESIGN, INSTALLATION, FUNCTIONAL TEST, AND COMMISSIONING.

ADD ALTERNATE #2

SHALL INCLUDE REPLACEMENT OF THE FOLLOWING EQUIPMENT AND CONTROLS:

1. THREE AIR-COOLED CHILLERS LOCATED ON GRADE: CH-4, 5 & 6.

GENERAL NOTES

1. PROVIDE ALL MATERIALS AND EQUIPMENT AND PERFORM ALL LABOR REQUIRED TO INSTALL COMPLETE AND OPERABLE MECHANICAL SYSTEMS AS INDICATED ON THE DRAWINGS, AS SPECIFIED, AND AS REQUIRED BY CODE.
2. VERIFY EXISTING CONDITIONS ON THE JOB SITE BEFORE BEGINNING ANY WORK. COORDINATE DEMOLITION AND NEW CONSTRUCTION WITH THE OWNER PRIOR TO COMMENCEMENT OF WORK. COMMENCEMENT OF WORK SIGNIFIES ACCEPTANCE OF CONDITIONS.
3. EXECUTE DEMOLITION IN A SAFE MANNER. EGRESS, EXITS AND EQUIPMENT REQUIREMENTS SHALL BE MAINTAINED. CONTRACTOR SHALL BE RESPONSIBLE FOR ALL DEMOLITION NECESSARY TO COMPLETE THE WORK.
4. CONTRACTOR SHALL BE RESPONSIBLE FOR ALL REMOVAL AND PROPER DISPOSAL OF DEMOLISHED ITEMS. THIS INCLUDES COSTS FOR RECYCLING OR RECLAMATION OF MATERIALS, AS WELL AS HAULING AND DUMPING OF ALL DEMOLISHED MATERIAL.
5. LOCATION AND QUANTITIES OF EQUIPMENT IS BASED ON THE BEST AVAILABLE INFORMATION AT TIME OF DESIGN. CONTRACTOR IS RESPONSIBLE FOR FIELD VERIFYING ALL EXISTING CONDITIONS PRIOR TO BID.
6. CONTRACT DOCUMENT DRAWINGS ARE DIAGRAMMATIC AND ARE INTENDED TO CONVEY SCOPE AND GENERAL ARRANGEMENT ONLY. PROVIDE OFFSETS AND ADAPT TO EXISTING PIPING AS REQUIRED.
7. INSTALL ALL MECHANICAL EQUIPMENT AND APPURTENANCES IN ACCORDANCE WITH MANUFACTURERS' RECOMMENDATIONS, CONTRACT DOCUMENTS, AND APPLICABLE CODES AND REGULATIONS.
8. COORDINATE CONSTRUCTION OF ALL MECHANICAL WORK WITH ELECTRICAL SHOWN ON CONTRACT DOCUMENT DRAWINGS.
9. MAINTAIN A MINIMUM 6'-8" CLEARANCE TO THE UNDERSIDE OF PIPES, CONDUITS, SUSPENDED EQUIPMENT, ETC., THROUGHOUT ACCESS ROUTES IN MECHANICAL ROOMS.
10. LOCATE ALL PRESSURE MEASURING DEVICES IN ACCESSIBLE LOCATIONS WITH THE STRAIGHT SECTION OF PIPE AS RECOMMENDED BY THE MANUFACTURER FOR GOOD ACCURACY.
11. ALL CONTROL WIRE AND CONDUIT SHALL COMPLY WITH THE NATIONAL ELECTRIC CODE AND ELECTRICAL SPECIFICATIONS.
12. ALL PRESSURES LISTED ARE GAUGE UNLESS OTHERWISE NOTED.

HVAC NOTES

A. REMOVE ALL UNUSED PIPING, DUCTWORK AND ACCESSORIES.

B. WHERE DRAINS OCCUR WITHIN THE LIMITS OF CONSTRUCTION, PREVENT CONSTRUCTION DEBRIS FROM ENTERING DRAIN BODY BY SEALING DRAIN OPENING PRIOR TO START OF WORK. UNSEAL DRAINS AT COMPLETION OF CONSTRUCTION.

C. FINAL PRODUCT SHALL BE A COMPLETE AND FUNCTIONING SYSTEM, AND SHALL CONFORM TO ALL REQUIREMENTS OF APPLICABLE FEDERAL, STATE, AND LOCAL CODES.

D. LOCATE DUCTWORK, PIPING AND MECHANICAL EQUIPMENT AWAY FROM THE SPACE ABOVE ELECTRICAL PANELS. TRANSFORMERS AND OTHER ELECTRICAL EQUIPMENT.

E. PENETRATIONS OF RATED ASSEMBLIES SHALL BE FIRE STOPPED. FIRE STOPPING SHALL BE AN APPROVED MATERIAL AS PRESCRIBED IN CSFM STANDARD 43-1 AND SHALL BE U.L. LISTED.

F. PROVIDE SLEEVES AND/OR OPENINGS TO RUN PIPES AND DUCTS THROUGH FOUNDATIONS, FLOORS, WALLS, AND ROOF.

G. MAINTAIN CLEAR ACCESS TO SERVICE EQUIPMENT AND OTHER ACCESSORIES REQUIRING SERVICE, VISUAL INSPECTION OR HAND OPERATION. WHERE INDICATED OR REQUIRED, PROVIDE ACCESS PANELS OF THE TYPE SELECTED TO SUIT MATERIALS IN WHICH INSTALLED.

H. ADJUST PIPING AND DUCTWORK SIZES TO PROPERLY CONNECT TO MECHANICAL EQUIPMENT.

I. INSTALL ALL EQUIPMENT IN ACCORDANCE WITH THE RESPECTIVE MANUFACTURER'S WRITTEN INSTALLATION INSTRUCTIONS, AT A LEVEL OF QUALITY AND WORKMANSHIP CONSISTENT WITH THE SPECIFICATIONS.

J. LOCATIONS OF PIPING, DUCTWORK AND EQUIPMENT AS INDICATED ON THE DRAWING, ARE APPROXIMATE AND SUBJECT TO MINOR ADJUSTMENTS IN THE FIELD. WORK SHALL BE COORDINATED WITH ALL OTHER TRADES TO AVOID INTERFERENCE IN THE FIELD.

K. THE CONTRACTOR'S WORK SCHEDULE SHALL BE SUBMITTED TO AND APPROVED BY THE OWNER.

L. PRIOR TO STARTING WORK, SUBMIT SHOP DRAWINGS FOR ALL MECHANICAL EQUIPMENT, PLUMBING FIXTURES, AND DIFFUSERS.

M. CONTRACTOR SHALL OBTAIN AND PAY FOR ALL NECESSARY PERMITS AND SHALL ARRANGE FOR ALL INSPECTIONS AS REQUIRED.

N. PROVIDE ONE YEAR WARRANTY FOR ALL WORKMANSHIP AND MATERIALS AFTER THE DATE OF FINAL ACCEPTANCE.

MECHANICAL SHEET INDEX

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1 UNION PLACE
HARTFORD, CT 06103

THIS SQUARE APPEARS 1/2"x1/2" ON FULL SIZE SHEETS

NO	DATE	REVISION

STAMP:

PROJECT NAME:
GHTD UNION STATION HVAC UPGRADES

1 UNION PLACE
HARTFORD, CT

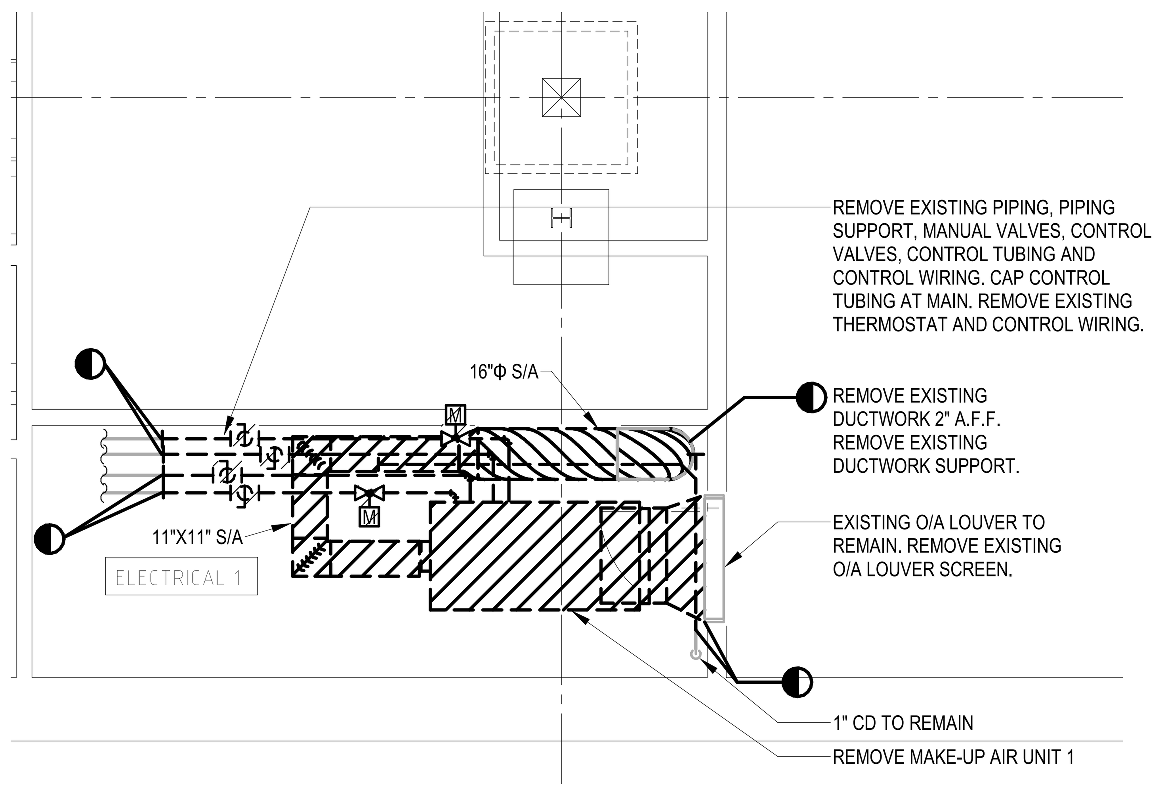
DRAWING TITLE:
MECHANICAL NOTES, SYMBOLS AND ABBREVIATIONS

FILE: 2022/3562
DRAWN BY: AJK
CHECKED BY:AP
ISSUE DATE: 11/01/2023
DRAWING NO:

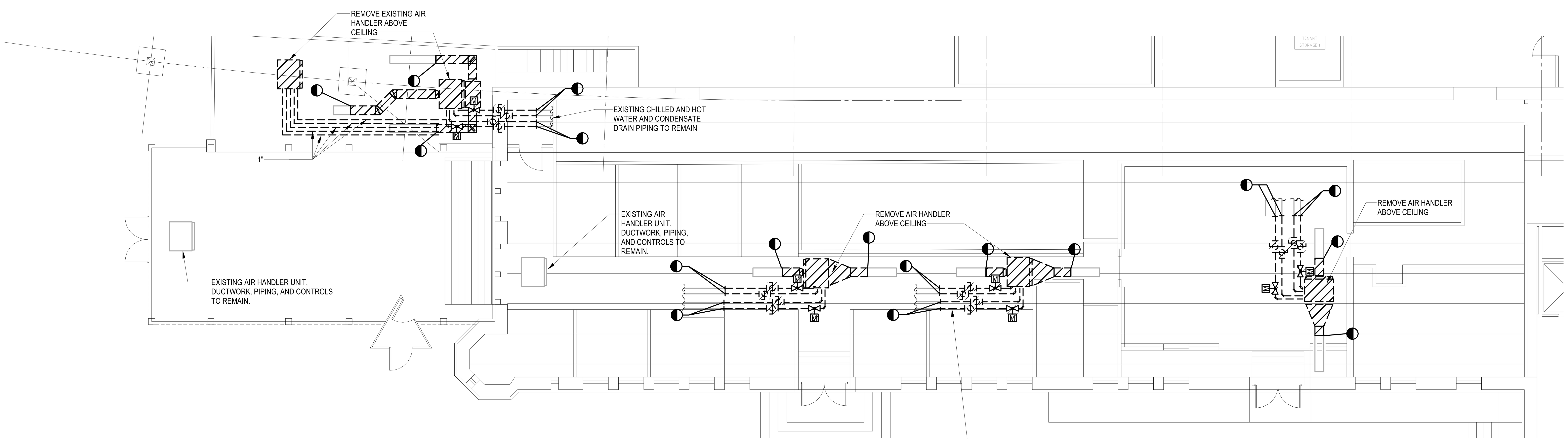
M001

GENERAL NOTES:

1. THE CONTRACTOR SHALL PERFORM DEMOLITION IN A SAFE AND NEAT MANNER. ALL DEBRIS SHALL BE PROPERLY DISPOSED. MEANS OF EGRESS SHALL BE MAINTAINED AT ALL TIMES.
2. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE COSTS OF REMOVING ALL DEBRIS.
3. THE PROJECT AREA OF WORK HAS BEEN SURVEYED AND TESTED FOR ASBESTOS CONTAINING MATERIAL AND LEAD. REFER TO REPORT FOR TESTING.
4. IF THE CONTRACTORFINDS SUSPICIOUS MATERIALPREVIOUSLY UNIDENTIFIED AND TESTED, STOP WORK AND CONTACT THE OWNER AND ENGINEER IMMEDIATELY FOR FURTHER EVALUATION.
5. THE CONTRACTOR SHALL REMOVE EXISTING EQUIPMENT AS SHOWN. ADDITIONAL DEMOLITION OF DUCTWORK AND PIPING SHALL BE LOCALIZED TO THE EQUIPMENT UNLESS SHOWN.
6. THE CONTRACTOR SHALL REMOVE THE EXISTING PNEUMATIC CONTROLS SYSTEM .
7. THE CONTRACTOR SHALL REMOVE PREVIOUSLY ABANDONED PIPING AND DUCTWORK IN THE WORK SPACES.
8. TO ACCESS SPACES ABOVE SUSPENDED CEILINGS: THE CONTRACTOR SHALL REMOVE CEILING TILES AS NEEDED TO ACCESS EQUIPMENT AND PROTECT FROM DAMAGE. THE CONTRACTOR SHALL CARRY THE COST FOR THE REPLACEMENT OF 20 CEILING TILES.
9. THE CONTRACTOR SHALL PATCH AND REPAIR ALL WALLS, CEILINGS, AND SURFACES TO MATCH EXISTING CONDITIONS TO THE BEST ABILITY THAT NEED TO BE DISTURBED DUE TO THE REMOVAL AND INSTALLATION OF EQUIPMENT, PIPING, DUCTWORK, AND ANY OTHER ACCESSORIES AS PART OF THE SCOPE OF THIS PROJECT.

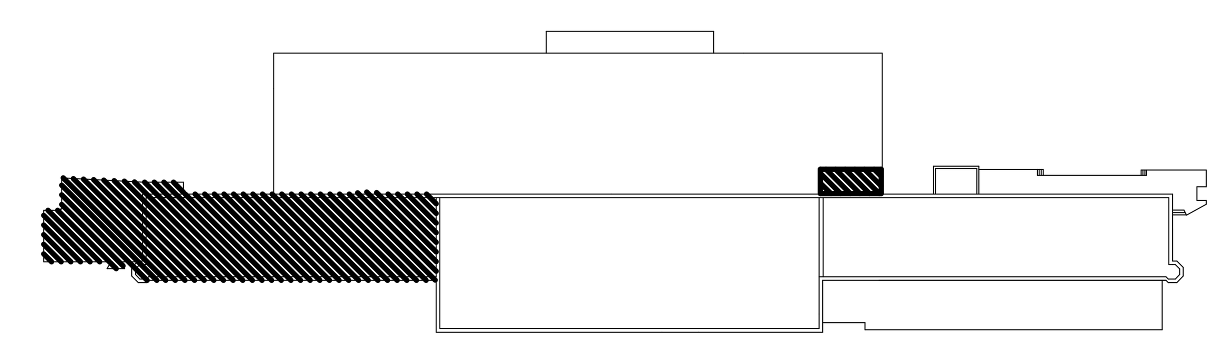


1 MD101 LEVEL 1 HVAC DEMOLITION PLAN - BASE BID
1/4" = 1'-0"



2 MD101 MECHANICAL LEVEL 1 DEMOLITION PLAN - BASE BID
1/8" = 1'-0"

REMOVE EXISTING PIPING, PIPING SUPPORT, MANUAL VALVES, CONTROL VALVES, CONTROL TUBING AND CONTROL WIRING.
CAP CONTROL TUBING AT MAIN.
REMOVE EXISTING THERMOSTAT AND CONTROL WIRING.
REMOVE EXISTING DUCTWORK AND DUCT SUPPORT, TYPICAL OF 5.
REMOVE AND REINSTALL EXISTING CEILING TILES, TYPICAL OF 5. REPLACE DAMAGED CEILING TILES, TYPICAL OF 5.



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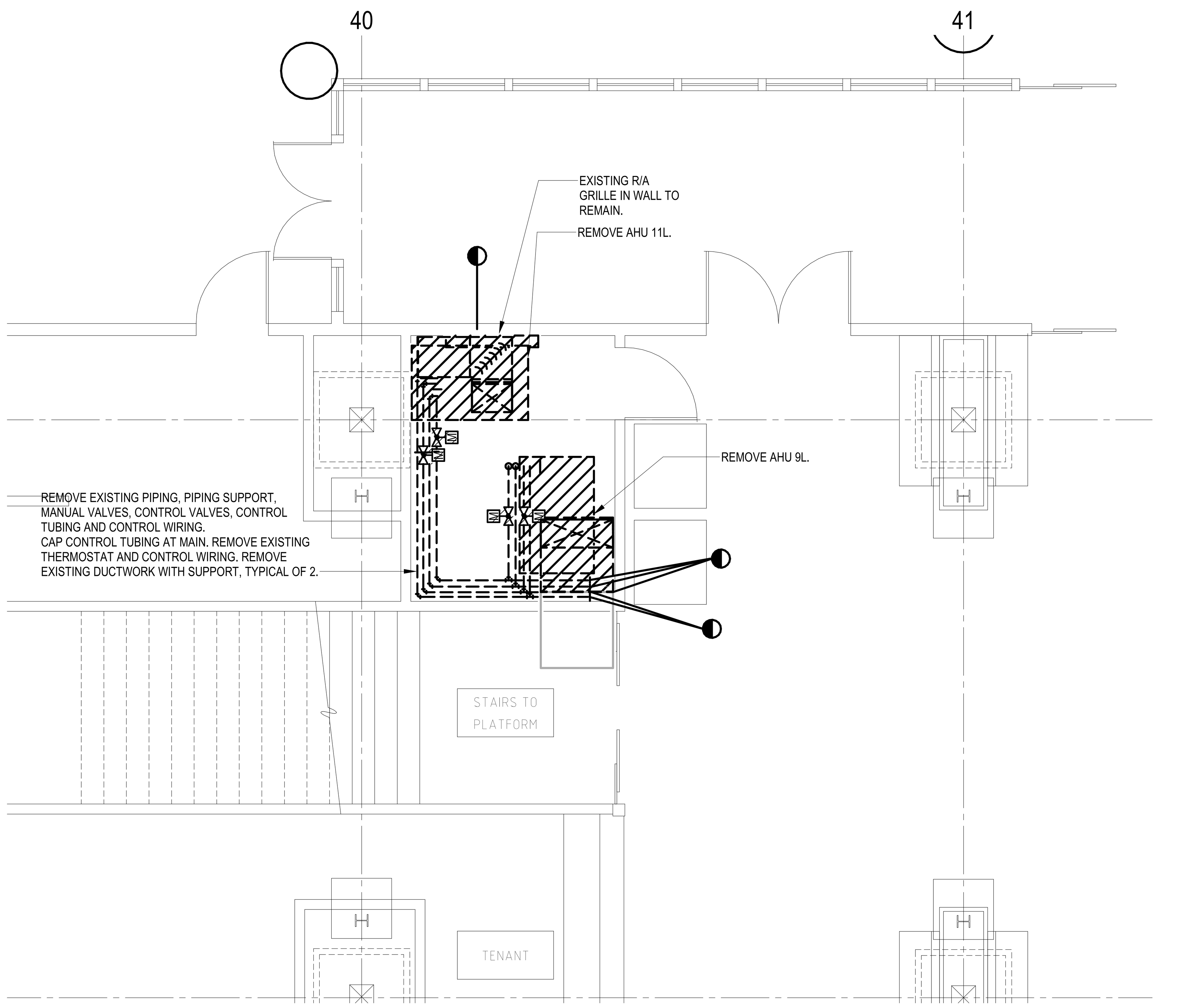
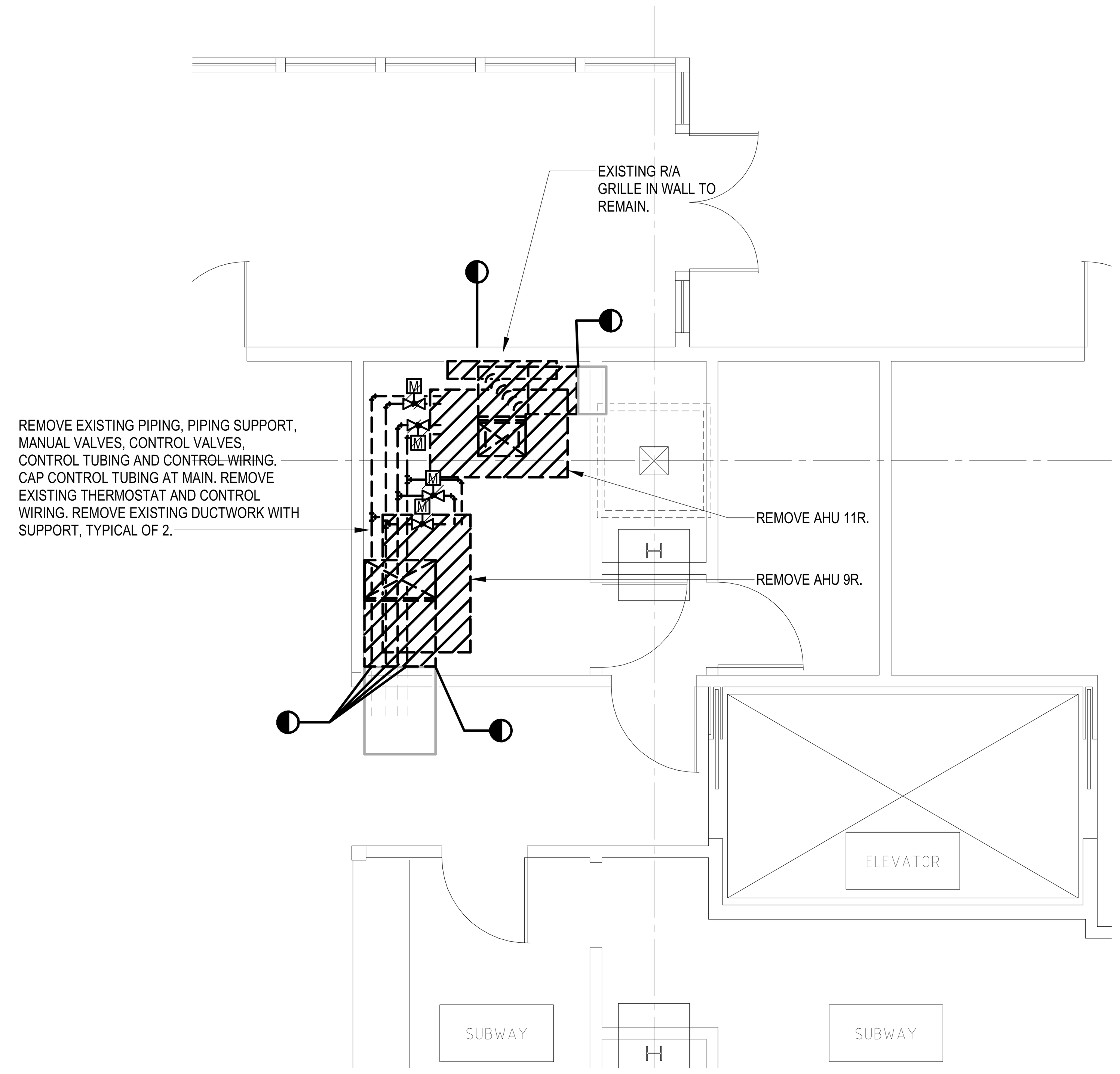
MECHANICAL LEVEL 1 DEMOLITION PLAN - BASE BID

FILE: 2022/3562
DRAWN BY: AJK
CHECKED BY:AP
ISSUE DATE: 11/01/2023
DRAWING NO: MD101



1 MD102 TRANSPORTATION SOUTH MECHANICAL ROOM DEMOLITION PLAN - BASE BID
1/4" = 1'-0"



2 MD102 TRANSPORTATION NORTH MECHANICAL ROOM DEMOLITION PLAN - BASE BID
1/4" = 1'-0"

GENERAL NOTES:

1. THE CONTRACTOR SHALL PERFORM DEMOLITION IN A SAFE AND NEAT MANNER. ALL DEBRIS SHALL BE PROPERLY DISPOSED. MEANS OF EGRESS SHALL BE MAINTAINED AT ALL TIMES.
2. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE COSTS OF REMOVING ALL DEBRIS.
3. THE PROJECT AREA OF WORK HAS BEEN SURVEYED AND TESTED FOR ASBESTOS CONTAINING MATERIAL AND LEAD. REFER TO REPORT FOR TESTING.
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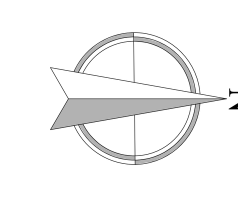

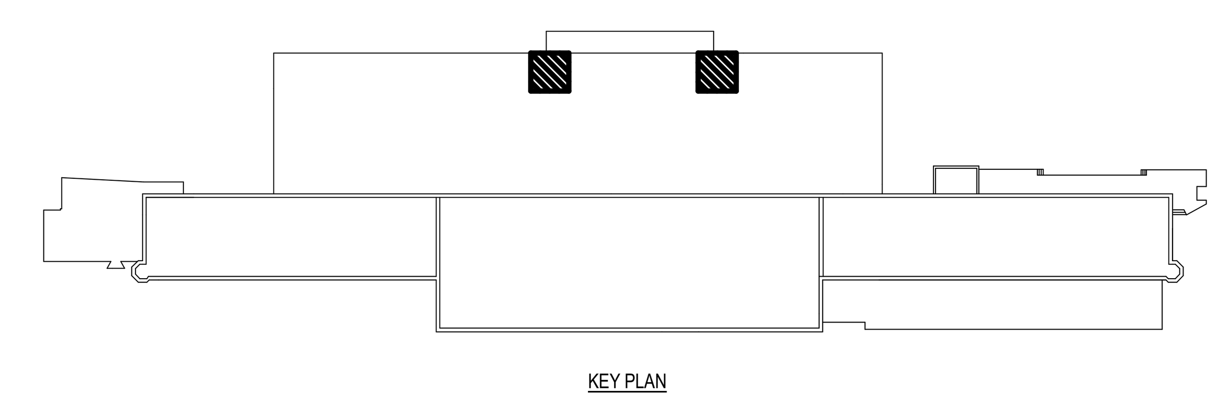

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1 UNION PLACE
HARTFORD, CT

DRAWING TITLE:
TRANSPORTATION MECHANICAL ROOMS DEMOLITION PLANS - BASE BID

FILE: 2022/3562
DRAWN BY: AJK
CHECKED BY:AP
ISSUE DATE: 11/01/2023
DRAWING NO:
MD102

GENERAL NOTES:

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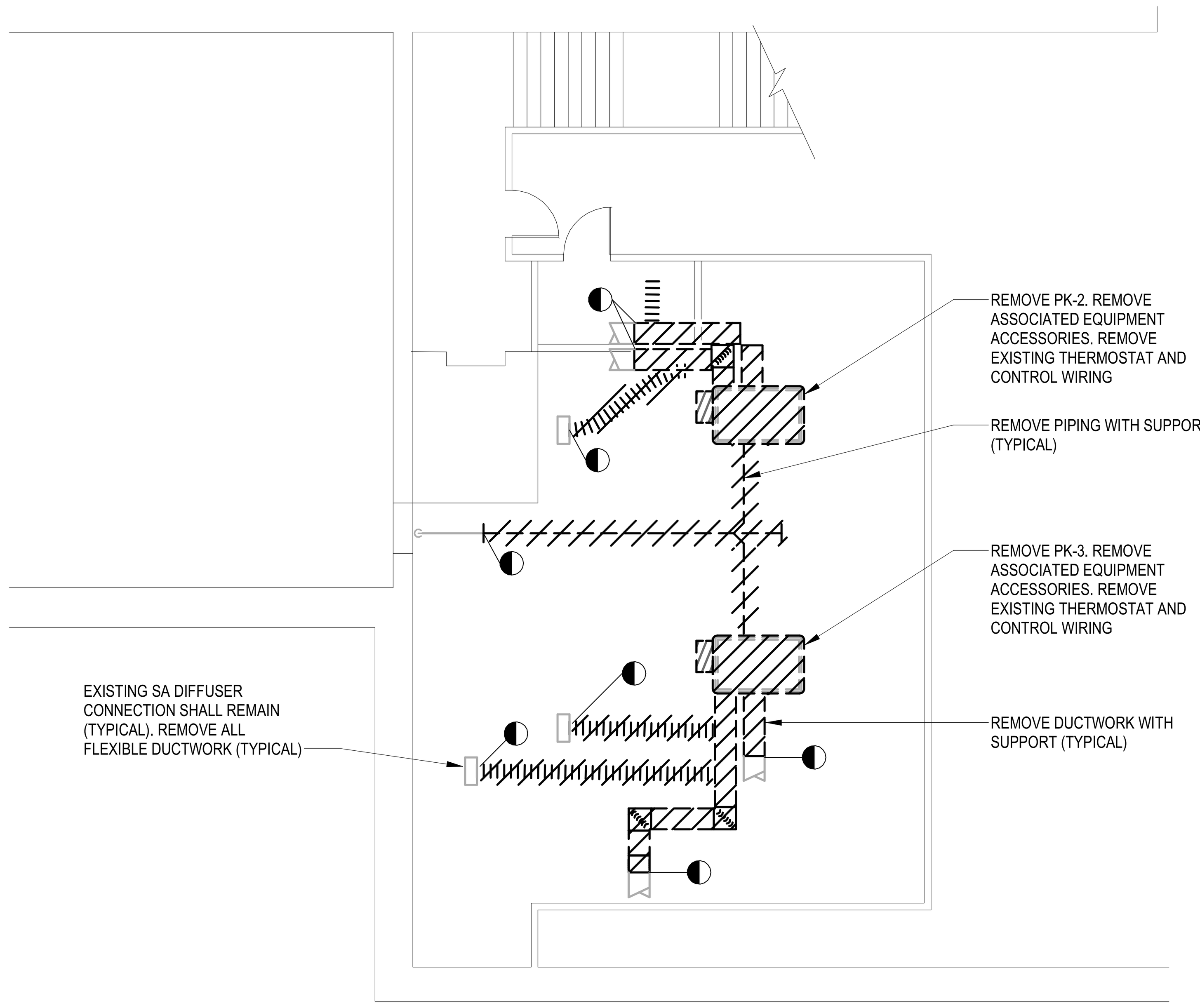
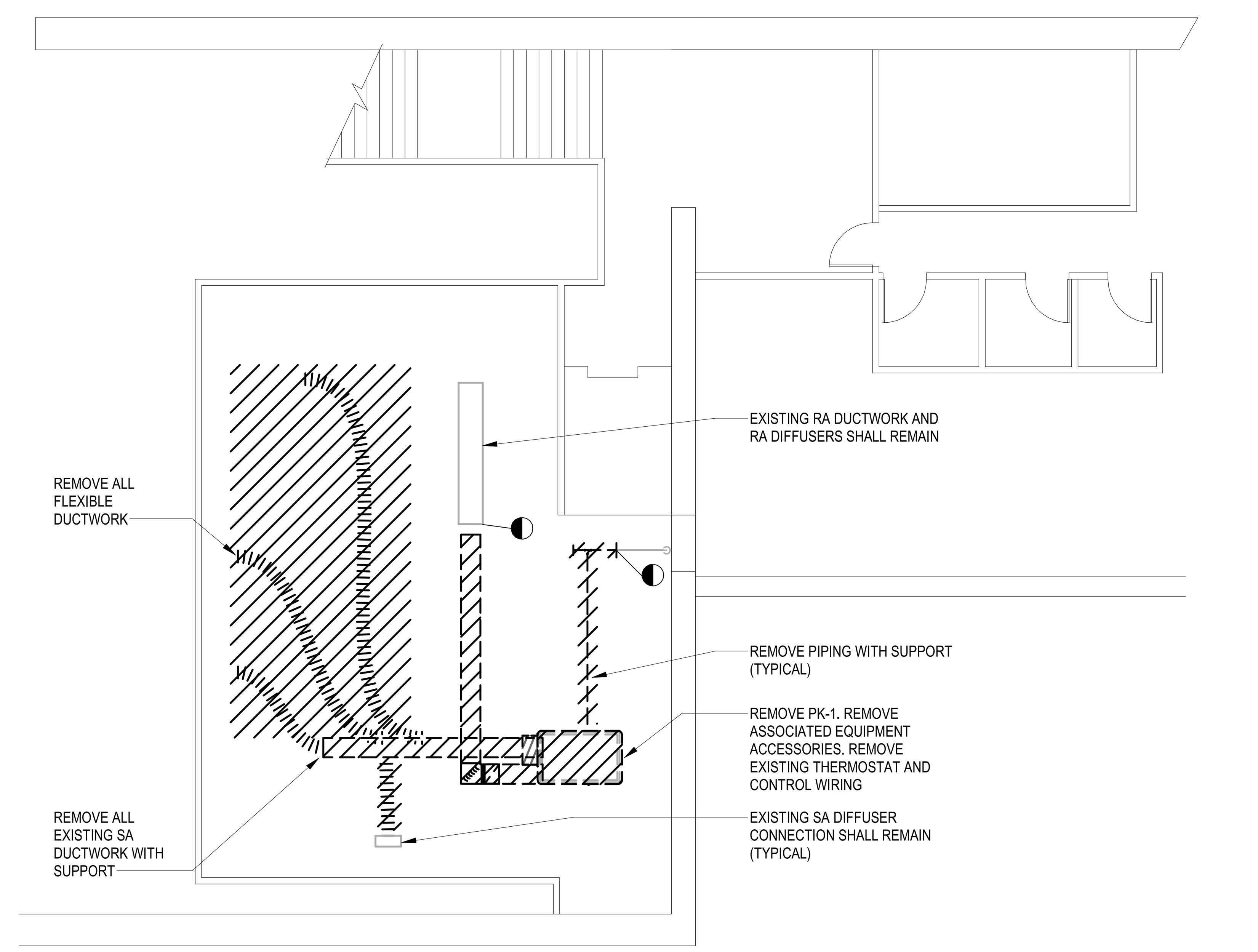
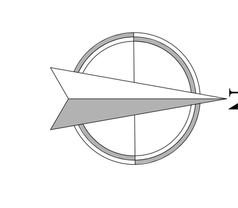
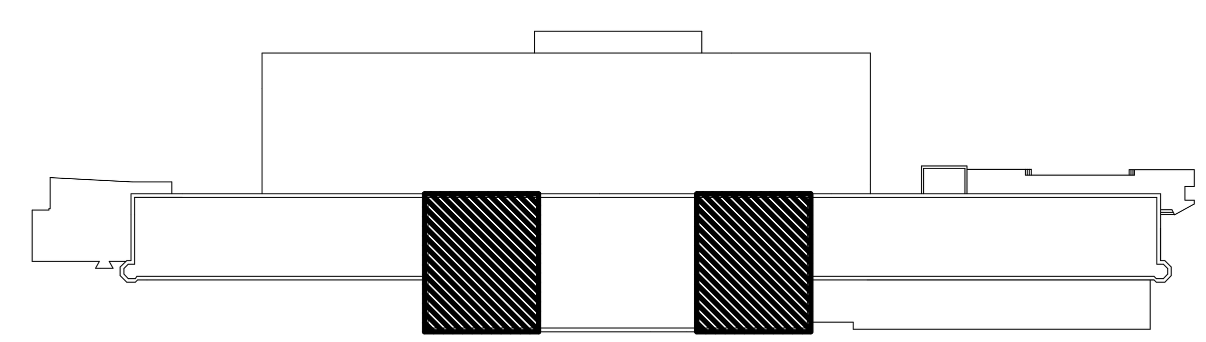


1 MD103 MECHANICAL SOUTH MEZZANINE DEMOLITION PLAN - BASE BID
1/8" = 1'-0"



2 MD103 MECHANICAL NORTH MEZZANINE DEMOLITION PLAN - BASE BID
1/8" = 1'-0"





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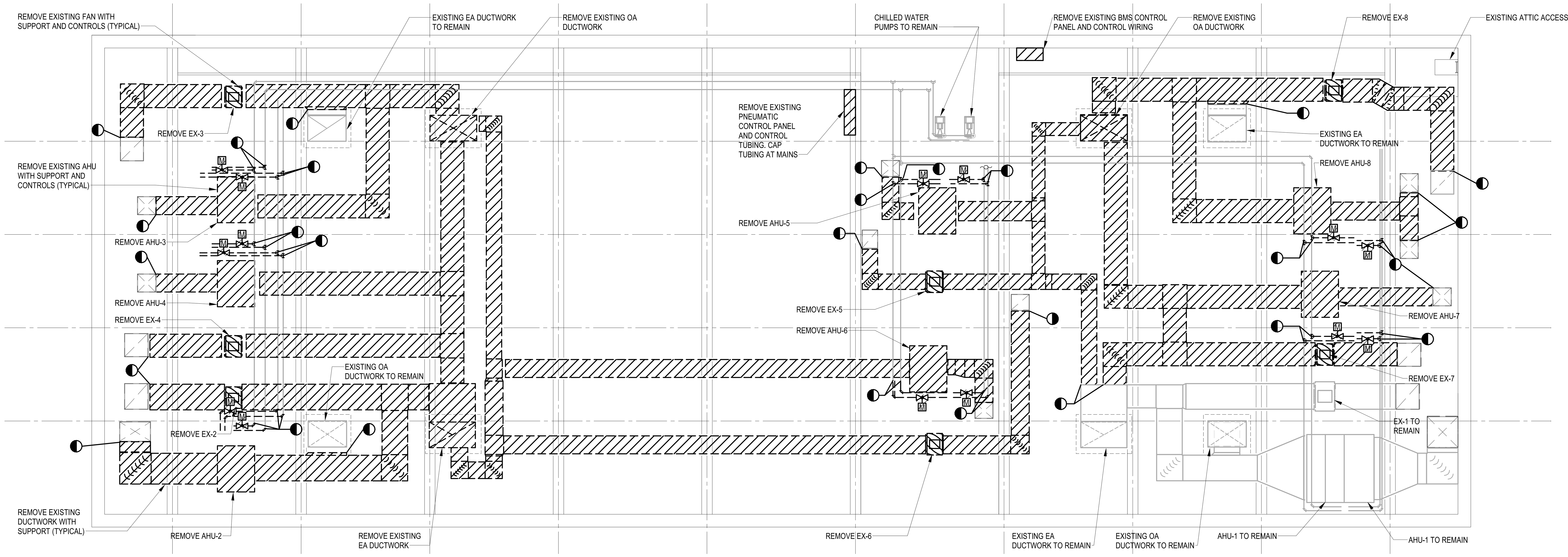
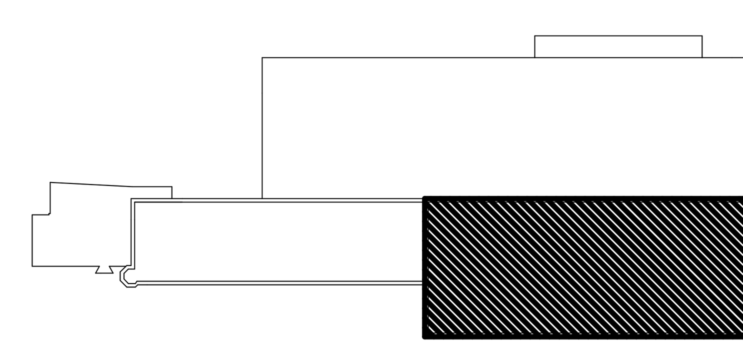


1 MD104 MECHANICAL ATTIC DEMOLITION PLAN - ADD ALTERNATE #1
1/8" = 1'-0"



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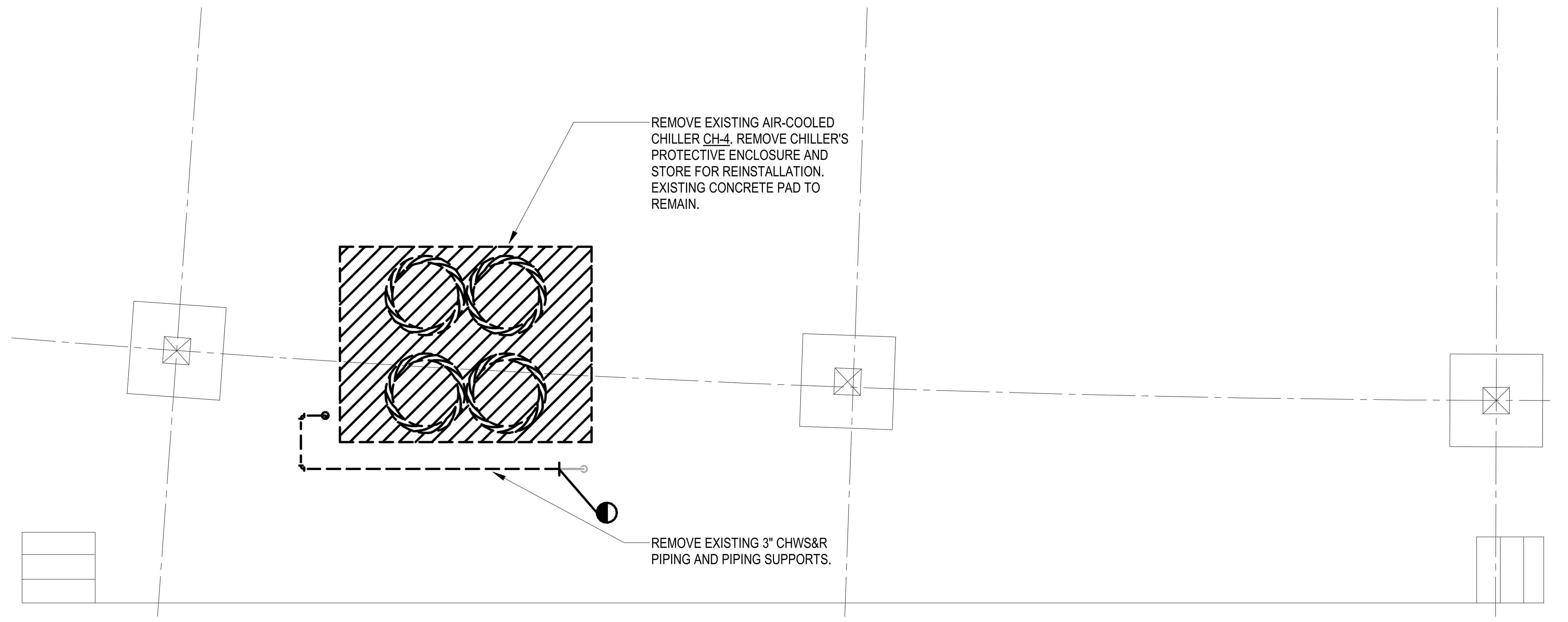
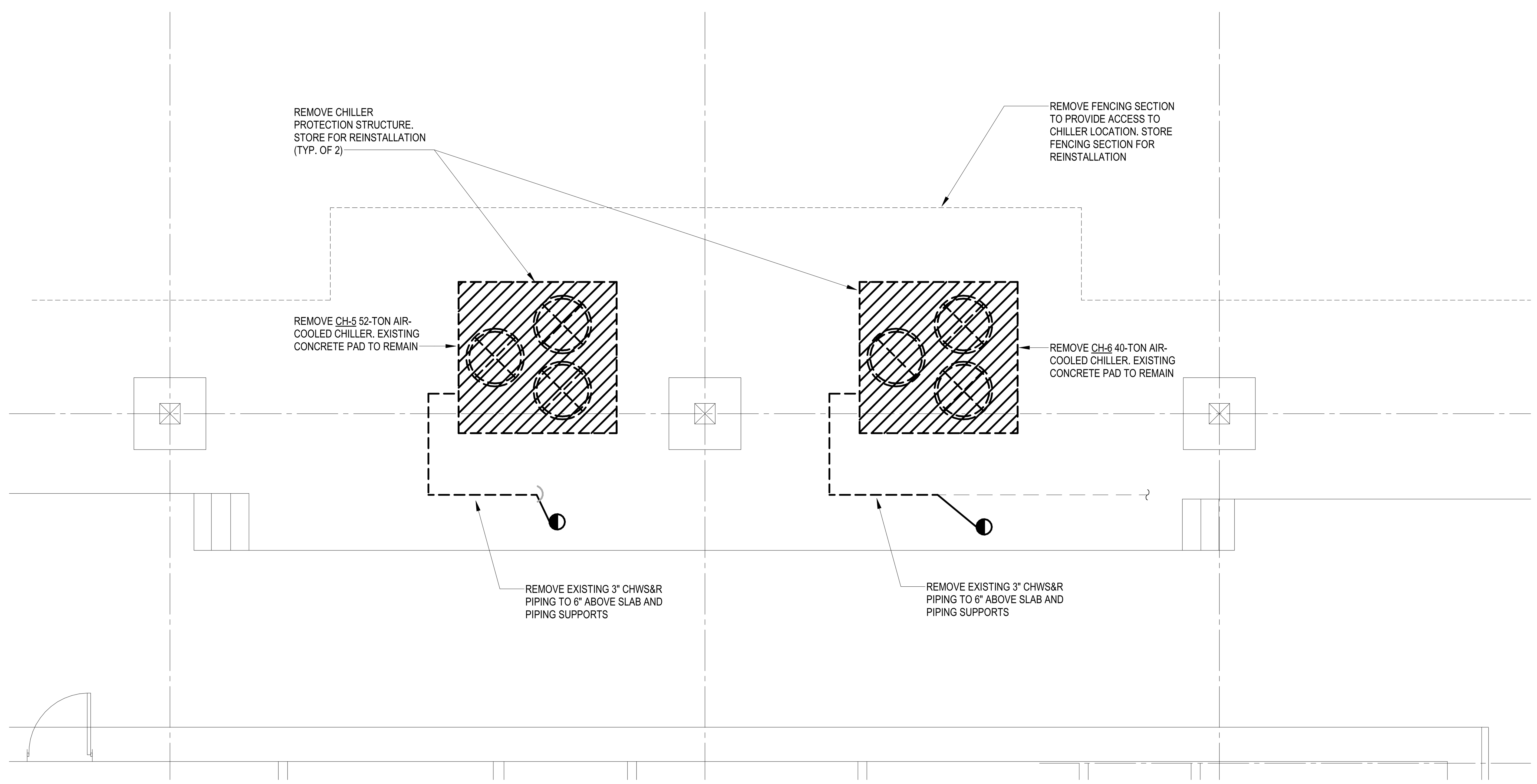
MECHANICAL ATTIC DEMOLITION PLAN - ADD ALTERNATE #1

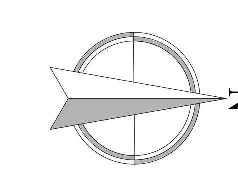
FILE: 2022/3562
DRAWN BY: AJK
CHECKED BY:AP
ISSUE DATE: 11/01/2023
DRAWING NO: **MD104**

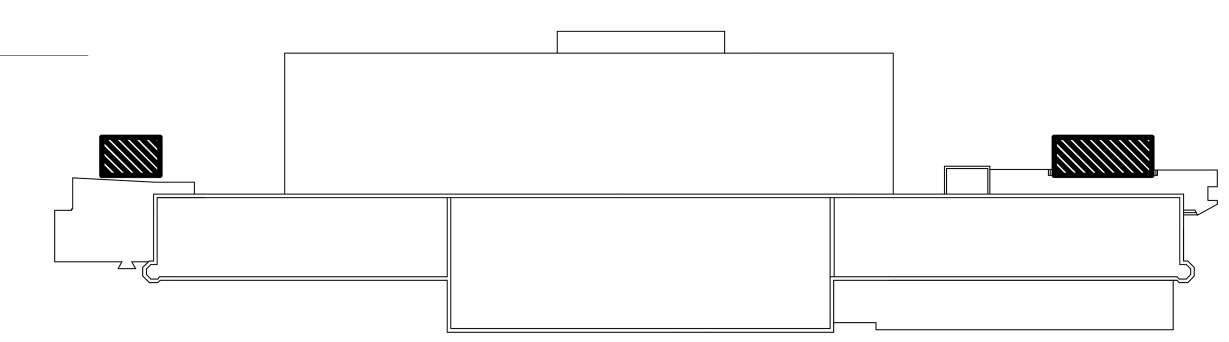


1 MD105 MECHANICAL AIR COOLED CHILLER CH-4 DEMOLITION PLAN - ADD ALTERNATE #2
1/4" = 1'-0"



2 MD105 MECHANICAL AIR COOLED CHILLERS CH-5 AND CH-6 DEMOLITION PLAN - ADD ALTERNATE #2
1/4" = 1'-0"





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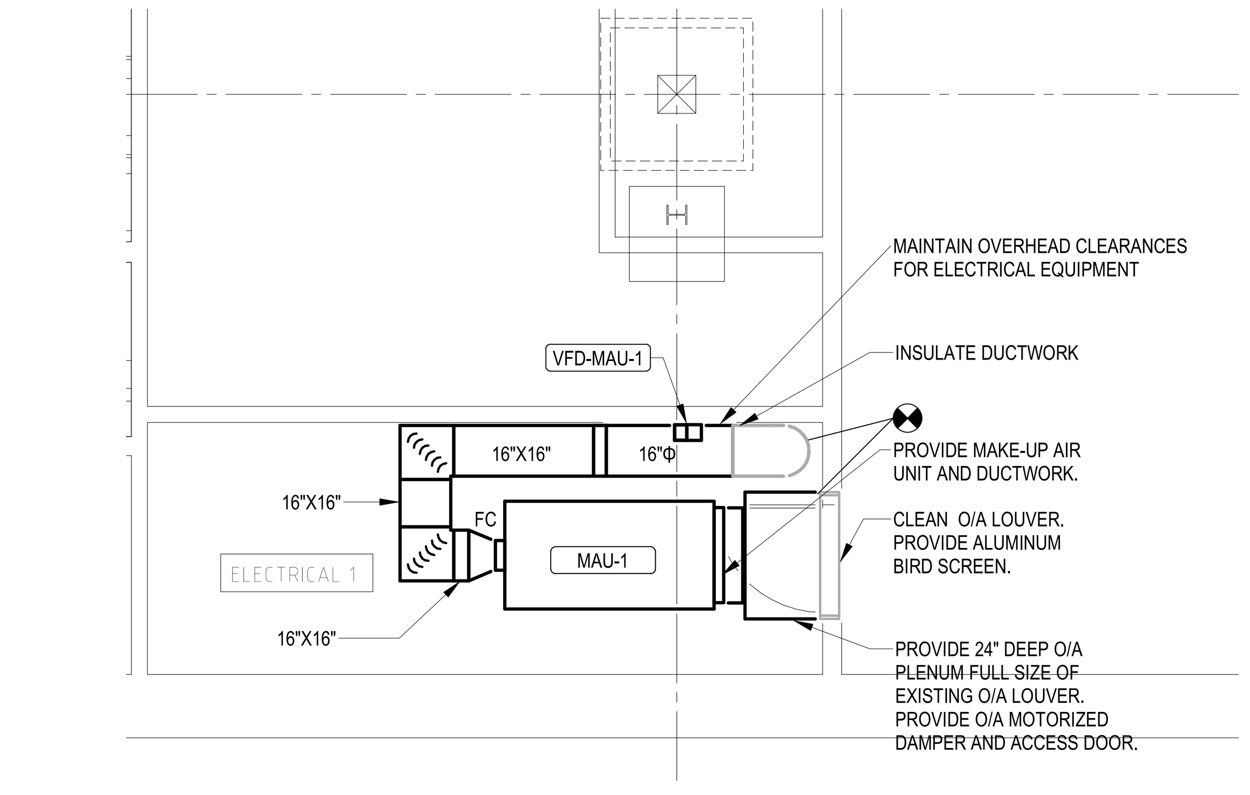
DRAWING TITLE:
MECHANICAL AIR COOLED CHILLERS DEMOLITION PLAN - ADD ALTERNATE #2

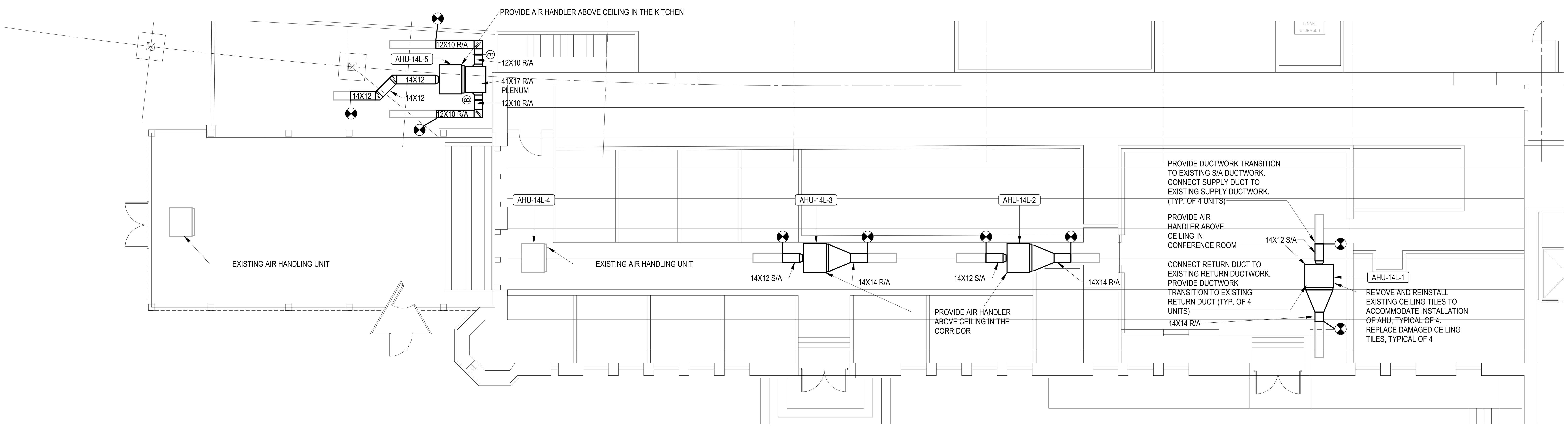
FILE: 2022/3562
DRAWN BY: Author
CHECKED BY: Checker
ISSUE DATE: 11/01/2023
DRAWING NO: **MD105**

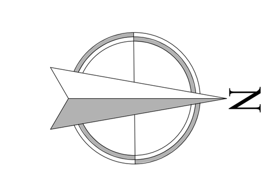
HVAC SHEET NOTES

A	CONTRACTOR SHALL BE RESPONSIBLE TO PROVIDE A COMPLETE AND WORKING SYSTEM.
B	INSTALL, SUPPORT, & BRACE NEW DUCTWORK AND ACCESSORIES PER SMACNA GUIDELINES.
C	DUCT SIZES SHOWN ARE CLEAR INSIDE DIMENSIONS. CONTRACTOR SHALL MAKE ALLOWANCE FOR ANY INTERIOR LINING, INSULATION, ETC.
D	ALL NEW DUCT ELBOWS SHALL BE RADIUS TYPE. WHERE NECESSARY, CONTRACTOR MAY SUBSTITUTE MITERED ELBOWS WITH TURNING VANES.
E	PROVIDE FLAT BLADE MANUAL VOLUME DAMPERS AT ALL TERMINAL DUCT BRANCHES AND AS INDICATED.
F	INSTALL EQUIPMENT PER MANUFACTURER'S RECOMMENDATIONS. ROOFTOP EQUIPMENT SHALL BE LOCATED NO CLOSER THAN 10'-0" FROM THE ROOF EDGE.
G	ALL PRIMARY CONDENSATE DRAIN PIPING SHALL BE INSULATED TO A MINIMUM THICKNESS OF 1/2" AND SHALL INCLUDE A VAPOR RETARDANT OUTSIDE THE INSULATION. SEAL ALL JOINTS AND PENETRATIONS.
H	COORDINATE ALL EXTERIOR PENETRATIONS INCLUDING ROOF PENETRATIONS WITH OTHER TRADES TO PROVIDE A COMPLETE AND FULLY WEATHER-PROOF INSTALLATION.
I	ALL TRANSFER DUCTWORK SHALL BE INTERNALLY LINED WITH MINIMUM 1/2" ACOUSTIC LINING.
J	CONTRACTOR SHALL ENGAGE A TESTING AND BALANCE FIRM CERTIFIED BY AABC TO PERFORM TESTING AND BALANCING PROCEDURES ON EACH SYSTEM ACCORDING TO THE PROCEDURES CONTAINED IN AABC'S "NATIONAL STANDARDS.
K	FOR TESTING AND BALANCING HEATING, VENTILATING, AND AIR CONDITIONING SYSTEMS" AND PROVIDE TWO COPIES OF THE CERTIFIED TAB REPORTS.
L	THIS DRAWING IS DIAGRAMMATIC IN NATURE AND SHALL NOT BE SCALED TO DETERMINE THE EXACT LOCATION OR EXTENT OF THE WORK. CONTRACTOR SHALL VERIFY ALL EXISTING CONDITIONS PRIOR TO THE START OF THE WORK. CONTRACTOR SHALL BE RESPONSIBLE TO PROVIDE A COMPLETE AND WORKING SYSTEM.
M	THIS DRAWING IS BASED ON VISUALLY OBSERVABLE EXISTING CONDITIONS AS OF THE TIME OF DESIGN. CONTRACTOR SHALL BE RESPONSIBLE TO FULLY VERIFY ALL EXISTING CONDITIONS, COMPONENTS, ETC. PRIOR TO THE START OF THE WORK. ANY DEVIATION FROM THIS DRAWING IN KIND, OR IN LOCATION EXCEEDING 1'-0", SHALL BE BROUGHT TO THE ATTENTION OF THE ENGINEER.

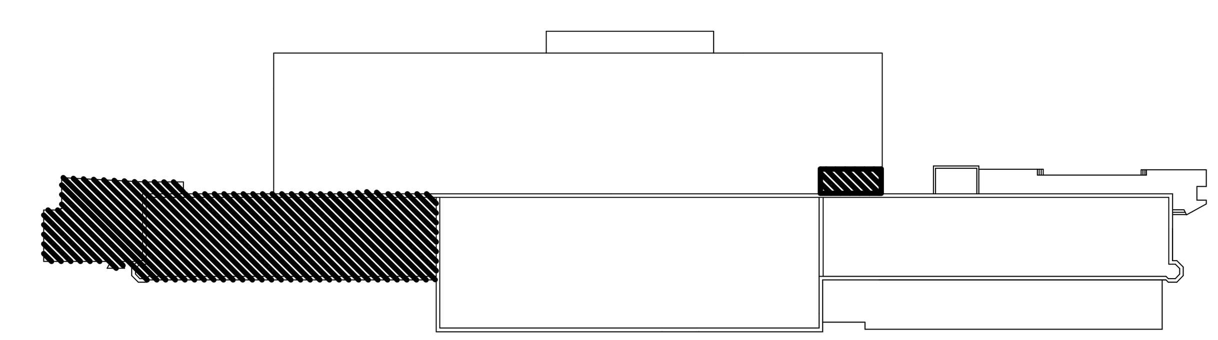


1 / M101 MAKEUP AIR UNIT HVAC PLAN - BASE BID
1/4" = 1'-0"





2 / M101 MECHANICAL PROPARK (SOUTH WING) PLAN - BASE BID
1/8" = 1'-0"



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DRAWING TITLE:
MECHANICAL LEVEL 1 PLAN - BASE BID

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HVAC SHEET NOTES

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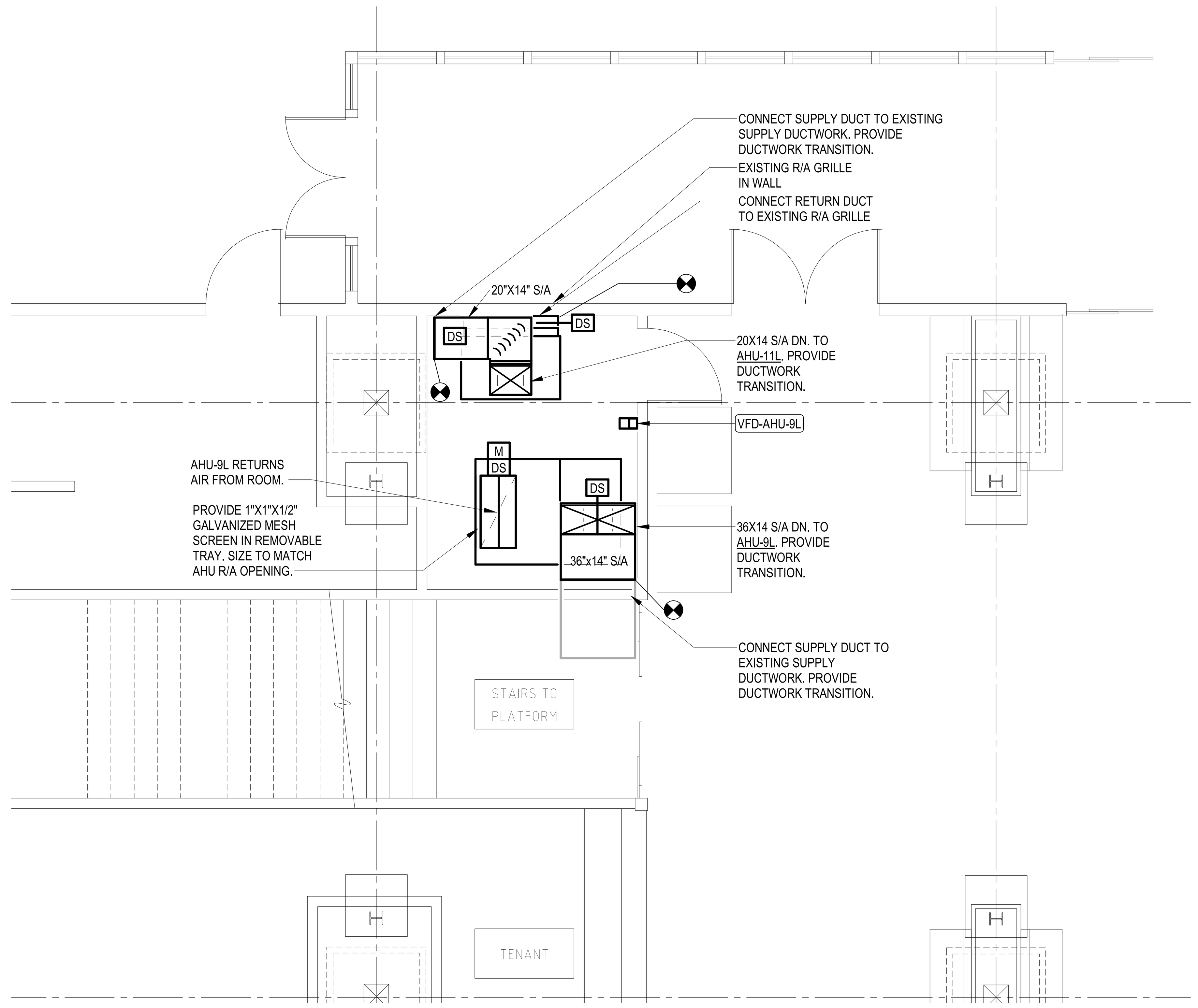
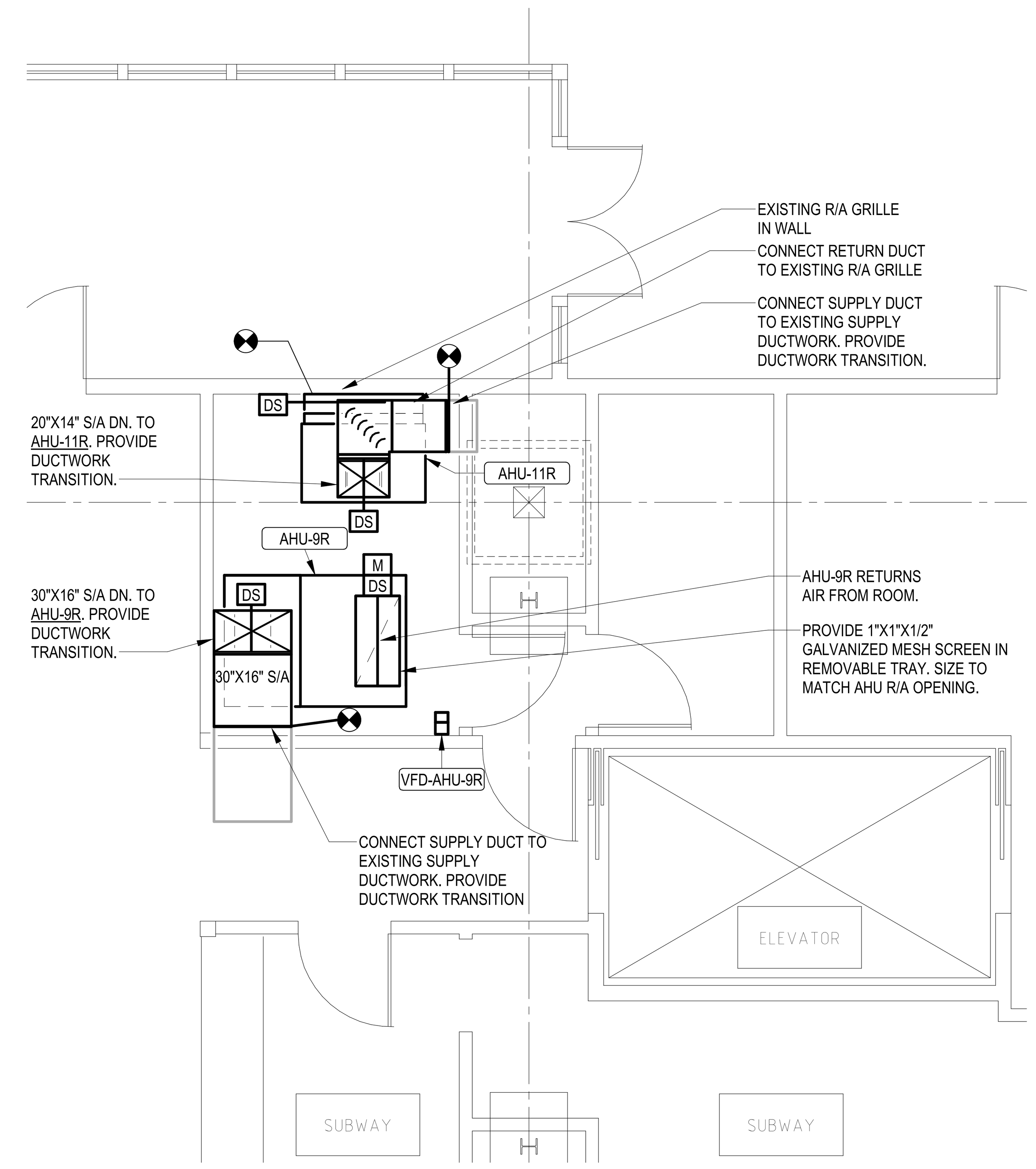
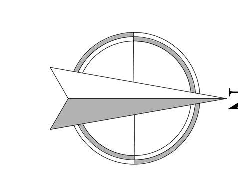
- E PROVIDE FLAT BLADE MANUAL VOLUME DAMPERS AT ALL TERMINAL DUCT BRANCHES AND AS INDICATED.
- F INSTALL EQUIPMENT PER MANUFACTURER'S RECOMMENDATIONS. ROOFTOP EQUIPMENT SHALL BE LOCATED NO CLOSER THAN 10'-0" FROM THE ROOF EDGE.
- G ALL PRIMARY CONDENSATE DRAIN PIPING SHALL BE INSULATED TO A MINIMUM THICKNESS OF 1/2" AND SHALL INCLUDE A VAPOR RETARDANT OUTSIDE THE INSULATION. SEAL ALL JOINTS AND PENETRATIONS.
- H COORDINATE ALL EXTERIOR PENETRATIONS INCLUDING ROOF PENETRATIONS WITH OTHER TRADES TO PROVIDE A COMPLETE AND FULLY WEATHER-PROOF INSTALLATION.
- I ALL TRANSFER DUCTWORK SHALL BE INTERNALLY LINED WITH MINIMUM 1/2" ACOUSTIC LINING.
- J CONTRACTOR SHALL ENGAGE A TESTING AND BALANCE FIRM CERTIFIED BY AABC TO PERFORM TESTING AND BALANCING PROCEDURES ON EACH SYSTEM ACCORDING TO THE PROCEDURES CONTAINED IN AABC'S "NATIONAL STANDARDS.
- K FOR TESTING AND BALANCING HEATING, VENTILATING, AND AIR CONDITIONING SYSTEMS" AND PROVIDE TWO COPIES OF THE CERTIFIED TAB REPORTS.
- L THIS DRAWING IS DIAGRAMMATIC IN NATURE AND SHALL NOT BE SCALED TO DETERMINE THE EXACT LOCATION OR EXTENT OF THE WORK. CONTRACTOR SHALL VERIFY ALL EXISTING CONDITIONS PRIOR TO THE START OF THE WORK.
  CONTRACTOR SHALL BE RESPONSIBLE TO PROVIDE A COMPLETE AND WORKING SYSTEM.
- M THIS DRAWING IS BASED ON VISUALLY OBSERVABLE EXISTING CONDITIONS AS OF THE TIME OF DESIGN. CONTRACTOR SHALL BE RESPONSIBLE TO FULLY VERIFY ALL EXISTING CONDITIONS, COMPONENTS, ETC. PRIOR TO THE START OF THE WORK. ANY DEVIATION FROM THIS DRAWING IN KIND, OR IN LOCATION EXCEEDING 1'-0", SHALL BE BROUGHT TO THE ATTENTION OF THE ENGINEER.

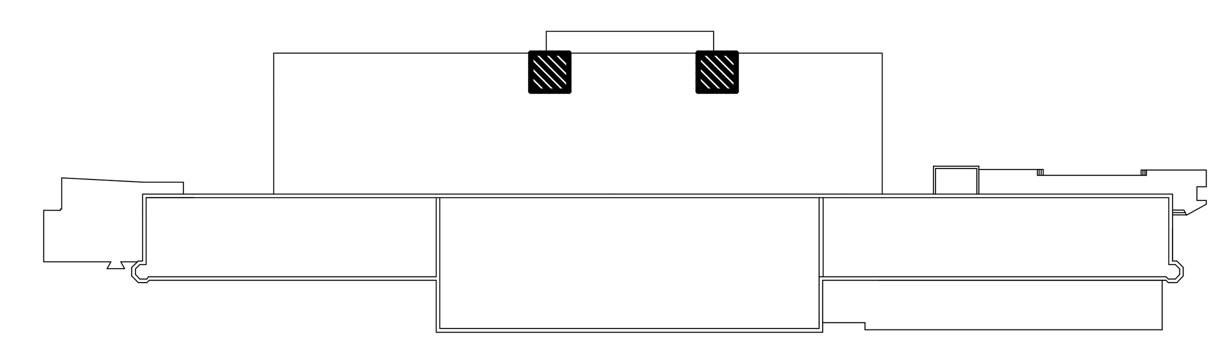


1 / M102 TRANSPORTATION SOUTH MECHANICAL ROOM HVAC NEW WORK PLAN - BASE BID
1/4" = 1'-0"



2 / M102 TRANSPORTATION NORTH MECHANICAL ROOM HVAC NEW WORK PLAN - BASE BID
1/4" = 1'-0"





KEY PLAN

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CLIENT:
GREATER HARTFORD TRANSIT DISTRICT
1 UNION PLACE
HARTFORD, CT 06103

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NO	DATE	REVISION

STAMP:

PROJECT NAME:
GHTD UNION STATION
HVAC UPGRADES

1 UNION PLACE
HARTFORD, CT

DRAWING TITLE:
TRANSPORTATION MECHANICAL ROOM HVAC PLANS - BASE BID

FILE: 2022/3562
DRAWN BY: AJK
CHECKED BY:AP
ISSUE DATE: 11/01/2023
DRAWING NO: **M102**

GENERAL NOTES:

1. PROVIDE AC CONDENSATE DRAIN PIPING PER DETAILS. VERIFY IN FIELD TIE IN LOCATION.
2. PROVIDE NEW PIPING CONNECTIONS TO ALL EQUIPMENT.
3. INSULATE ALL DUCTWORK. INSULATION THICKNESS SHALL BE PER CODE AND SPECIFICATIONS.
4. AC CONDENSATE PIPING SHALL BE INSULATED WITH A MINIMUM OF 1/2" THICK ELASTOMERIC INSULATION WITH A VAPOR BARRIER.
5. REFER TO DETAILS FOR PIPING CONNECTIONS, ACCESSORY LAYOUTS, AND EQUIPMENT DETAILS.

HVAC SHEET NOTES

A CONTRACTOR SHALL BE RESPONSIBLE TO PROVIDE A COMPLETE AND WORKING SYSTEM.
B INSTALL, SUPPORT, & BRACE NEW DUCTWORK AND ACCESSORIES PER SMACNA GUIDELINES.
C DUCT SIZES SHOWN ARE CLEAR INSIDE DIMENSIONS. CONTRACTOR SHALL MAKE ALLOWANCE FOR ANY INTERIOR LINING, INSULATION, ETC.
D ALL NEW DUCT ELBOWS SHALL BE RADIUS TYPE. WHERE NECESSARY, CONTRACTOR MAY SUBSTITUTE MITERED ELBOWS WITH TURNING VANES.
E PROVIDE FLAT BLADE MANUAL VOLUME DAMPERS AT ALL TERMINAL DUCT BRANCHES AND AS INDICATED.
F INSTALL EQUIPMENT PER MANUFACTURER'S RECOMMENDATIONS. ROOFTOP EQUIPMENT SHALL BE LOCATED NO CLOSER THAN 10'-0" FROM THE ROOF EDGE.
G ALL PRIMARY CONDENSATE DRAIN PIPING SHALL BE INSULATED TO A MINIMUM THICKNESS OF 1/2" AND SHALL INCLUDE A VAPOR RETARDANT OUTSIDE THE INSULATION. SEAL ALL JOINTS AND PENETRATIONS.
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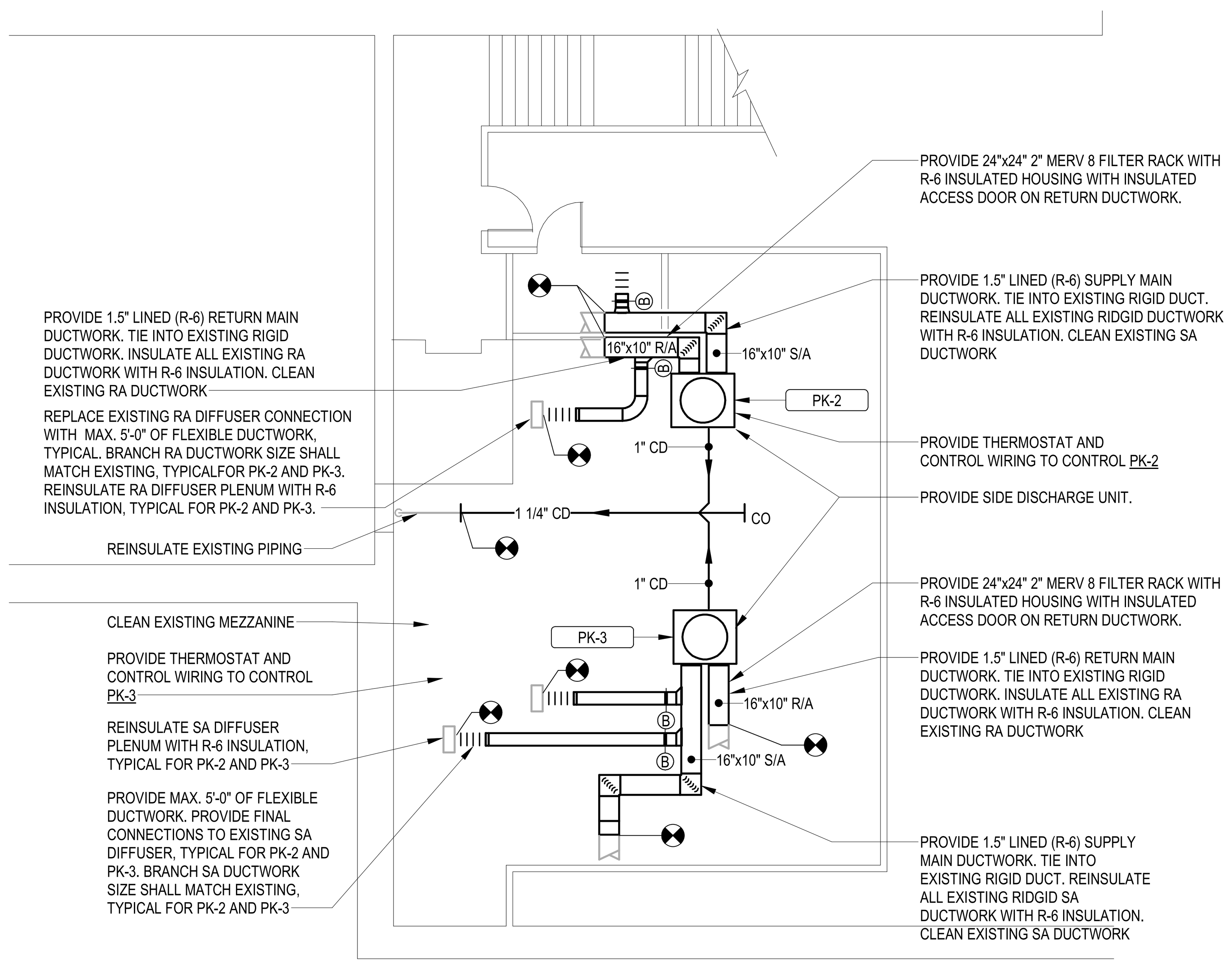
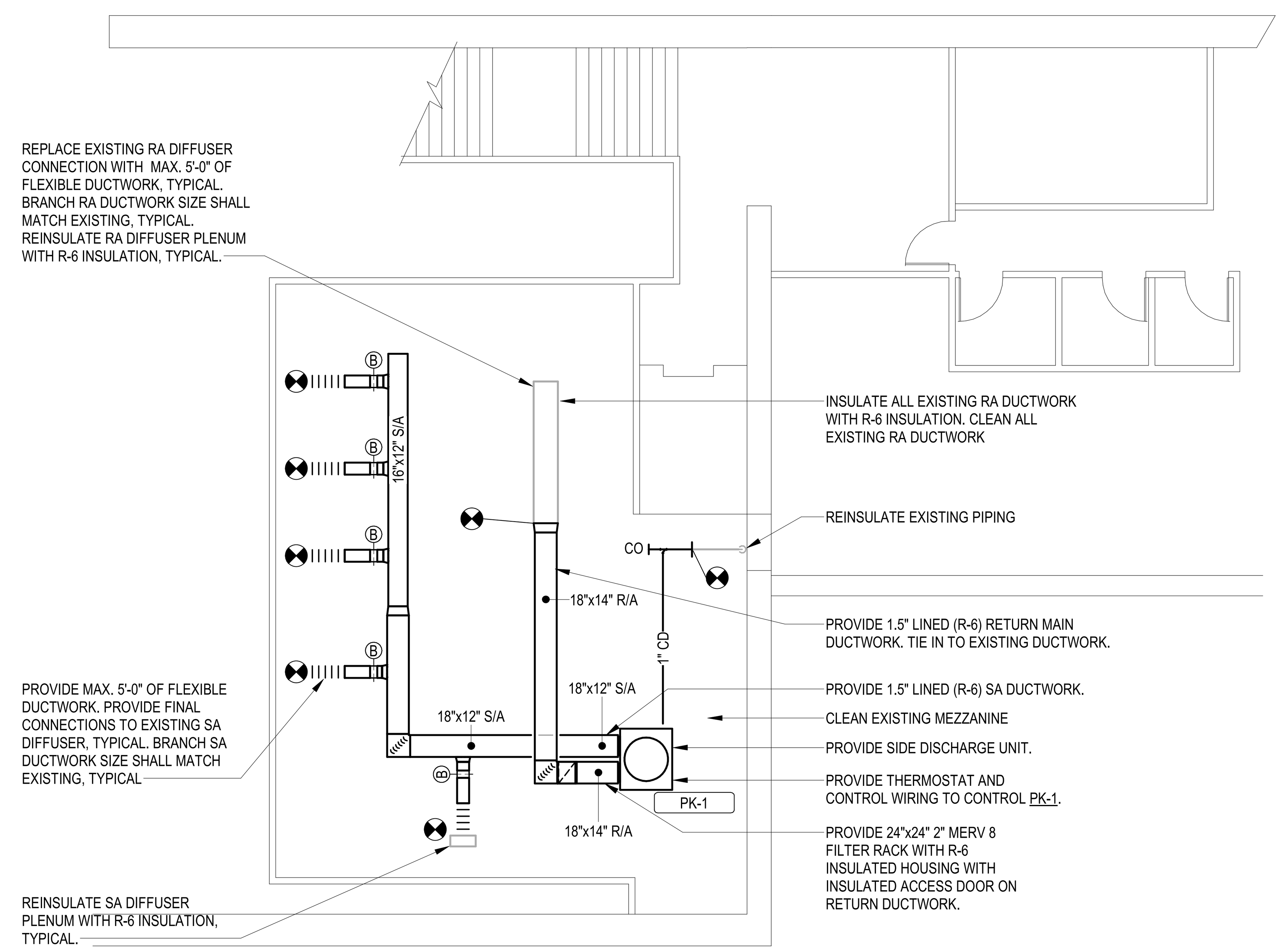
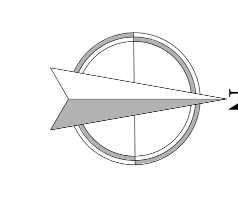
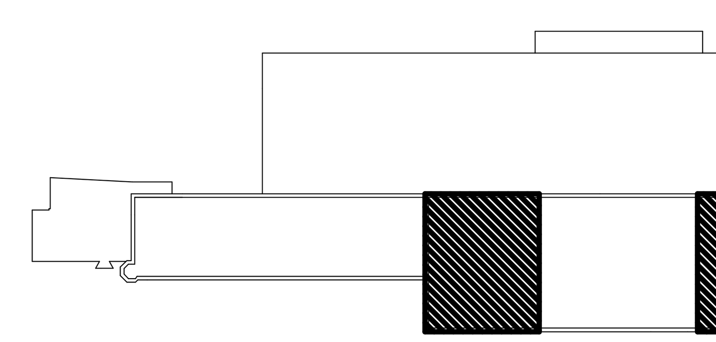


1 M103 MECHANICAL SOUTH MEZZANINE PLAN - BASE BID
1/8" = 1'-0"



2 M103 MECHANICAL NORTH MEZZANINE PLAN - BASE BID
1/8" = 1'-0"





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CLIENT:
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1 UNION PLACE
HARTFORD, CT 06103

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STAMP:

PROJECT NAME:
GHTD UNION STATION HVAC UPGRADES

1 UNION PLACE
HARTFORD, CT

DRAWING TITLE:
MECHANICAL MEZZANINE PLANS - BASE BID

FILE: 2022/3562
DRAWN BY: AJK
CHECKED BY:AP
ISSUE DATE: 11/01/2023
DRAWING NO:
M103

HVAC SHEET NOTES

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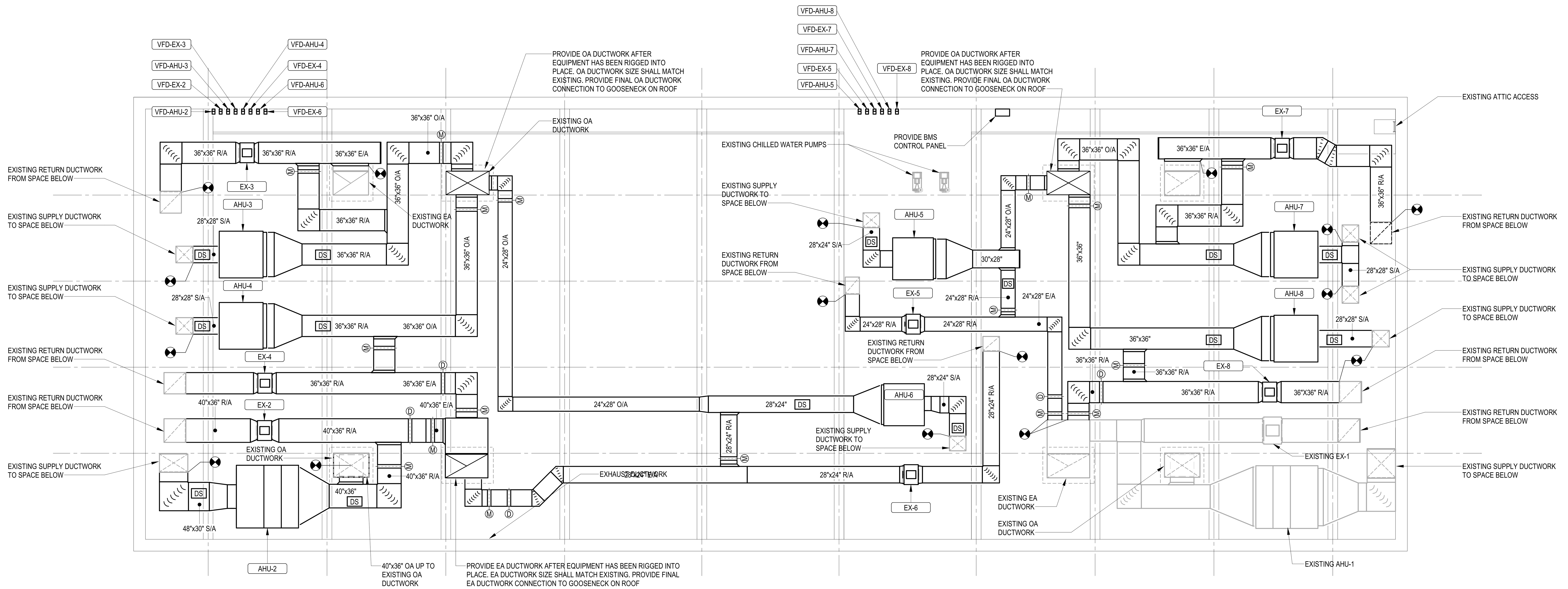
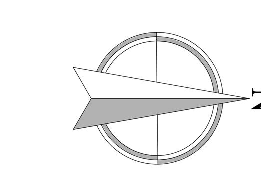
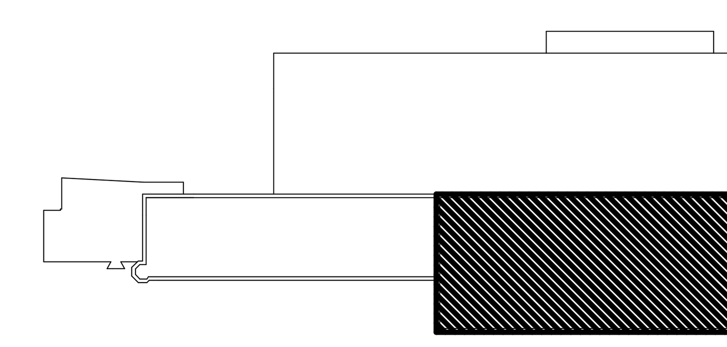


1 M104 MECHANICAL ATTIC PLAN - ADD ALTERNATE #1
1/8" = 1'-0"





KEY PLAN

CLIENT:
GREATER HARTFORD TRANSIT DISTRICT
1 UNION PLACE
HARTFORD, CT 06103

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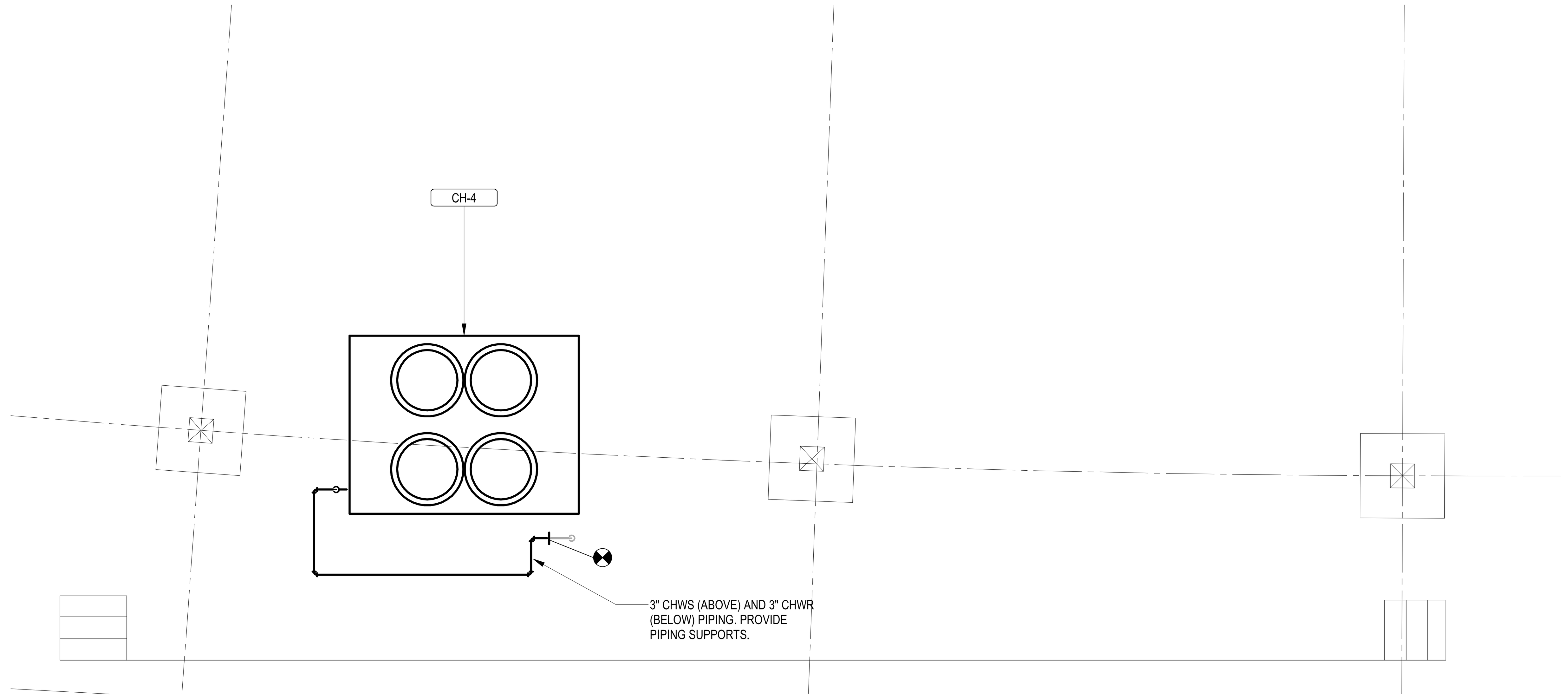
STAMP:

PROJECT NAME:
GHTD UNION STATION HVAC UPGRADES

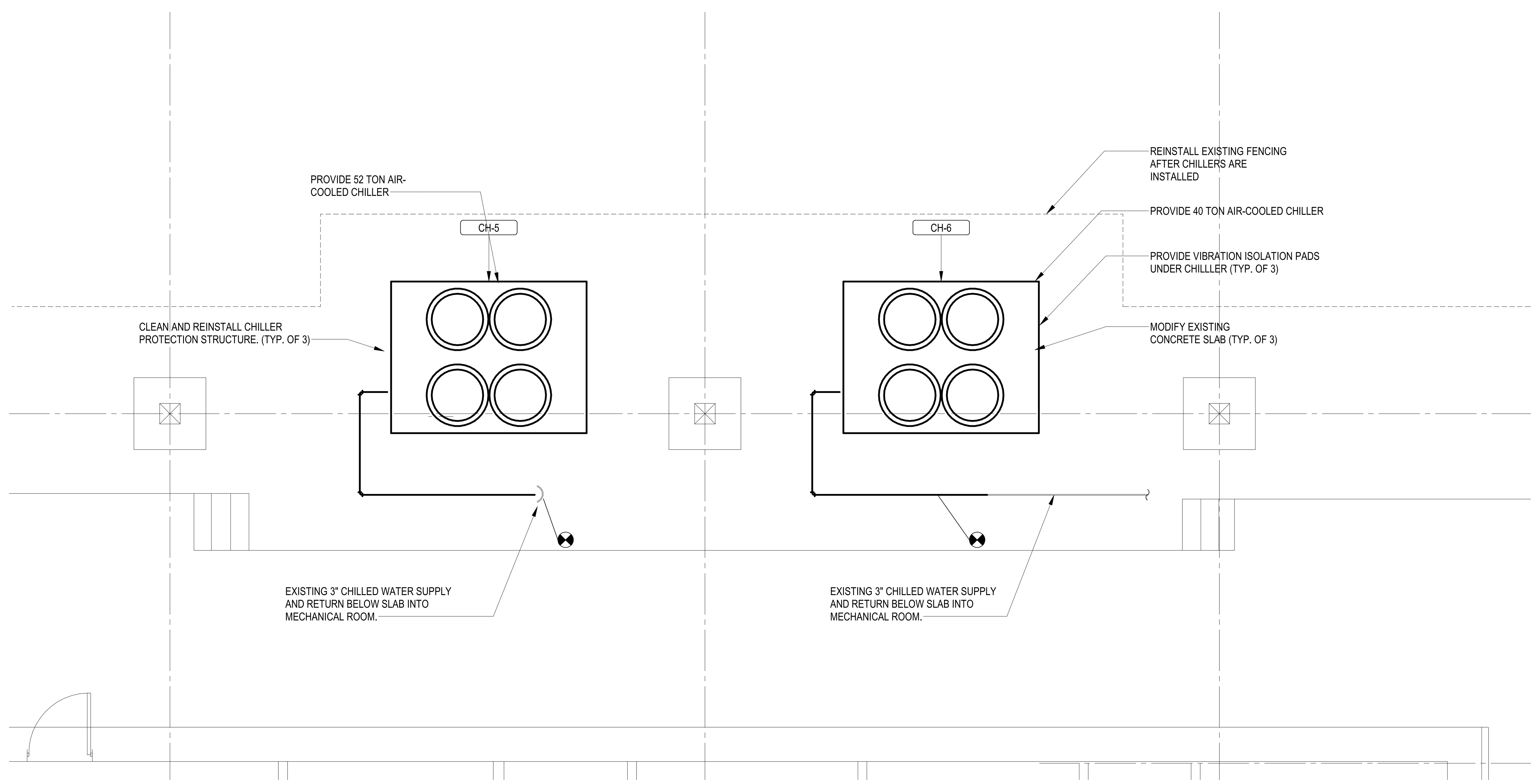
1 UNION PLACE
HARTFORD, CT

DRAWING TITLE:
MECHANICAL ATTIC PLAN - ADD ALTERNATE #1

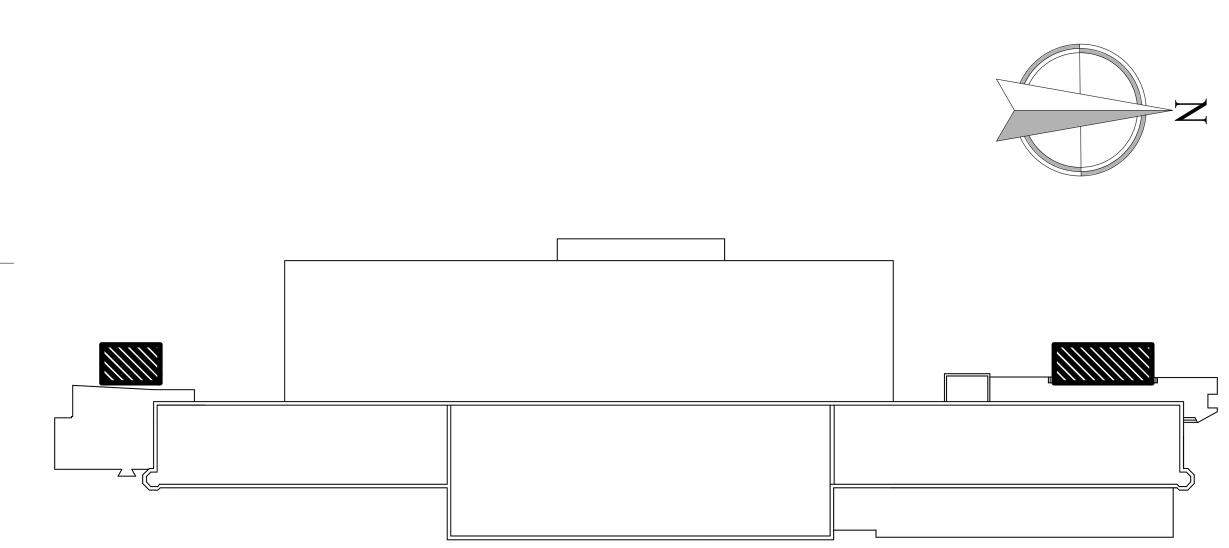
FILE: 2022/3562
DRAWN BY: AJK
CHECKED BY:AP
ISSUE DATE: 11/01/2023
DRAWING NO: M104



1 M105 MECHANICAL AIR COOLED CHILLERS CH-4 PLAN - ADD ALTERNATE #2
1/4" = 1'-0"



2 M105 MECHANICAL AIR COOLED CHILLERS CH-5 AND CH-6 PLAN - ADD ALTERNATE #2
1/4" = 1'-0"



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STAMP:

PROJECT NAME:
GHTD UNION STATION HVAC UPGRADES

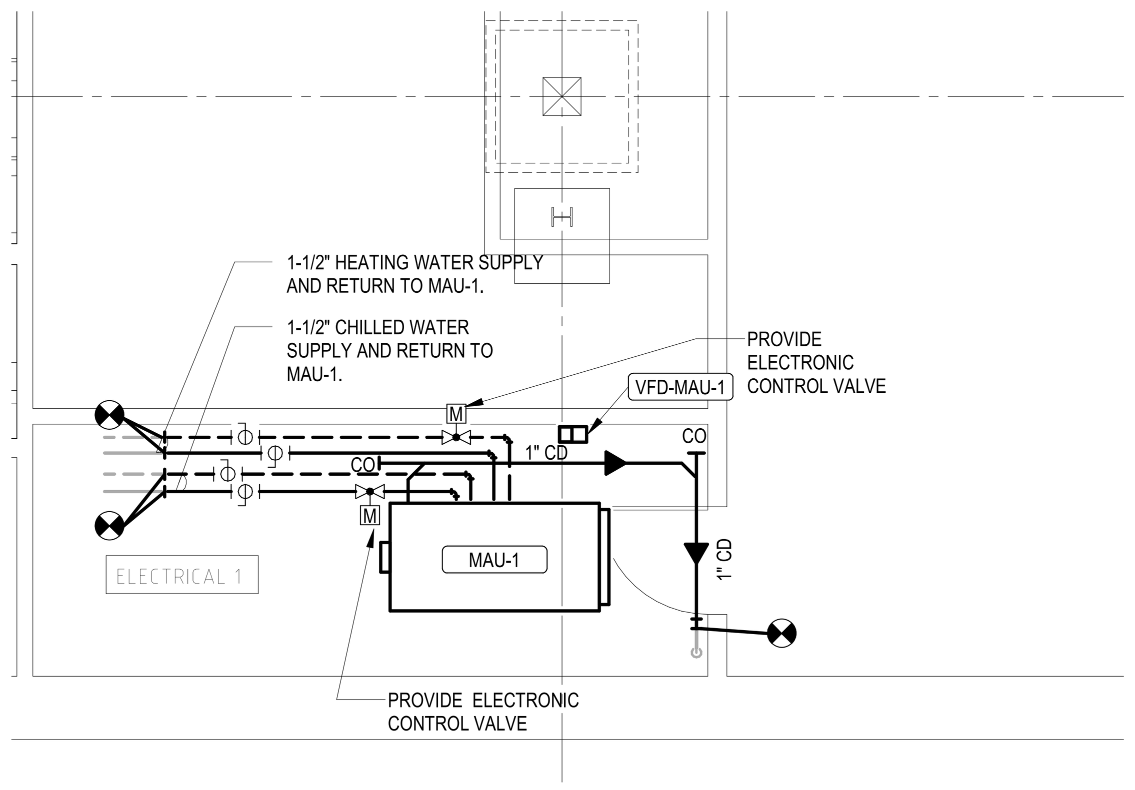
1 UNION PLACE
HARTFORD, CT

DRAWING TITLE:
MECHANICAL AIR COOLED CHILLERS - ADD ALTERNATE #2

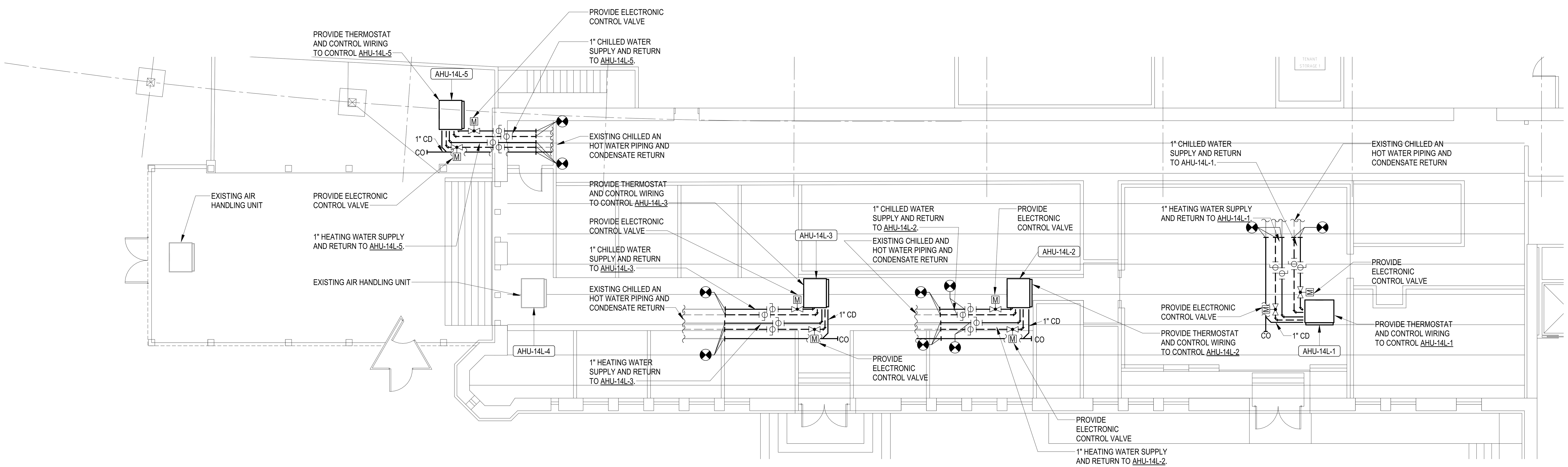
FILE: 2022/3562
DRAWN BY: Author
CHECKED BY: Checker
ISSUE DATE: 11/01/2023
DRAWING NO: M105

GENERAL NOTES:

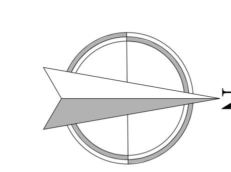
1. PROVIDE AC CONDENSATE DRAIN PIPING PER DETAILS. VERIFY IN FIELD TIE IN LOCATION.
2. PROVIDE NEW PIPING CONNECTIONS TO ALL EQUIPMENT.
3. INSULATE ALL PIPING. INSULATION THICKNESS SHALL BE PER CODE AND SPECIFICATIONS.
4. AC CONDENSATE PIPING SHALL BE INSULATED WITH A MINIMUM OF 1/2" THICK ELASTOMERIC INSULATION WITH A VAPOR BARRIER.
5. REFER TO DETAILS FOR PIPING CONNECTIONS, ACCESSORY LAYOUTS, AND PIPING DETAILS.

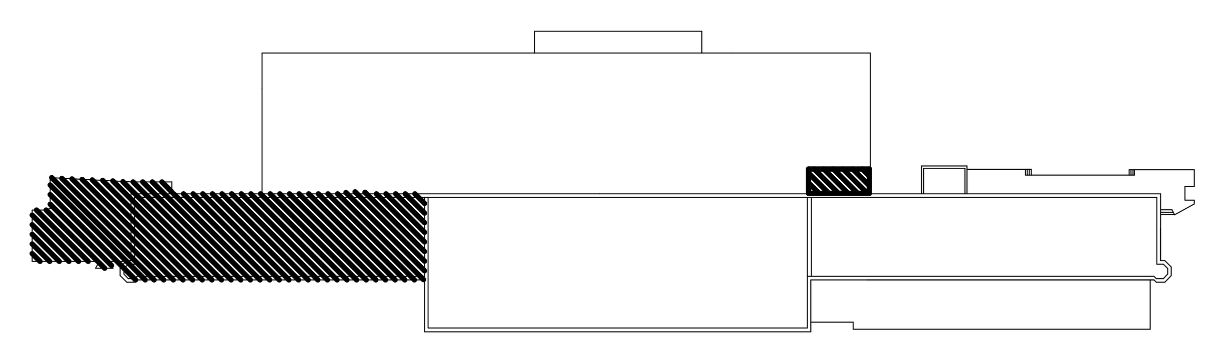


1 M111 MAKE-UP AIR UNIT MECHANICAL PIPING PLAN - BASE BID
1/4" = 1'-0"



2 M111 PROPARK SOUTH MECHANICAL PIPING PLAN - BASE BID
1/8" = 1'-0"





KEY PLAN

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CLIENT:
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1 UNION PLACE
HARTFORD, CT 06103

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NO	DATE	REVISION

STAMP:

PROJECT NAME:
GHTD UNION STATION HVAC UPGRADES

1 UNION PLACE
HARTFORD, CT

DRAWING TITLE:
MECHANICAL LEVEL 1 PIPING PLAN

FILE: 2022/3562
DRAWN BY: AJK
CHECKED BY:AP
ISSUE DATE: 11/01/2023
DRAWING NO: M111

GENERAL NOTES:

1. PROVIDE AC CONDENSATE DRAIN PIPING PER DETAILS. VERIFY IN FIELD TIE IN LOCATION.
2. PROVIDE NEW PIPING CONNECTIONS TO ALL EQUIPMENT.
3. INSULATE ALL PIPING. INSULATION THICKNESS SHALL BE PER CODE AND SPECIFICATIONS.
4. AC CONDENSATE PIPING SHALL BE INSULATED WITH A MINIMUM OF 1/2" THICK ELASTOMERIC INSULATION WITH A VAPOR BARRIER.
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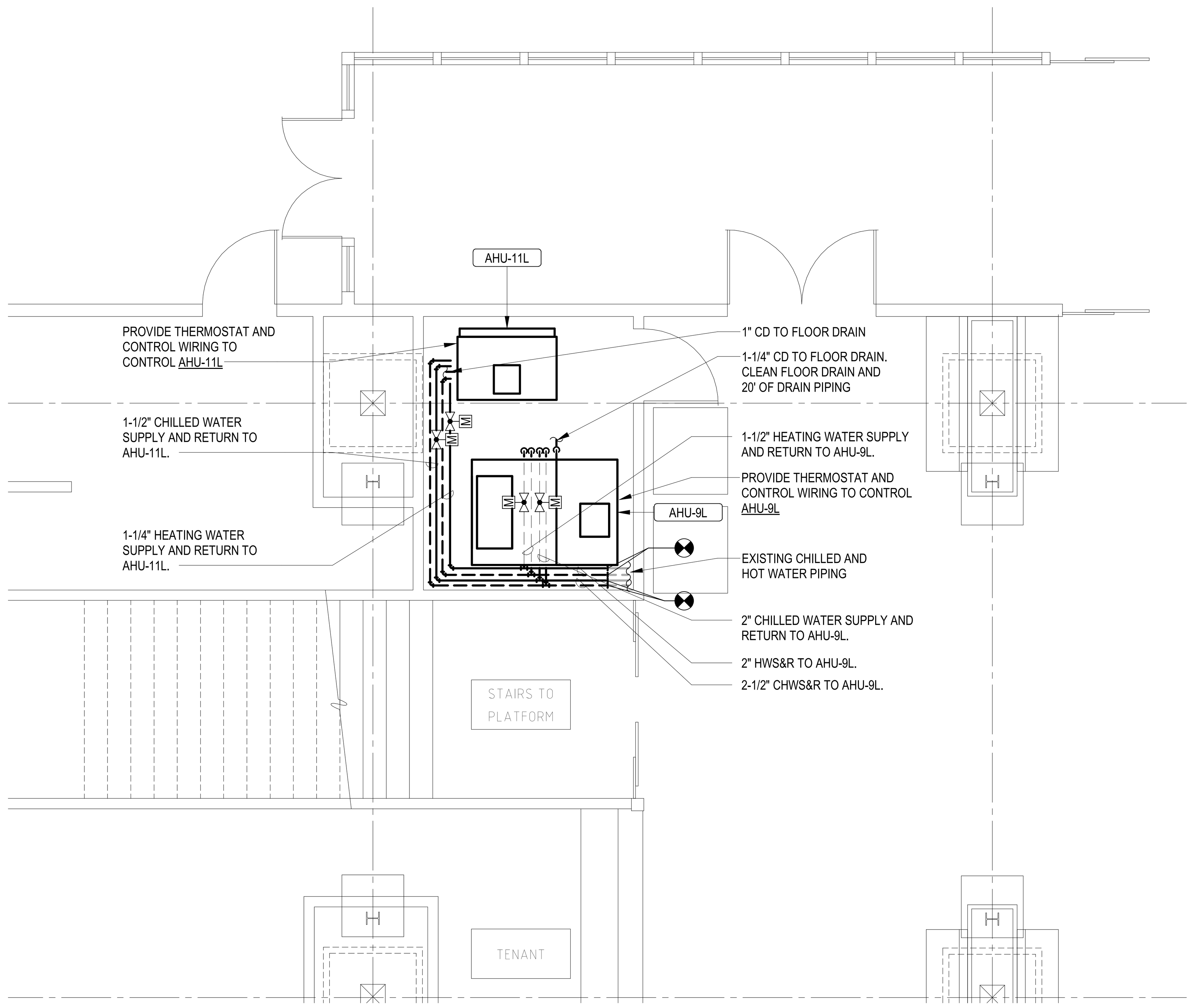
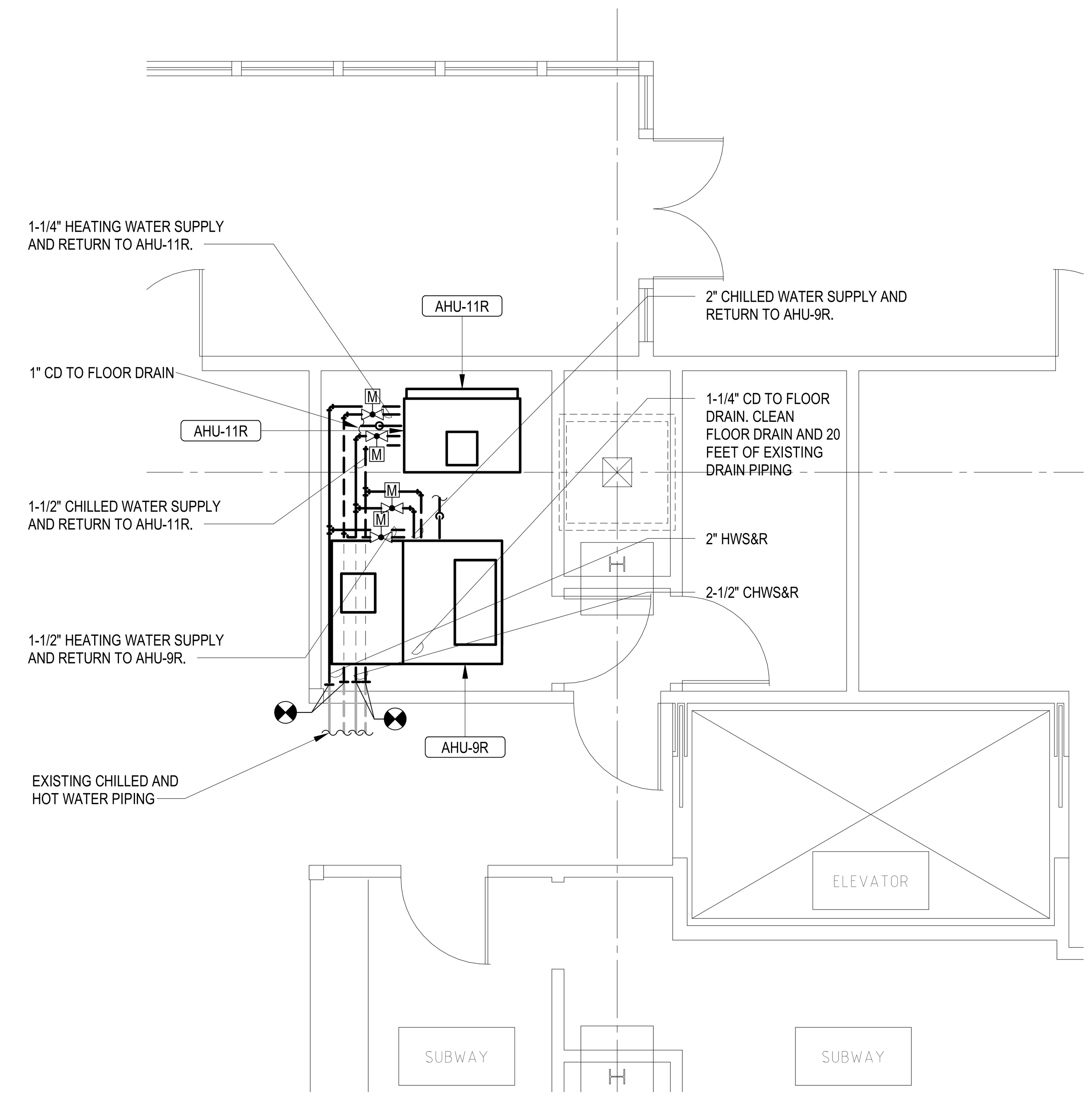
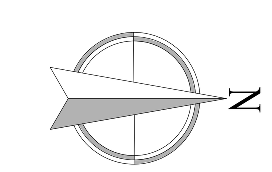
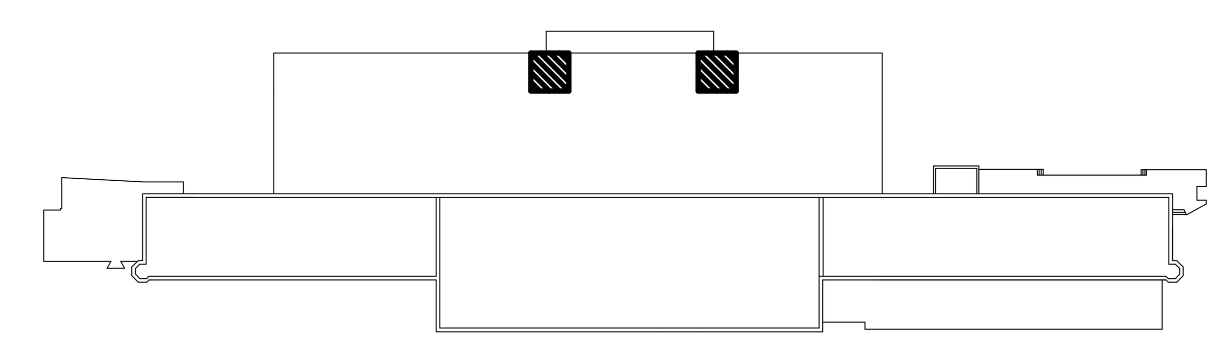


1 M112 TRANSPORTATION SOUTH MECHANICAL ROOM PIPING PLAN - BASE BID
1/4" = 1'-0"



2 M112 TRANSPORTATION NORTH MECHANICAL ROOM PIPING PLAN - BASE BID
1/4" = 1'-0"





KEY PLAN

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PROJECT NAME:
GHTD UNION STATION HVAC UPGRADES

1 UNION PLACE
HARTFORD, CT

DRAWING TITLE:
TRANSPORTATION MECHANICAL ROOMS PIPING PLANS

FILE: 2022/3562
DRAWN BY: AJK
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M112

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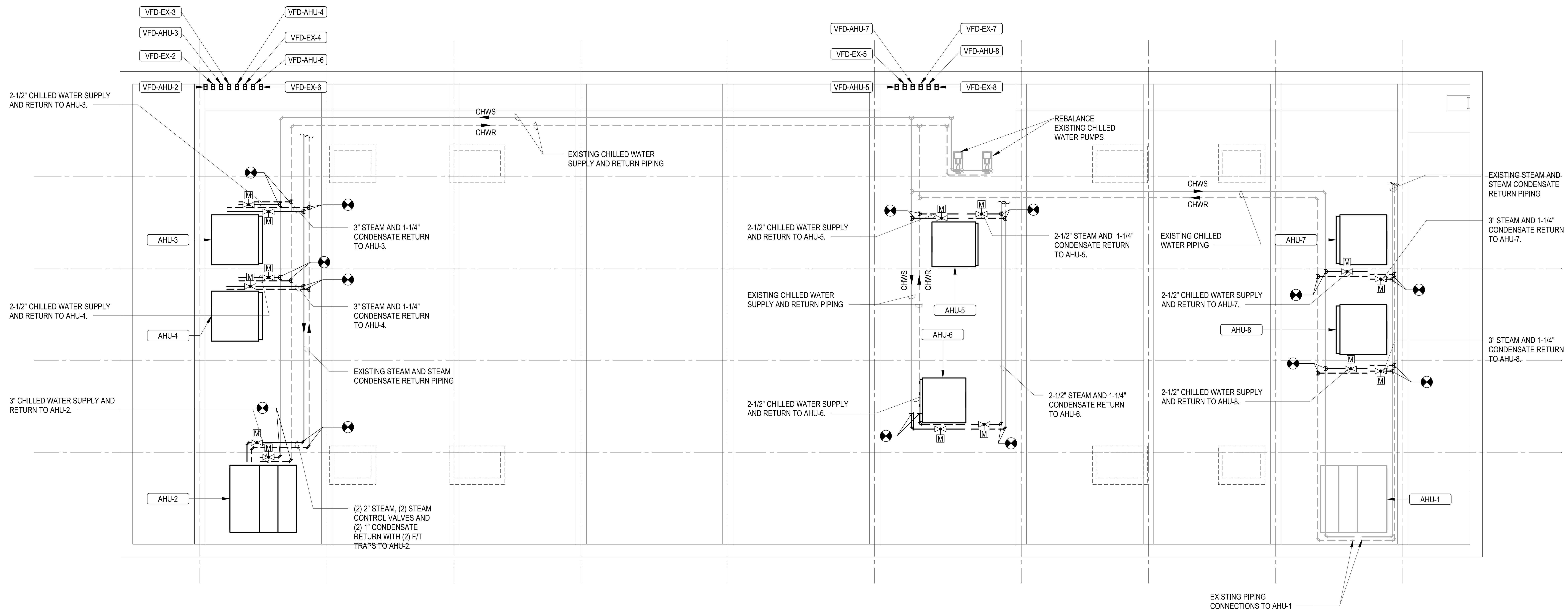

1
M114
ATTIC MECHANICAL PIPING PLAN - ADD ALTERNATE #1
1/8" = 1'-0"

NOTES:

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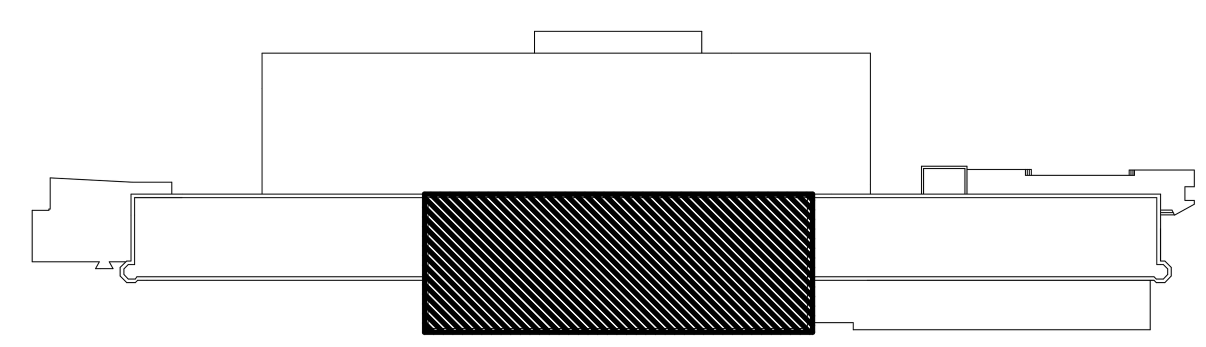

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1 UNION PLACE
HARTFORD, CT 06103

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PROJECT NAME:
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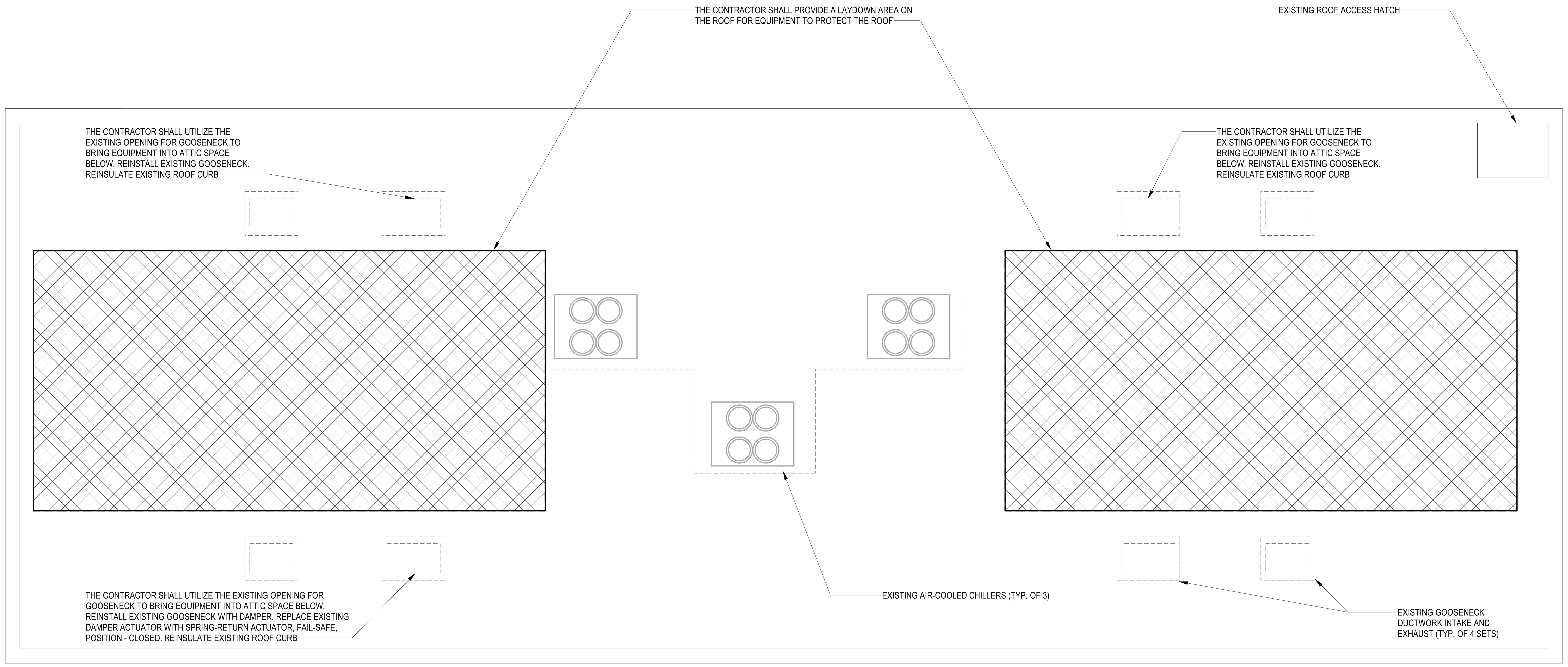
1 UNION PLACE
HARTFORD, CT

DRAWING TITLE:
MECHANICAL ATTIC PIPING PLAN - ADD ALTERNATE #1

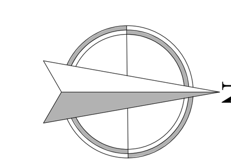
FILE: 2022/3562
DRAWN BY: AJK
CHECKED BY: AP
ISSUE DATE: 11/01/2023
DRAWING NO:
M114

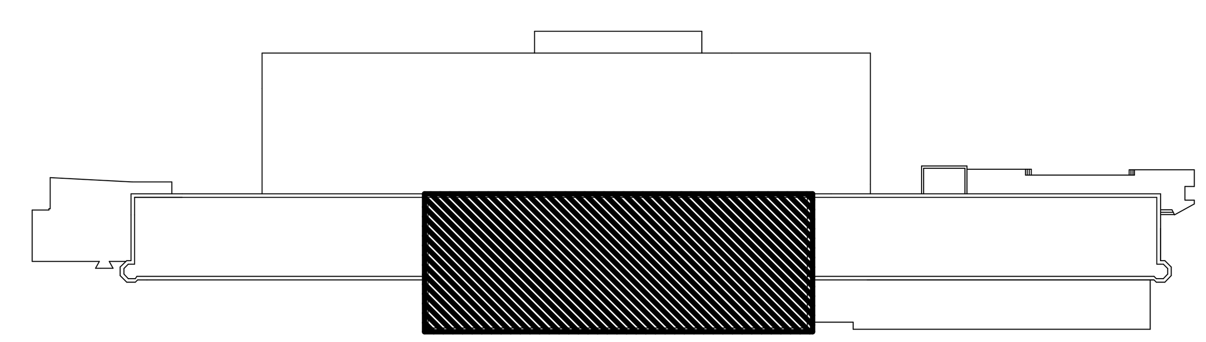


1
M120
MECHANICAL ROOF PLAN - ADD ALTERNATE #1
1/8" = 1'-0"

NOTES:

1. UTILIZE EXISTING GOOSENECK DUCTWORK OPENINGS FOR EQUIPMENT ACCESS INTO AND OUT OF THE ATTIC SPACE BELOW. OPENINGS SHALL BE PROTECTED FROM INTRUSION OF WIND, RAIN AND ANIMALS.
2. COORDINATE THE REMOVAL, STORAGE AND REINSTALLATION OF THE GOOSENECK DUCTWORK. THE GOOSENECKS SHALL BE PROTECTED FROM DAMAGE. GOOSENECK AND ROOFING SHALL BE WATERPROOFED AND SEALED TO AS-FOUND CONDITION OR BETTER.
3. WHILE UTILIZING THE ROOF SPACE, THE CONTRACTOR SHALL PROVIDE A PROTECTIVE LAYDOWN AREA. THE LAYDOWN AREA SHALL PROTECT THE ROOF FROM INCIDENTAL DAMAGE AND PROVIDE BETTER FOOTING.
4. ANY DAMAGE CAUSED TO THE ROOF SHALL BE REPORTED TO THE OWNERS IMMEDIATELY. THE CONTRACTOR SHALL REPAIR ANT DAMAGE INCURRED TO THE ROOF. ANY REPAIR WORK SHALL BE COORDINATED WITH THE OWNER'S INSTALLER TO MAINTAIN THE ROOF WARRANTY.
5. THE ROOF SHALL BE MAINTAINED IN A NEAT AND ORDERLY FASHION. ALL DEBRIS SHALL BE REMOVED IMMEDIATELY.





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CLIENT:
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1 UNION PLACE
HARTFORD, CT 06103

THIS SQUARE APPEARS 1/2"x1/2" ON FULL SIZE SHEETS

NO	DATE	REVISION

STAMP:

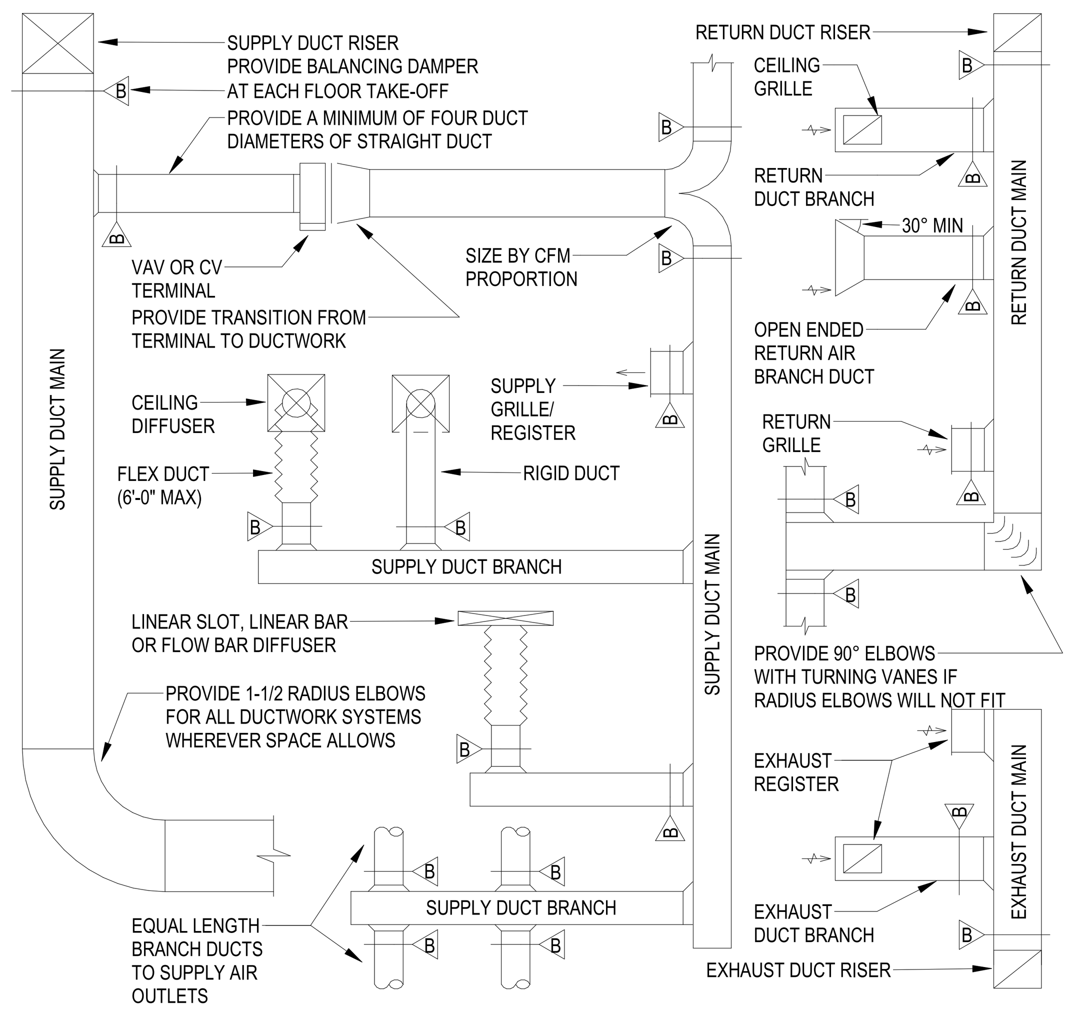
PROJECT NAME:
GHTD UNION STATION HVAC UPGRADES

1 UNION PLACE
HARTFORD, CT

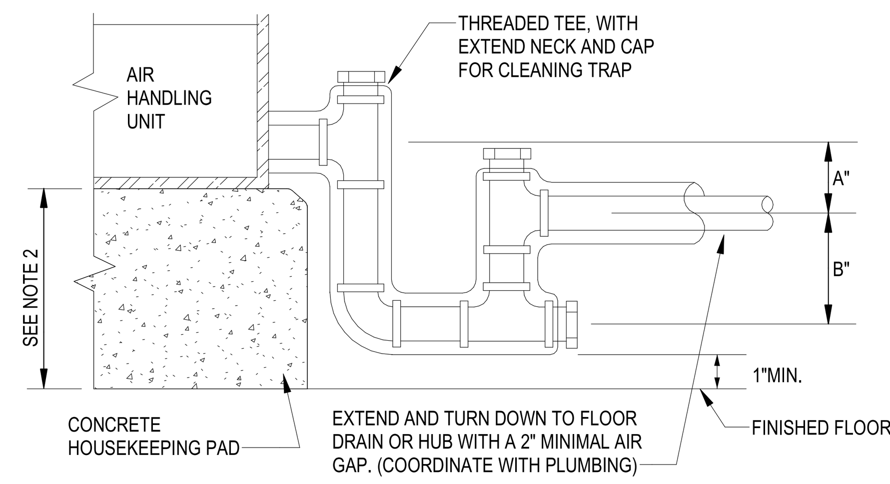
DRAWING TITLE:
MECHANICAL ROOF PLAN - ADD ALTERNATE #1

FILE: 2022/3562
DRAWN BY: AJK
CHECKED BY:AP
ISSUE DATE: 11/01/2023
DRAWING NO:
M120

NOTES:
1. REFER TO HVAC FLOOR PLANS FOR DUCT SIZES
2. REFER TO SCHEDULES FOR GRILLES, REGISTERS, DIFFUSERS AND TERMINAL SIZES AND TYPES
3. PROVIDE A MANUAL TYPE BALANCING DAMPER FOR EACH SUPPLY OUTLET AND RETURN INLET
4. ALL DUCT RUNOUTS TO DIFFUSERS SHALL BE THE SAME SIZE AS DIFFUSER NECK SIZE, UNLESS OTHERWISE NOTED
5. FLEX DUCT WILL NOT BE ALLOWED ON RETURN OR EXHAUST DUCTWORK SYSTEMS
6. PROVIDE 12" AIR CUSHION AT THE END OF EACH SUPPLY MAIN AND BRANCH DUCT
7. INDIVIDUAL BRANCH BALANCING DAMPERS NOT REQUIRED FOR SUPPLY OR EXHAUST REGISTERS



1 M501 DUCTWORK INSTALLATION DIAGRAM
NOT TO SCALE

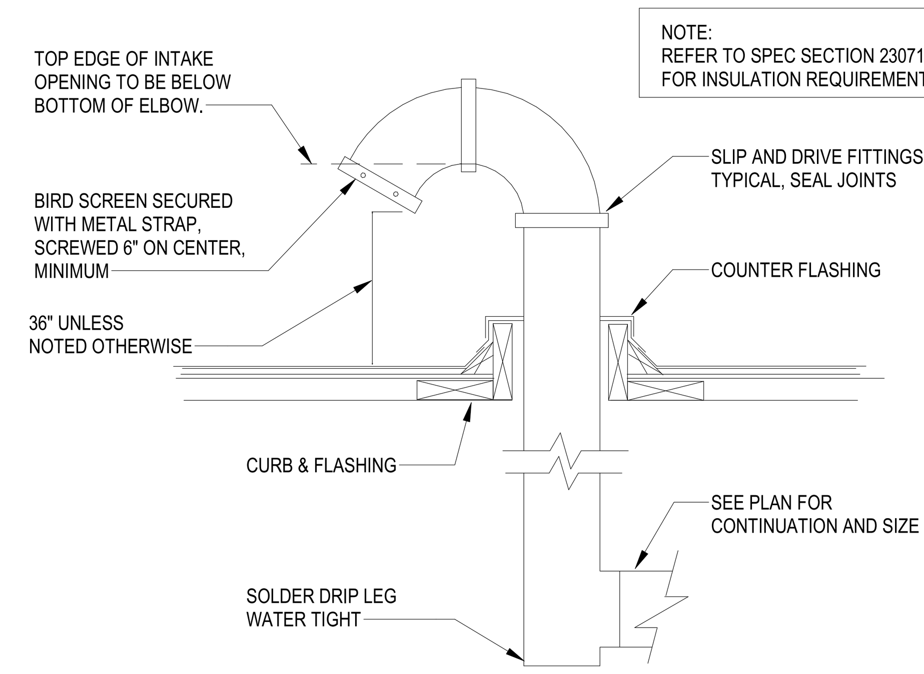


NOTES:
1. PIPE SIZES AS INDICATED ON PLANS. WHERE NOT SHOWN, SIZE SHALL BE FULL SIZE OF DRAIN TAP ON AHU OR 1-1/4" MINIMUM.
2. 6" MAXIMUM PAD HEIGHT, IF HIGHER ELEVATION IS REQUIRED FOR TRAP, USE OPTIONAL AHU BASE RAIL AND 4" HIGH HOUSEKEEPING PAD.
3. SEE SPECIFICATIONS FOR INSULATION REQUIREMENTS.

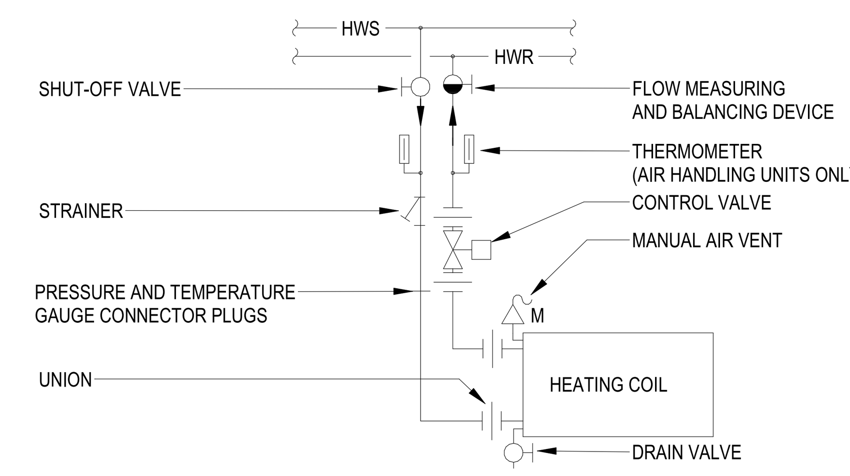
A = SCHEDULED FAN STATIC PLUS ONE INCH
B = 1/2 OF SCHEDULED FAN STATIC

2 M501 CONDENSATE DRAIN TRAP
NOT TO SCALE

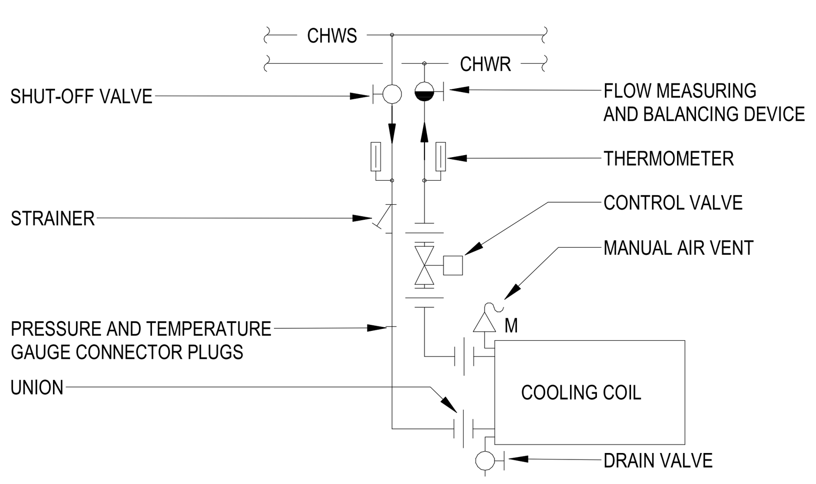
NOTE:
REFER TO SPEC SECTION 230713 FOR INSULATION REQUIREMENTS



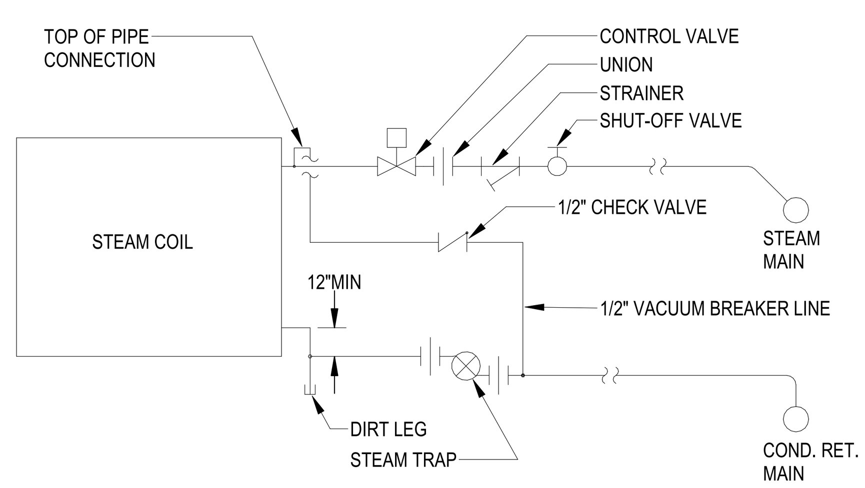
3 M501 INTAKE OR EXHAUST GOOSENECK
NOT TO SCALE



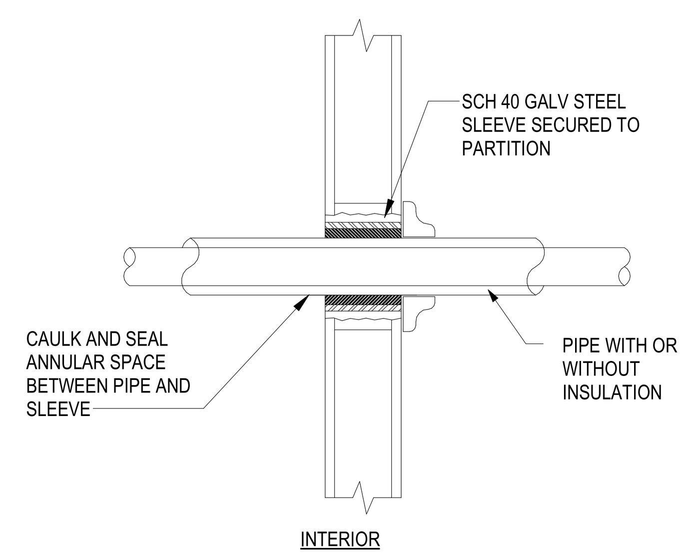
4 M501 HOT WATER COIL PIPING DETAIL W/2-WAY VALVE - SINGLE
NOT TO SCALE



5 M501 CHILLED WATER COIL PIPING DETAIL W/2-WAY VALVE - SINGLE
NOT TO SCALE

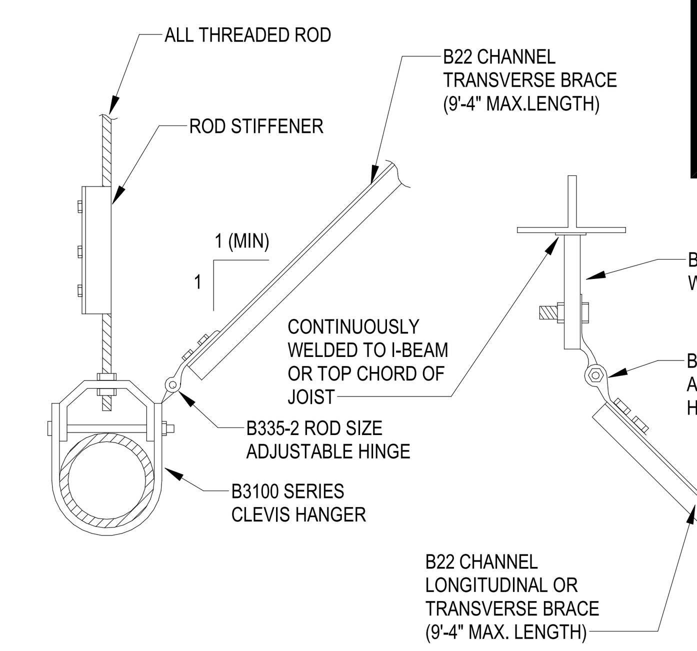


6 M501 STEAM COIL PIPING DETAIL
NOT TO SCALE



NOTES:
1. TYPICAL FOR NON-INSULATED PIPE AND CONDUIT.
2. ALL CAULKING AND SEALANT SHALL BE FIRE RATED (SEE SPECIFICATIONS).
3. WHERE PIPING IS EXPOSED AT FINISHED WALL, FLUSH MOUNT SLEEVE AND PROVIDE AN ESCUTCHEON PLATE.

7 M501 PIPE PENETRATION THRU INTERIOR WALLS
NOT TO SCALE



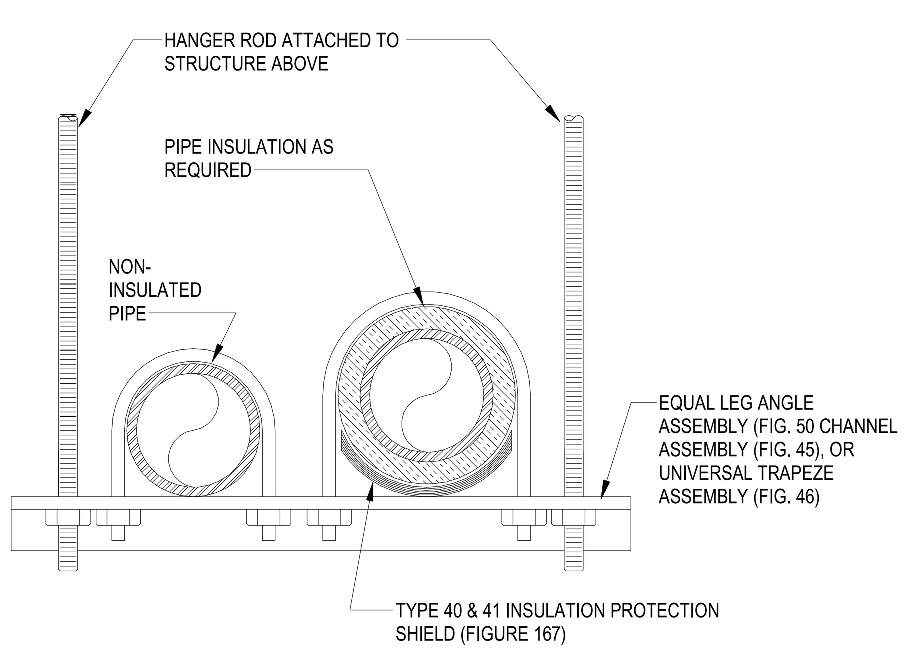
NOTE: SEISMIC ZONE X RESTRAINTS SHALL NOT BE REQUIRED FOR THE FOLLOWING INSTALLATIONS.

1. GAS PIPING LESS THAN 1 INCH INSIDE DIAMETER.
2. PIPING IN BOILER AND MECHANICAL ROOMS LESS THAN 1-1/4 INCH INSIDE DIAMETER.
3. ALL OTHER PIPING LESS THAN 2-1/2" INSIDE DIAMETER.
4. ALL PIPING SUSPENDED BY INDIVIDUAL HANGERS 12" OR LESS IN LENGTH FROM THE TOPOF THE PIPE TO THE BOTTOM OF THE SUPPORT FOR THE HANGER.

DIA.	STANDARD WEIGHT PIPE
	MAX TRANSVERSE SPAN
1	10'-3"
1-1/2	12'-0"
2	13'-6"
2-1/2	14'-9"
3	16'-3"
3-1/2	17'-6"
4	18'-3"
5	20'-3"
6	22'-0"
8	24'-9"
10	27'-0"
12	29'-0"

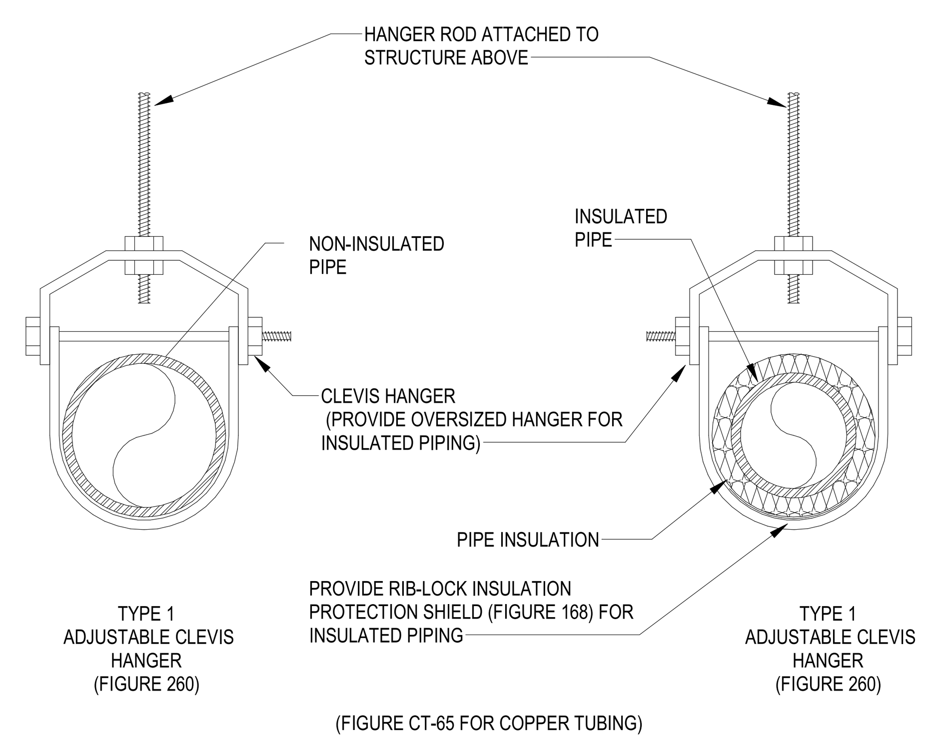
1. MAXIMUM SPAN FOR TRANSVERSE BRACING FOR SEISMIC ZONE X.
2. MAXIMUM SPAN FOR LATERAL BRACING SHALL NOT EXCEED TWICE THAT SHOWN FORTRANSVERSE BRACING

8 M501 CLEVIS HANGER TRANSVERSE BRACING DETAIL
NOT TO SCALE



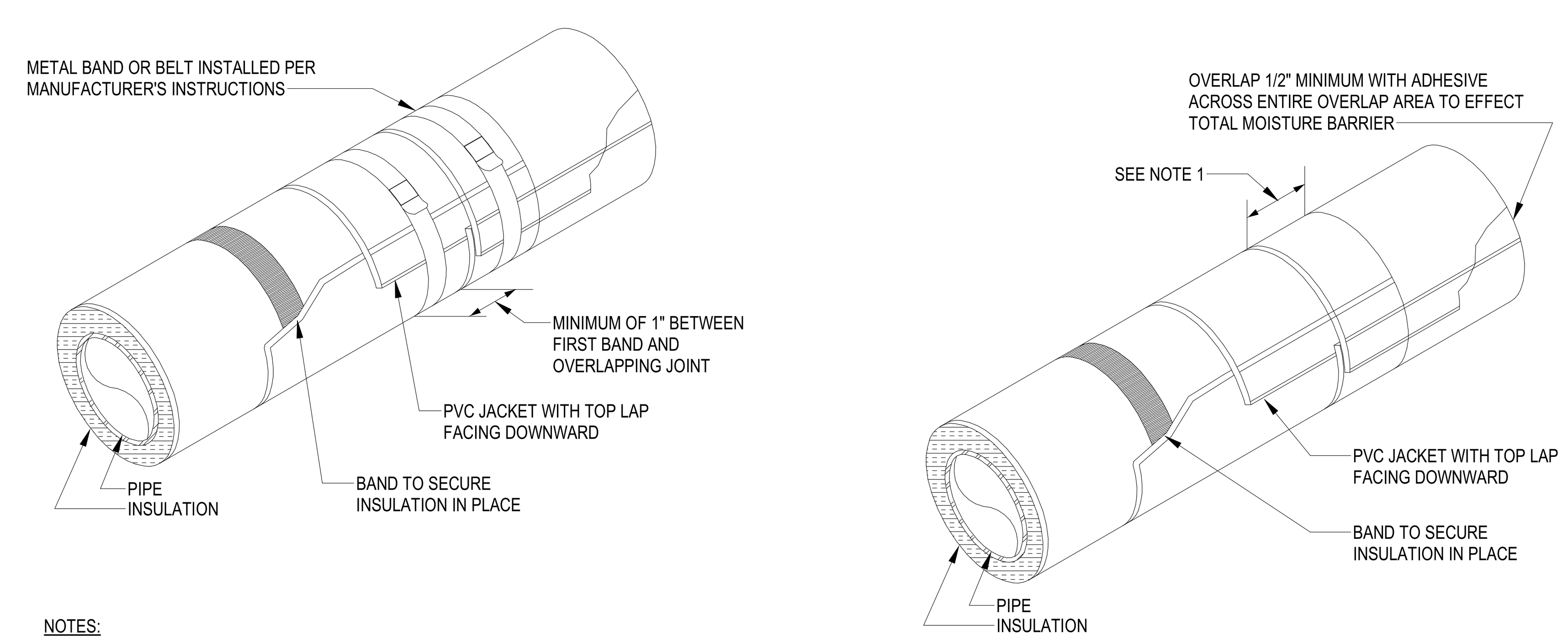
NOTES:
1. SIZE RODS, SPRING CUSHION, AND HORIZONTAL MEMBER APPROVED TO SATISFY LOAD REQUIREMENT WITH SAFETY FACTOR OF 5.
2. FIGURE NUMBERS ARE TYPICAL TO GRINNELL SUPPORT NUMBERS.

9 M501 TRAPEZE TYPE PIPE SUPPORT
NOT TO SCALE



NOTE:
FIGURE NUMBERS ARE TYPICAL TO GRINNELL SUPPORT NUMBERS.

10 M501 SINGLE PIPE CLEVIS HANGER
NOT TO SCALE



NOTES:
1. OVERLAP JACKET MINIMUM OF 1-1/2" WITH WELDED ADHESIVE ACROSS ENTIRE JOINT OVERLAP TO EFFECT TOTAL MOISTURE BARRIER.
2. LONGITUDINAL JACKETING SEAMS SHALL BE POSITIONED AT 3 O'CLOCK OR 9 O'CLOCK ONLY WITH TOP LAP FACING DOWNWARD FOR WEATHER PROTECTION.

11 M501 FIELD APPLIED PVC PIPE JACKETING OVER PIPE INSULATION
NOT TO SCALE

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NO	DATE	REVISION

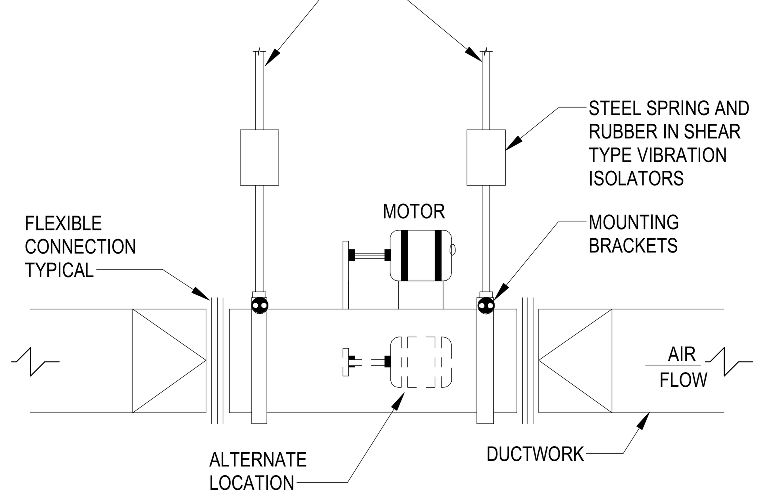
STAMP:

PROJECT NAME:
GHTD UNION STATION
HVAC UPGRADES

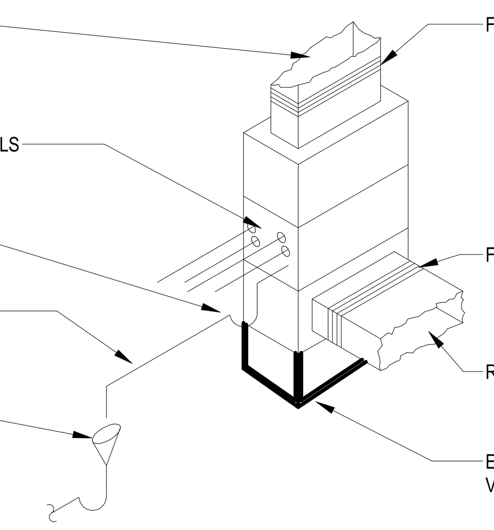
1 UNION PLACE
HARTFORD, CT

DRAWING TITLE:
MECHANICAL DETAILS

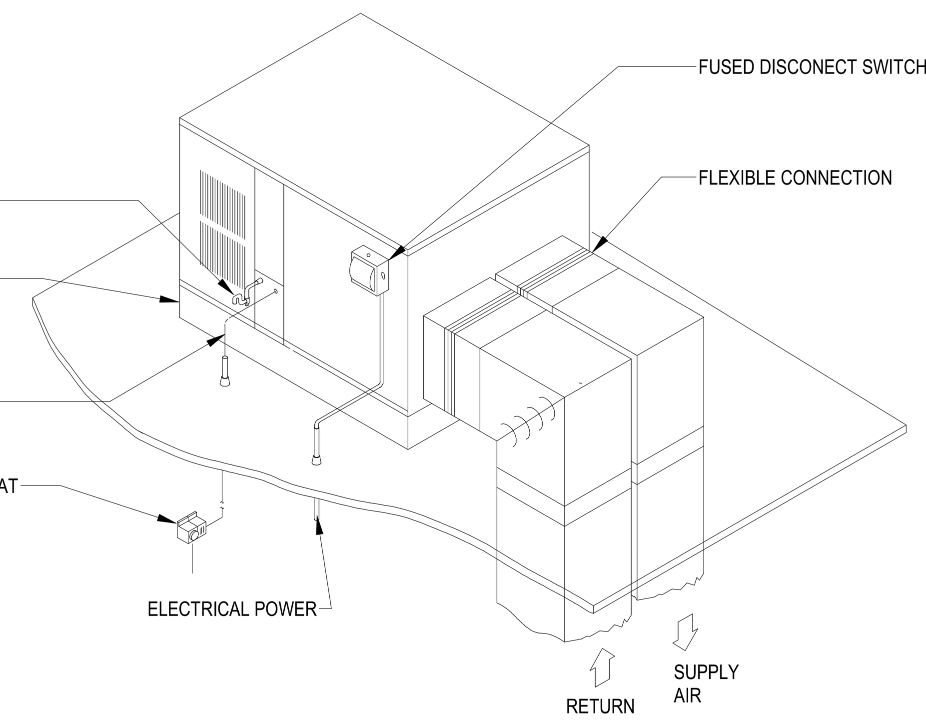
FILE: 2022/3562
DRAWN BY: AJK
CHECKED BY:AP
ISSUE DATE: 11/01/2023
DRAWING NO:
M501



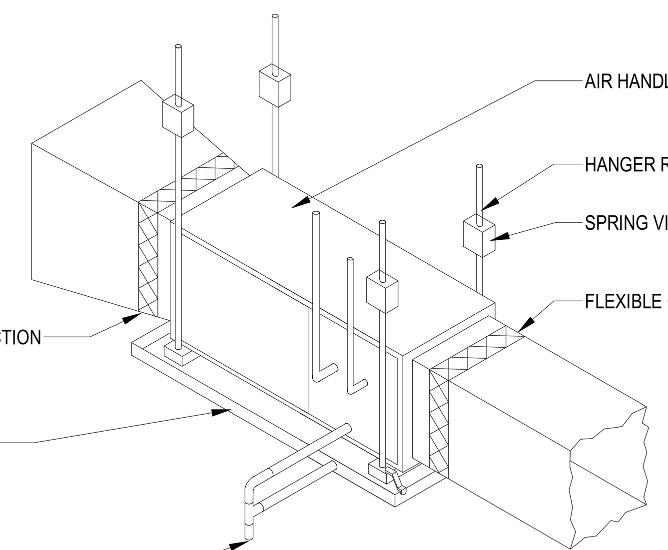
1 M502 IN-LINE FAN SUPPORT DETAIL
NOT TO SCALE



2 M502 AIR HANDLING UNIT DETAIL
NOT TO SCALE



3 M502 PK UNIT DETAIL
NOT TO SCALE



4 M502 SUSPENDED AIR HANDLING UNIT DETAIL
NOT TO SCALE

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NO	DATE	REVISION

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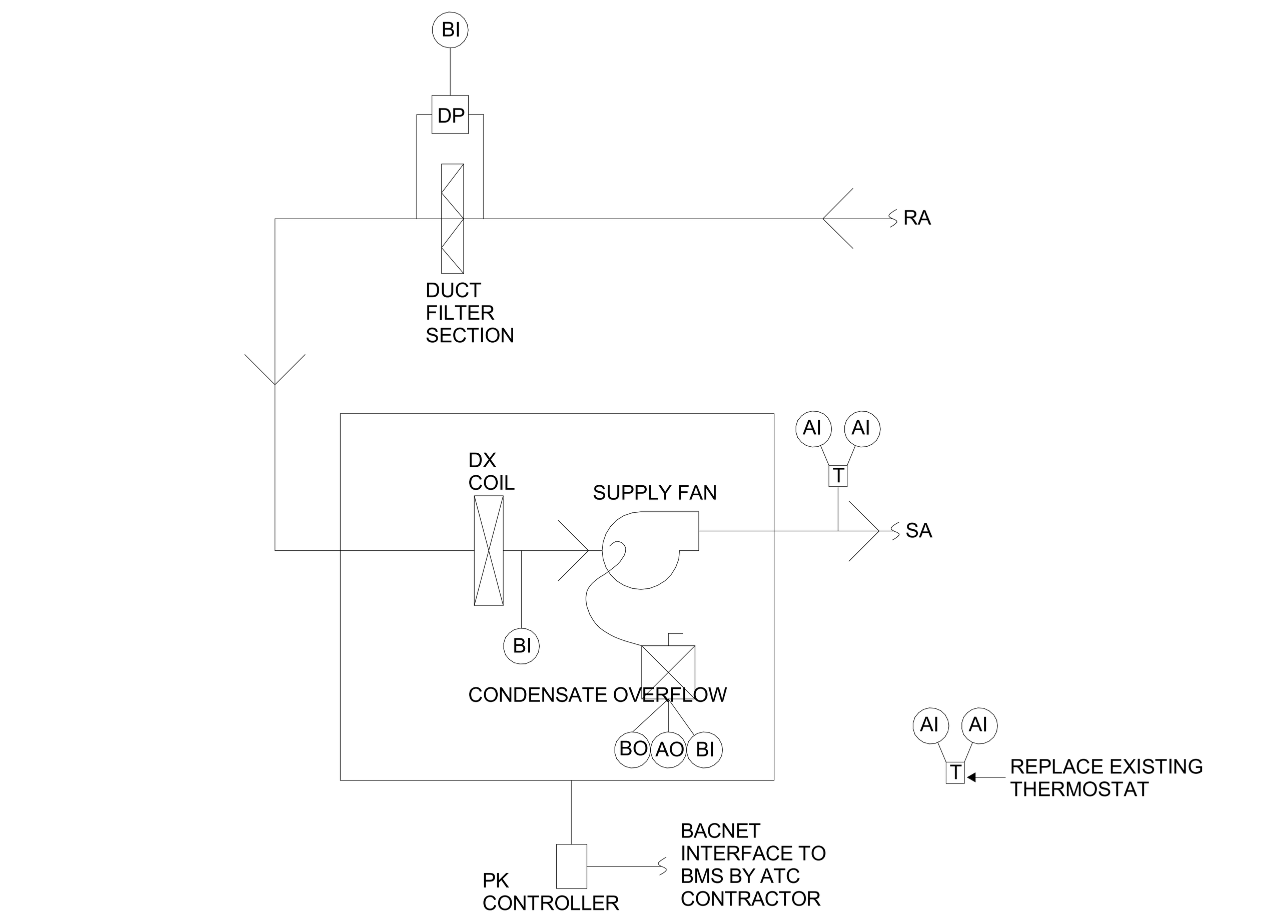
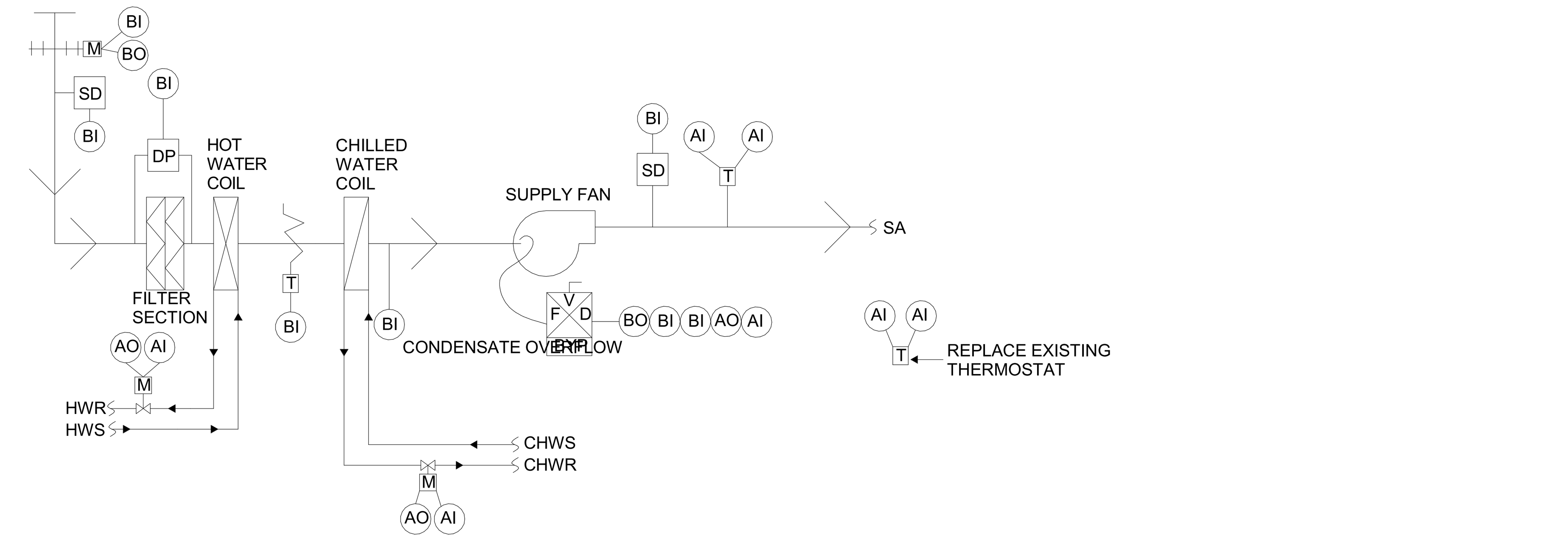
PROJECT NAME:
GHTD UNION STATION HVAC UPGRADES
1 UNION PLACE
HARTFORD, CT

DRAWING TITLE:
EQUIPMENT DETAILS

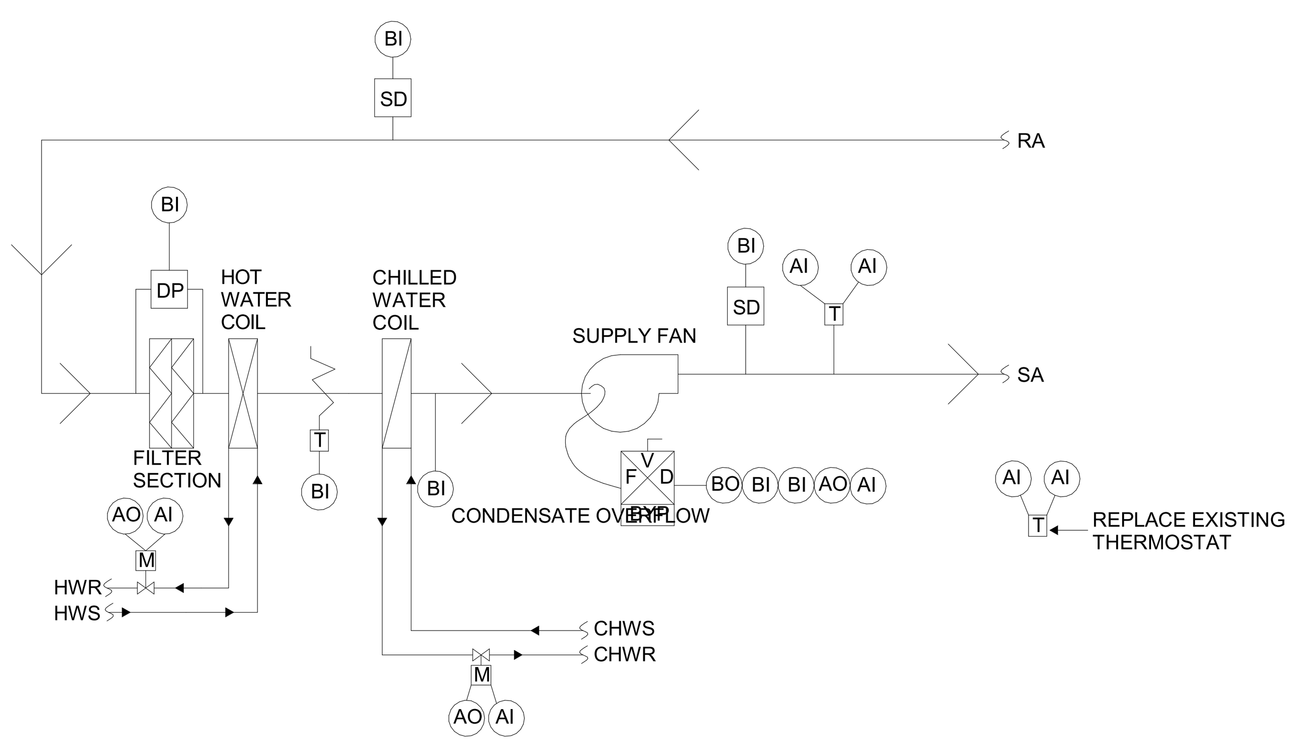
FILE: 2022/3562
DRAWN BY: Author
CHECKED BY: Checker
ISSUE DATE: 11/01/2023
DRAWING NO: M502



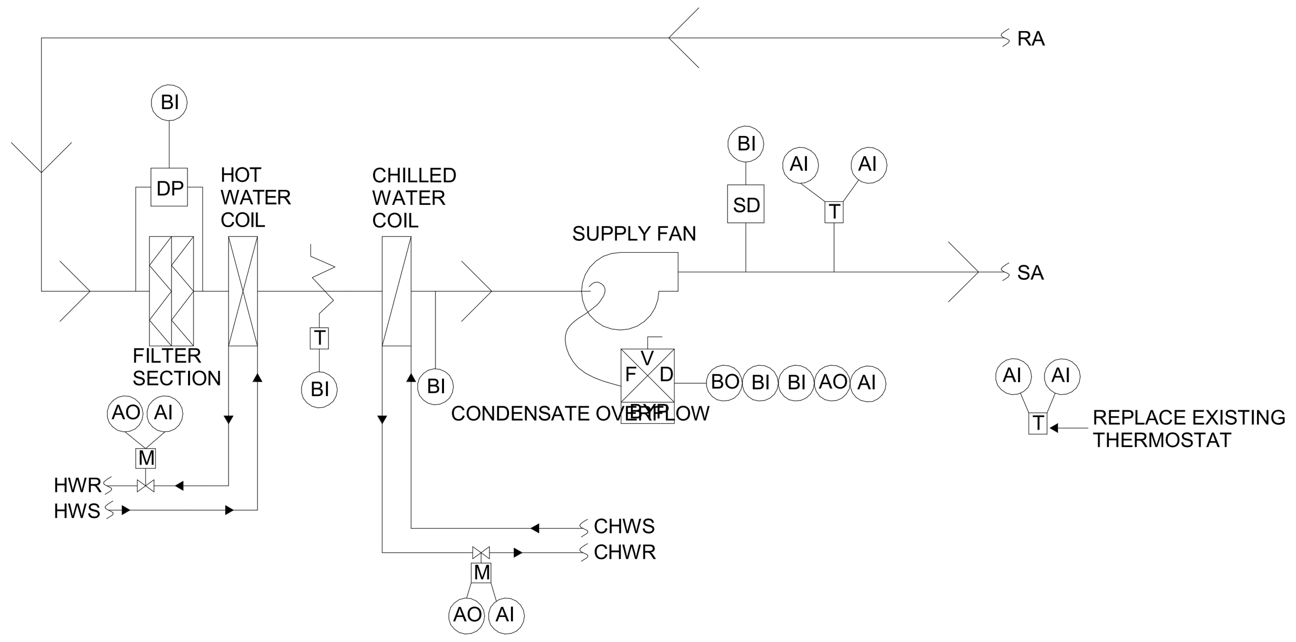
1 M503 PKS CONTROL DIAGRAM - BASE BID
NOT TO SCALE



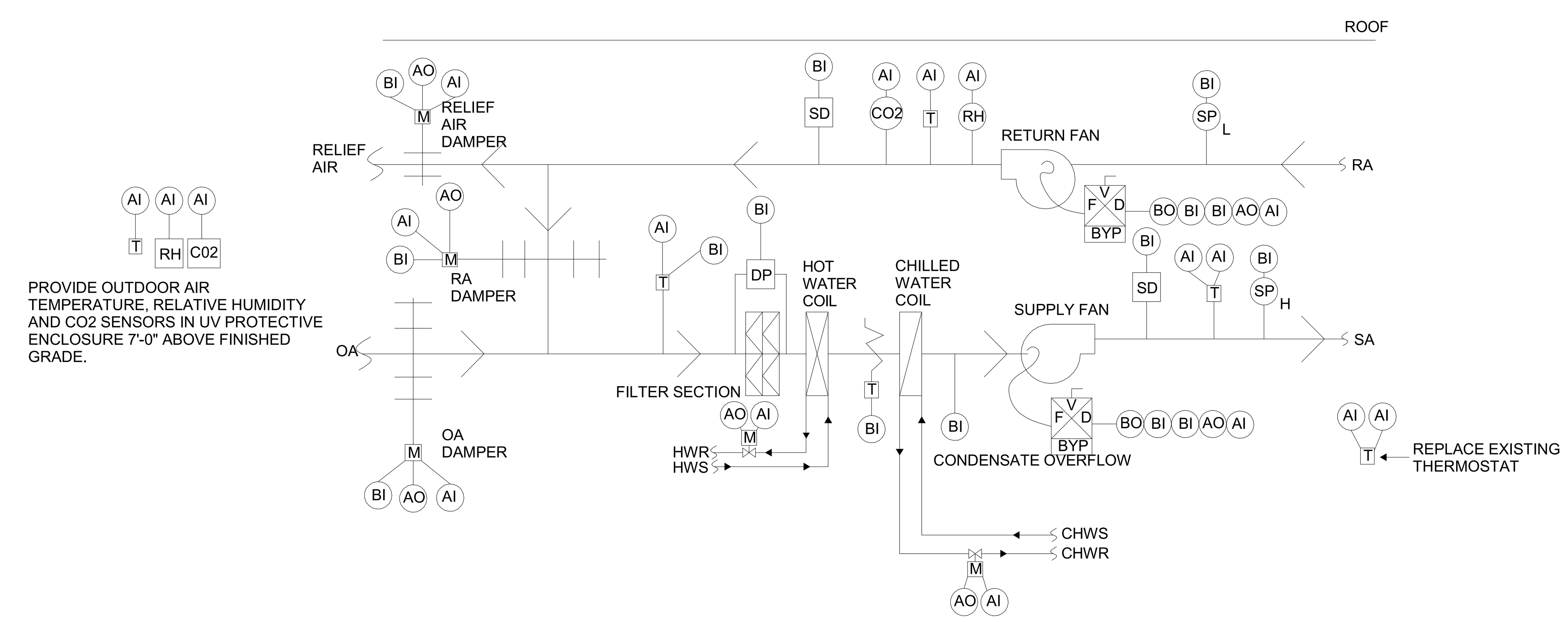
2 M503 AHU-9L & 9R CONTROL DIAGRAM - BASE BID
NOT TO SCALE



3 M503 AHU-11L & 11R CONTROL DIAGRAM - BASE BID
NOT TO SCALE



4 M503 PROPARK AHUS CONTROL DIAGRAM - BASE BID
NOT TO SCALE



5 M503 AHU-2, 3, 4, 5, 6, 7 & 8 CONTROL DIAGRAM - ADD ALTERNATE #1
NOT TO SCALE

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GHTD UNION STATION HVAC UPGRADES

1 UNION PLACE
HARTFORD, CT

DRAWING TITLE:
MECHANICAL CONTROLS DIAGRAMS

FILE: 2022/3562
DRAWN BY: Author
CHECKED BY: Checker
ISSUE DATE: 11/01/2023
DRAWING NO: M503

POINTS LIST: AHU-9L & AHU-9R - BASE BID

System Point Description	POINTS										ALARMS				
	GRAPHIC	ANALOG HARDWARE INPUT (AI)	BINARY HARDWARE INPUT (BI)	ANALOG HARDWARE OUTPUT (AO)	BINARY HARDWARE OUTPUT (BO)	SOFTWARE POINT (SFT)	HARDWARE INTERLOCK (HDW)	WIRELESS (WLS)	NETWORK (NET)	HIGH ANALOG LIMIT	LOW ANALOG LIMIT	BINARY	LATCH DIAGNOSTIC	SENSOR FAIL	COMMUNICATION FAIL
HOT WATER CONTROL VALVE COMMAND	X			X											
HOT WATER CONTROL VALVE POSITION	X	X													
CHILLED WATER CONTROL VALVE COMMAND	X			X											
CHILLED WATER CONTROL VALVE POSITION	X	X													
FREEZSTAT	X		X				X					X	X	X	
RA DAMPER COMMAND	X			X											
RA DAMPER POSITION	X	X													
RA DAMPER FAILURE	X		X									X			
FILTER STATUS	X		X									X			
CONDENSATE OVERFLOW	X		X									X	X	X	
SUPPLY FAN START/STOP COMMAND	X				X										
SUPPLY FAN SPEED	X			X											
SUPPLY FAN STATUS	X		X							X	X			X	
SUPPLY FAN FAILURE	X					X						X	X		
VFD SUPPLY FAN FAILURE	X					X						X	X		
VFD SUPPLY FAN FEEDBACK	X	X													
VFD SUPPLY FAN STATUS	X		X												
SUPPLY AIR SMOKE DETECTOR	X		X									X	X		
SUPPLY AIR TEMPERATURE	X	X												X	
SUPPLY AIR COOLING RESET TEMPERATURE						X									
SUPPLY AIR HEATING RESET TEMPERATURE						X									
RETURN AIR SMOKE DETECTOR	X		X									X	X		
BAS COMMUNICATION STATE	X					X									X
MAINTENANCE REQUIRED	X					X						X			
OCCUPIED COOLING SETPOINT	X					X									
OCCUPIED HEATING SETPOINT	X					X									
UNOCCUPIED COOLING SETPOINT	X					X									
UNOCCUPIED HEATING SETPOINT	X					X									

POINTS LIST: AHU-11L & AHU-11R - BASE BID

System Point Description	POINTS										ALARMS				
	GRAPHIC	ANALOG HARDWARE INPUT (AI)	BINARY HARDWARE INPUT (BI)	ANALOG HARDWARE OUTPUT (AO)	BINARY HARDWARE OUTPUT (BO)	SOFTWARE POINT (SFT)	HARDWARE INTERLOCK (HDW)	WIRELESS (WLS)	NETWORK (NET)	HIGH ANALOG LIMIT	LOW ANALOG LIMIT	BINARY	LATCH DIAGNOSTIC	SENSOR FAIL	COMMUNICATION FAIL
HOT WATER CONTROL VALVE COMMAND	X			X											
HOT WATER CONTROL VALVE POSITION	X	X													
CHILLED WATER CONTROL VALVE COMMAND	X			X											
CHILLED WATER CONTROL VALVE POSITION	X	X													
FREEZSTAT	X		X				X					X	X	X	
FILTER STATUS	X		X									X			
CONDENSATE OVERFLOW	X		X									X	X	X	
SUPPLY FAN START/STOP COMMAND	X				X										
SUPPLY FAN SPEED	X			X											
SUPPLY FAN STATUS	X		X							X	X			X	
SUPPLY FAN FAILURE	X					X						X	X		
SUPPLY AIR SMOKE DETECTOR	X		X									X	X		
SUPPLY AIR TEMPERATURE	X	X												X	
SUPPLY AIR COOLING RESET TEMPERATURE						X									
SUPPLY AIR HEATING RESET TEMPERATURE						X									
RETURN AIR SMOKE DETECTOR	X		X									X	X		
BAS COMMUNICATION STATE	X					X									X
MAINTENANCE REQUIRED	X					X						X			
OCCUPIED COOLING SETPOINT	X					X									
OCCUPIED HEATING SETPOINT	X					X									
UNOCCUPIED COOLING SETPOINT	X					X									
UNOCCUPIED HEATING SETPOINT	X					X									

POINTS LIST: AHU-14L-1, AHU-14L-2,AHU-14L-3 AND AHU-14L-5 - BASE BID

System Point Description	POINTS										ALARMS				
	GRAPHIC	ANALOG HARDWARE INPUT (AI)	BINARY HARDWARE INPUT (BI)	ANALOG HARDWARE OUTPUT (AO)	BINARY HARDWARE OUTPUT (BO)	SOFTWARE POINT (SFT)	HARDWARE INTERLOCK (HDW)	WIRELESS (WLS)	NETWORK (NET)	HIGH ANALOG LIMIT	LOW ANALOG LIMIT	BINARY	LATCH DIAGNOSTIC	SENSOR FAIL	COMMUNICATION FAIL
HOT WATER CONTROL VALVE COMMAND	X			X											
HOT WATER CONTROL VALVE POSITION	X	X													
CHILLED WATER CONTROL VALVE COMMAND	X			X											
CHILLED WATER CONTROL VALVE POSITION	X	X													
FREEZSTAT	X		X				X					X	X	X	
FILTER STATUS	X		X									X			
CONDENSATE OVERFLOW	X		X									X	X	X	
SUPPLY FAN START/STOP COMMAND	X				X										
SUPPLY FAN SPEED	X			X											
SUPPLY FAN STATUS	X		X							X	X			X	
SUPPLY FAN FAILURE	X					X						X	X		
SUPPLY AIR TEMPERATURE	X	X												X	
SUPPLY AIR COOLING RESET TEMPERATURE						X									
SUPPLY AIR HEATING RESET TEMPERATURE						X									
BAS COMMUNICATION STATE	X					X									X
MAINTENANCE REQUIRED	X					X						X			
OCCUPIED COOLING SETPOINT	X					X									
OCCUPIED HEATING SETPOINT	X					X									
UNOCCUPIED COOLING SETPOINT	X					X									
UNOCCUPIED HEATING SETPOINT	X					X									

POINTS LIST: PK-1, PK-2 AND PK-3 - BASE BID

System Point Description	POINTS										ALARMS				
	GRAPHIC	ANALOG HARDWARE INPUT (AI)	BINARY HARDWARE INPUT (BI)	ANALOG HARDWARE OUTPUT (AO)	BINARY HARDWARE OUTPUT (BO)	SOFTWARE POINT (SFT)	HARDWARE INTERLOCK (HDW)	WIRELESS (WLS)	NETWORK (NET)	HIGH ANALOG LIMIT	LOW ANALOG LIMIT	BINARY	LATCH DIAGNOSTIC	SENSOR FAIL	COMMUNICATION FAIL
CONDENSATE OVERFLOW	X		X									X	X	X	
SUPPLY FAN START/STOP COMMAND	X				X										
SUPPLY FAN SPEED	X			X											
SUPPLY FAN FAILURE	X					X						X	X		
SUPPLY AIR TEMPERATURE	X	X												X	
SUPPLY AIR COOLING RESET TEMPERATURE						X									
SUPPLY AIR HEATING RESET TEMPERATURE						X									
COMPRESSOR 1 START/STOP COMMAND	X				X							X	X		
COMPRESSOR 1 SPEED	X			X											
COMPRESSOR 1 STATUS	X		X												
COMPRESSOR 1 FAILURE						X						X			
BAS COMMUNICATION STATE	X					X									X
MAINTENANCE REQUIRED	X					X						X			
OCCUPIED COOLING SETPOINT	X					X									
OCCUPIED HEATING SETPOINT	X					X									
UNOCCUPIED COOLING SETPOINT	X					X									
UNOCCUPIED HEATING SETPOINT	X					X									

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STAMP:

PROJECT NAME:
GHTD UNION STATION
HVAC UPGRADES

1 UNION PLACE
HARTFORD, CT

DRAWING TITLE:
MECHANICAL CONTROL POINTS LISTS

FILE: 2022/3562
DRAWN BY: AJK
CHECKED BY: AP
ISSUE DATE: 11/01/2023
DRAWING NO:
M504

POINTS LIST: ATTIC AHU'S - ADD ALTERNATE #1

System Point Description	POINTS									ALARMS					
	GRAPHIC	ANALOG HARDWARE INPUT (AI)	BINARY HARDWARE INPUT (BI)	ANALOG HARDWARE OUTPUT (AO)	BINARY HARDWARE OUTPUT (BO)	SOFTWARE POINT (SFT)	HARDWARE INTERLOCK (HDW)	WIRELESS (WLS)	NETWORK (NET)	HIGH ANALOG LIMIT	LOW ANALOG LIMIT	BINARY	LATCH DIAGNOSTIC	SENSOR FAIL	COMMUNICATION FAIL
HOT WATER CONTROL VALVE COMMAND	X			X											
HOT WATER CONTROL VALVE POSITION	X	X													
CHILLED WATER CONTROL VALVE COMMAND	X			X											
CHILLED WATER CONTROL VALVE POSITION	X	X													
FREEZSTAT	X		X				X					X	X	X	
OA DAMPER COMMAND	X			X											
OA TEMPERATURE	X	X													
OA DAMPER POSITION	X	X													
OA RH	X	X													
OA DAMPER FAILURE	X		X									X			
OA CO2	X	X													
RA DAMPER COMMAND	X			X											
RELIEF AIR COMMAND	X			X											
RA DAMPER POSITION	X	X													
RELIEF AIR POSITION	X	X													
RA DAMPER FAILURE	X		X									X			
RELIEF AIR FAILURE	X		X									X			
MIXING AIR TEMPERATURE	X		X									X			
MIXING AIR TEMPERATURE LOW LIMIT	X		X									X			
FILTER STATUS	X		X									X			
CONDENSATE OVERFLOW	X		X									X	X	X	
SUPPLY FAN START/STOP COMMAND	X				X										
RETURN FAN START/STOP COMMAND	X				X										
SUPPLY FAN SPEED	X			X											
RETURN FAN SPEED	X			X											
SUPPLY FAN STATUS	X		X							X	X			X	
RETURN FAN STATUS	X		X							X	X			X	
SUPPLY FAN FAILURE	X					X						X	X		
RETURN FAN FAILURE	X					X						X	X		
VFD SUPPLY FAN FAILURE	X					X						X	X		
VFD RETURN FAN FAILURE	X					X						X	X		
VFD SUPPLY FAN FEEDBACK	X	X													
VFD RETURN FAN FEEDBACK	X	X													
VFD SUPPLY FAN STATUS	X		X												
VFD RETURN FAN STATUS	X		X												

POINTS LIST: ATTIC AHU'S - ADD ALTERNATE #1 (CONTINUED)

System Point Description	POINTS									ALARMS					
	GRAPHIC	ANALOG HARDWARE INPUT (AI)	BINARY HARDWARE INPUT (BI)	ANALOG HARDWARE OUTPUT (AO)	BINARY HARDWARE OUTPUT (BO)	SOFTWARE POINT (SFT)	HARDWARE INTERLOCK (HDW)	WIRELESS (WLS)	NETWORK (NET)	HIGH ANALOG LIMIT	LOW ANALOG LIMIT	BINARY	LATCH DIAGNOSTIC	SENSOR FAIL	COMMUNICATION FAIL
SUPPLY AIR SMOKE DETECTOR	X		X									X	X		
SUPPLY AIR TEMPERATURE	X	X												X	
SUPPLY AIR COOLING RESET TEMPERATURE						X									
SUPPLY AIR HEATING RESET TEMPERATURE						X									
RETURN DUCT LOW STATIC PRESSURE	X		X									X	X	X	
RETURN AIR SMOKE DETECTOR	X		X									X	X		
RETURN AIR RELATIVE HUMIDITY	X	X													
RETURN AIR TEMPERATURE	X	X													
RETURN AIR CO2	X	X													
BAS COMMUNICATION STATE	X					X									X
MAINTENANCE REQUIRED	X					X						X			
OCCUPIED COOLING SETPOINT	X					X									
OCCUPIED HEATING SETPOINT	X					X									
UNOCCUPIED COOLING SETPOINT	X					X									
UNOCCUPIED HEATING SETPOINT	X					X									

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THIS SQUARE APPEARS 1/2"x1/2" ON FULL SIZE SHEETS

NO	DATE	REVISION

STAMP:

PROJECT NAME:
GHTD UNION STATION HVAC UPGRADES

1 UNION PLACE
HARTFORD, CT

DRAWING TITLE:
MECHANICAL CONTROL POINT LIST

FILE: 2022/3562
DRAWN BY: Author
CHECKED BY: Checker
ISSUE DATE: 11/01/2023
DRAWING NO:

M505

SEQUENCE OF OPERATION: PK UNITS - BASE BID

BUILDING AUTOMATION SYSTEM INTERFACE:
THE BUILDING AUTOMATION SYSTEM (BAS) SHALL SEND THE CONTROLLER OCCUPIED BYPASS, MORNING WARM-UP/PRE-COOL, OCCUPIED/UNOCCUPIED AND HEAT/COOL MODES. IF A BAS IS NOT PRESENT, OR COMMUNICATION IS LOST WITH THE BAS THE CONTROLLER SHALL OPERATE USING DEFAULT MODES AND SETPOINTS.

OCCUPIED:
UPON A CALL FOR DX HEATING OR COOLING, THE UNIT CONTROLLER SHALL ENABLE THE FIRST FIXED SPEED COMPRESSOR. IF THE FIXED SPEED COMPRESSOR CANNOT SATISFY THE LOAD CONDITIONS, THE UNIT CONTROLLER SHALL START THE NEXT FIXED SPEED COMPRESSOR IN SEQUENCE TO ADD TO THE TOTAL UNIT HEATING OR COOLING LOAD PERCENTAGE. THIS PROCESS SHALL REPEAT UNTIL ALL OF THE FIXED SPEED COMPRESSORS HAVE BEEN STARTED OR UNTIL THE ACTIVE SPACE TEMPERATURE SETPOINT IS SATISFIED. THE DISCHARGE AIR TEMPERATURE SETPOINT SHALL BE DYNAMICALLY RESET BASED ON THE DEVIATION OF ACTUAL SPACE TEMPERATURE FROM THE ACTIVE SPACE TEMPERATURE SETPOINT.

OPTIMAL START:
THE BAS SHALL MONITOR THE SCHEDULED OCCUPIED TIME, OCCUPIED SPACE SETPOINTS AND SPACE TEMPERATURE TO CALCULATE WHEN THE OPTIMAL START OCCURS.

MORNING WARM-UP MODE:
DURING OPTIMAL START, IF THE SPACE TEMPERATURE IS BELOW THE OCCUPIED HEATING SETPOINT A MORNING WARM-UP MODE SHALL BE ACTIVATED. WHEN MORNING WARM-UP IS INITIATED THE UNIT SHALL ENABLE THE HEATING AND FAN(S). THE OUTSIDE AIR DAMPER SHALL REMAIN CLOSED. WHEN THE SPACE TEMPERATURE REACHES THE OCCUPIED HEATING SETPOINT (ADJ.), THE UNIT SHALL TRANSITION TO THE OCCUPIED MODE.

PRE-COOL MODE:
DURING OPTIMAL START, IF THE SPACE TEMPERATURE IS ABOVE THE OCCUPIED COOLING SETPOINT, PRE-COOL MODE SHALL BE ACTIVATED. WHEN PRE-COOL IS INITIATED THE UNIT SHALL ENABLE THE FAN AND COOLING. THE OUTSIDE AIR DAMPER SHALL REMAIN CLOSED. WHEN THE SPACE TEMPERATURE REACHES OCCUPIED COOLING SETPOINT (ADJ.), THE UNIT SHALL TRANSITION TO THE OCCUPIED MODE.

OPTIMAL STOP:
THE BAS SHALL MONITOR THE SCHEDULED UNOCCUPIED TIME, OCCUPIED SETPOINTS AND SPACE TEMPERATURE TO CALCULATE WHEN THE OPTIMAL STOP OCCURS. WHEN THE OPTIMAL STOP MODE IS ACTIVE THE UNIT CONTROLLER SHALL MAINTAIN THE SPACE TEMPERATURE TO THE SPACE TEMPERATURE OFFSET SETPOINT. OUTSIDE AIR DAMPER SHALL REMAIN ENABLED TO PROVIDE MINIMUM VENTILATION.

OCCUPIED BYPASS:
THE BAS SHALL MONITOR THE STATUS OF THE ON AND CANCEL BUTTONS OF THE SPACE TEMPERATURE SENSOR. WHEN AN OCCUPIED BYPASS REQUEST IS RECEIVED FROM A SPACE SENSOR, THE UNIT SHALL TRANSITION FROM ITS CURRENT OCCUPANCY MODE TO OCCUPIED BYPASS MODE AND THE UNIT SHALL MAINTAIN THE SPACE TEMPERATURE TO THE OCCUPIED SETPOINTS (ADJ.).

HEAT/COOL MODE:
WHEN THE SPACE TEMPERATURE RISES ABOVE THE OCCUPIED COOLING SETPOINT THE MODE SHALL TRANSITION TO COOLING. WHEN THE SPACE TEMPERATURE FALLS BELOW THE OCCUPIED HEATING SETPOINT THE MODE SHALL TRANSITION TO HEATING. WHEN THE SPACE TEMPERATURE IS ABOVE THE OCCUPIED COOLING SETPOINT OR BELOW THE OCCUPIED HEATING SETPOINT THE MODE SHALL REMAIN IN ITS LAST STATE. IF THE SPACE TEMPERATURE SENSOR FAILS THE MODE SHALL REMAIN IN ITS LAST STATE AND AN ALARM SHALL ANNUNCIATE AT THE BAS. IF THE LOCAL AND COMMUNICATED SETPOINTS FAIL THE CONTROLLER SHALL DISABLE THE SUPPLY FAN AND AN ALARM SHALL ANNUNCIATE AT THE BAS.

SUPPLEMENTAL HEAT FOR HEAT PUMP CONFIGURATION
THE SUPPLEMENTAL ELECTRIC HEAT SHALL BE CYCLED ON AS THE LAST STAGE OF HEATING. SUPPLEMENTAL ELECTRIC HEAT SHALL OPERATE CONCURRENTLY WITH THE DX HEATING, AS NEEDED, TO MAINTAIN SPACE TEMPERATURE.

VENTILATION CONTROL:
WHEN IN THE OCCUPIED MODE, THE FLOW-MEASURING OUTDOOR-AIR AND DAMPER SHALL MODULATE TO MAINTAIN THE CURRENT VENTILATION AIRFLOW SETPOINT. THE VENTILATION AIRFLOW SETPOINT SHALL BE RESET TO THE OPTIMAL VENTILATION SETPOINT COMMUNICATED BY THE BAS. THE BAS SHALL RESET THE VENTILATION SETPOINT BASED ON THE CURRENT VENTILATION NEEDS OF THE VAV TERMINALS.

SUPPLY FAN:
THE UNIT CONTROLLER SHALL VARY THE SUPPLY FAN SPEED TO OPTIMIZE MINIMUM FAN SPEED IN ALL COOLING AND HEATING MODES.

RELIEF AIR AND BUILDING PRESSURE CONTROL:
A DIFFERENTIAL PRESSURE TRANSDUCER SHALL ACTIVELY MONITOR THE DIFFERENCE IN PRESSURE BETWEEN THE BUILDING (INDOORS) AND OUTDOORS. IF THE BUILDING PRESSURE INCREASES ABOVE THE DESIRED SETPOINT, THE ASSOCIATED CONTROLLER SHALL MODULATE THE RELIEF AIR DAMPER TO CONTROL BUILDING PRESSURE AT SETPOINT. IF THE BUILDING PRESSURE DECREASES BELOW THE DESIRED SETPOINT, THE ASSOCIATED CONTROLLER SHALL CLOSE THE RELIEF AIR DAMPER.

FILTER STATUS:
A DIFFERENTIAL PRESSURE SWITCH SHALL MONITOR THE DIFFERENTIAL PRESSURE ACROSS THE FILTER(S) WHEN THE FAN IS RUNNING. IF THE SWITCH CLOSES DURING NORMAL OPERATION A DIRTY FILTER ALARM SHALL ANNUNCIATE AT THE BAS.

SMOKE DETECTOR SHUTDOWN:
THE UNIT SHALL SHUT DOWN IN RESPONSE TO A SIGNAL FROM THE SMOKE DETECTOR INDICATING THE PRESENCE OF SMOKE. THE SMOKE DETECTOR SHALL BE INTERLOCKED TO THE UNIT THROUGH THE DRY CONTACTS OF THE SMOKE DETECTOR. A MANUAL RESET OF THE SMOKE DETECTOR SHALL BE REQUIRED TO RESTART THE UNIT.

CONDENSATE OVERFLOW SHUTDOWN:
THE UNIT SHALL SHUT DOWN IN RESPONSE TO A SIGNAL FROM THE CONDENSATE OVERFLOW SENSOR. THE SENSOR SHALL BE INTERLOCKED TO THE UNIT COOLING CONTROLLER FOR IMMEDIATE SHUTDOWN OF COOLING.

SEQUENCE OF OPERATION: AIR HANDLING UNITS AND RETURN FANS – ALTERNATE #1

A. GENERAL:
  1. OCCUPIED GLOBAL SETPOINT
    a. HEATING (DEFINED AS OUTSIDE AIR TEMPERATURE IS ≤ 65°F): 70°F (ADJUSTABLE).
    b. COOLING (DEFINED AS OUTSIDE AIR TEMPERATURE IS ABOVE 65°F): 75°F (ADJUSTABLE).
  2. UNOCCUPIED GLOBAL SETPOINT
    a. HEATING: 60°F (ADJUSTABLE).
    b. COOLING: 82°F (ADJUSTABLE).
  3. OCCUPANCY SENSORS
    a. WHERE BACNET OCCUPANCY SENSORS ARE IN THE SAME SPACE AS A TEMPERATURE SENSOR:
      • OCCUPIED MODE
        1. SPACES INDEXED TO OCCUPIED MODE SHALL REMAIN IN OCCUPIED MODE UNLESS THE OCCUPANCY SENSORS DO NOT DETECT OCCUPANCY FOR 10 MINUTES CONTINUOUSLY. AT 10 MINUTES SINCE THE LAST DETECTION OF OCCUPANCY, THE COOLING AND HEATING SETPOINTS OF THE SPACES SHALL BE RESET TO 2°F HIGHER AND 2°F LOWER THAN THE SETPOINT RESPECTIVELY.
        2. ONCE IN UNOCCUPIED MODE, THE COOLING AND HEATING SETPOINTS SHALL REMAIN AT THE RESET TEMPERATURES (2°F HIGHER AND LOWER) UNTIL THE OCCUPANCY SENSORS DETECT OCCUPANCY FOR 5 MINUTES CONTINUOUS. AT 5 MINUTES CONTINUOUS OCCUPANCY, THE OCCUPIED SETPOINT SHALL BE RESTORED.
      • UNOCCUPIED MODE
        1. SPACES INDEXED TO UNOCCUPIED MODE SHALL REMAIN IN UNOCCUPIED MODE UNLESS THE OCCUPANCY SENSORS DETECT OCCUPANCY FOR 10 MINUTES CONTINUOUSLY. AT 10 MINUTES CONTINUOUS OCCUPANCY, THE OCCUPIED SETPOINT SHALL BE USED.
        2. ONCE IN THE OCCUPIED MODE, THE SETPOINT SHALL REMAIN AT THE OCCUPIED SETPOINT UNTIL THE OCCUPANCY SENSORS DO NOT DETECT OCCUPANCY FOR 5 MINUTES CONTINUOUS. AT 5 MINUTES SINCE THE LAST DETECTION OF OCCUPANCY, THE UNOCCUPIED SETPOINTS SHALL BE RESTORED.

B. UNOCCUPIED MODE OF OPERATION (ALL AHUS)
  1. HEATING:
    a. SA AND RA FANS SHUT DOWN.
    b. OA DAMPER FULLY CLOSED.
    c. RELIEF AIR DAMPER FULLY CLOSED.

C. WHENEVER SPACE TEMPERATURE IS NOT AT UNOCCUPIED SETPOINT: BMS SHALL START SA AND RA FANS AND MODULATE HOT WATER CONTROL VALVE TO MAINTAIN SPACE TEMPERATURE AT UNOCCUPIED SET POINT. WHEN SPACE IS AT UNOCCUPIED TEMPERATURE SET POINT FOR 10 MINUTES (ADJUSTABLE) THE BMS SHALL SHUT DOWN SA AND RA FANS.

D. WARM-UP AND COOL - DOWN MODE OF OPERATIONS (ALL AHUS)
  1. THE HVAC EQUIPMENT SHALL BE INDEXED TO WARM-UP AND COOL-DOWN MODES VIA THE BAS, OPTIMAL START/STOP SHALL BE PROGRAMMED IN FOR ALL EQUIPMENT SO THAT EQUIPMENT STARTS AND START TIMES ARE DETERMINED BASED ON OUTSIDE AIR CONDITIONS AND SYSTEM LEARNS BASED ON PAST BUILDING HISTORY. THE OPERATOR STATION SOFTWARE CONFIGURATION SHALL ALLOW THE OWNER TO EASILY SELECT THE OCCUPIED AND UNOCCUPIED HOURS BY INDIVIDUAL ZONE, GLOBAL BY AIR HANDLER, OR GLOBAL BY BUILDING. THE BAS SHALL TREND THE OUTSIDE AIR TEMPERATURE WITH RESPECT TO THE WARM UP AND COOL DOWN TIMES, AND SHALL OPTIMIZE THE WARM UP AND COOL DOWN TIMES SUCH THAT THE SPACES REACH OCCUPIED TEMPERATURE BY THE TIME SELECTED.
    a. WARM-UP (MORNING) WHENEVER SPACE TEMPERATURE IS NOT AT OCCUPIED SETPOINT: UNIT SHALL OPERATE IN THE WARM-UP MODE UNTIL THE SPACE REACHES THE OCCUPIED TEMPERATURE SETPOINT, AT WHICH POINT THE UNIT SHALL BE INDEXED TO THE OCCUPIED MODE.
      1. SA AND RA FANS SHALL RUN CONTINUOUSLY.
      2. OA DAMPER FULLY CLOSED.
      3. RELIEF AIR DAMPER FULLY CLOSED.
    b. COOL-DOWN (MORNING): WHENEVER SPACE TEMPERATURE IS NOT AT OCCUPIED SETPOINT: UNIT SHALL OPERATE IN THE COOL-DOWN MODE UNTIL THE SPACE REACHES THE OCCUPIED TEMPERATURE SETPOINT, AT WHICH POINT THE UNIT SHALL BE INDEXED TO THE OCCUPIED MODE.
      1. THE FIRST STAGE OF COOLING SHALL BE ECONOMIZER.
      2. SA AND RA FANS SHALL RUN CONTINUOUSLY.
      3. OA DAMPER FULLY CLOSED.
      4. RELIEF AIR DAMPER FULLY CLOSED.

E. OCCUPIED MODE OF OPERATION (ALL AHUS)
  1. HEATING (ALL AHUS):
    a. SA AND RA FANS SHALL RUN CONTINUOUSLY.
    b. OA DAMPER OPENED TO ITS MINIMUM VENTILATION POSITION.
    c. RELIEF AIR DAMPER FULLY CLOSED.
    d. HOT WATER COIL CONTROL VALVE: BAS SHALL MODULATE HOT WATER COIL CONTROL VALVE TO MAINTAIN SUPPLY AIR RESET TEMPERATURE BASE ON INPUT FROM SPACE TEMPERATURE SENSOR.
  2. COOLING (ALL AHUS):
    a. SA AND RA FANS SHALL RUN CONTINUOUSLY.
    b. OA DAMPER OPENED TO ITS MINIMUM VENTILATION POSITION.
    c. RELIEF AIR DAMPER FULLY CLOSED.
    d. BAS SHALL MODULATE CHILLED WATER CONTROL VALVE TO MAINTAIN SUPPLY AIR RESET TEMPERATURE BASE ON INPUT FROM SPACE TEMPERATURE SENSOR.
      • THE FIRST STAGE OF COOLING SHALL BE ECONOMIZER.

F. BAS SHALL ENABLE ECONOMIZER COOLING AS FIRST STAGE OF COOLING FOR AHUS AS FOLLOWS:
  1. ECONOMIZER COOLING SHALL BE ENABLED WHEN ALL OF THE FOLLOWING ARE TRUE:
    a. THE OUTSIDE AIR TEMPERATURE IS LESS THAN 72°F.
    b. THE OUTSIDE AIR TEMPERATURE IS LESS THAN THE RETURN AIR TEMPERATURE.
    c. THE OUTSIDE AIR ENTHALPY IS LESS THAN THE RETURN AIR ENTHALPY.
  2. THE BAS SYSTEM OPERATOR SHALL, VIA SINGLE CLICK EDITING, BE EASILY ABLE TO SELECT ANY OR ALL OF ITEMS A. THRU C. OF THE PREVIOUS PARAGRAPH FOR ECONOMIZER ENABLING, FOR INDIVIDUAL AIR HANDLING SYSTEMS AND FOR AIR HANDLING SYSTEMS GLOBALLY. ADDITIONALLY, THE BAS SYSTEM OPERATOR SHALL BE EASILY ABLE TO GLOBALLY CHANGE THE SETPOINTS FOR ITEMS A. AND C. OF THE PREVIOUS PARAGRAPH.
  3. ECONOMIZER COOLING SHALL BE INTEGRATED; ECONOMIZER COOLING SHALL CONTINUE TO OPERATE DURING STAGES OF MECHANICAL COOLING AS LONG AS ALL THREE OF THE CONDITIONS INDICATED IN PARAGRAPH 1 ARE TRUE (OR AS SELECTED BY THE SYSTEM OPERATOR PER PARAGRAPH 2).
  4. WHEN BOTH MECHANICAL COOLING IS ANTICIPATED TO BE REQUIRED THE NEXT DAY (BY TRENDING THE OUTSIDE AIR ENTHALPY), AND ECONOMIZER COOLING IS AVAILABLE DURING THE UNOCCUPIED CYCLE, ECONOMIZER COOLING SHALL BE OPERATED DURING THE UNOCCUPIED CYCLE TO PRE-COOL THE SPACES SERVED BY THE AIR HANDLER TO 78°F (ADJUSTABLE).
  5. BAS SHALL TERMINATE THE ECONOMIZER WHENEVER SUPPLY AIR TEMPERATURE IS < 50ºF (ADJUSTABLE).
  6. PROVIDE FAULT DETECTION AND DIAGNOSTICS (FDD) SYSTEM.
  7. RETURN FANS:
    a. DURING ECONOMIZER MODE OF OPERATION OF DEDICATED AHU:
      1. RELIEF AIR DAMPER SHALL FULLY OPEN, AND
      2. RA DAMPER SHALL FULLY CLOSE.

G. DEMAND VENTILATION CONTROL (DVC) VIA CO2 SENSOR (ALL AHUS):
  1. BMS SHALL MONITOR RETURN AIR (RA) DUCT MOUNTED CO2 SENSOR PROVIDED BY THIS CONTRACTOR. WHENEVER RA CO2 SET POINT IS 900PPM (ADJUSTABLE) ABOVE AMBIENT CO2 LEVEL THEN BMS SHALL:
    a. OVERRIDE MINIMUM VENTILATION OUTDOOR AIR (OA) DAMPER POSITION AND MODULATE BETWEEN DAMPER'S MINIMUM AND MAXIMUM SPECIFIED POSITIONS TO MAINTAIN RA CO2 LEVEL AT SET POINT. WHEN RA CO2 LEVEL AT SET POINT FOR 10 MINUTES (ADJUSTABLE) BMS SHALL MODULATE OA DAMPER TO ITS ORIGINAL MINIMUM VENTILATION SET POINT. OA DAMPER MINIMUM AND MAXIMUM VENTILATION POSITIONS SHALL BE DETERMINED IN FIELD WITH ASSISTANCE BY BALANCING CONTRACTOR.

H. DUCT SMOKE DETECTORS (ALL AHUS)
  1. HARD WIRE SMOKE DETECTORS TO EQUIPMENT STARTER.
    a. UPON SIGNAL FROM AND DUCT MOUNTED SMOKE DETECTOR THE BMS SHALL:
      1. SHUT DOWN ALL FANS.
      2. FULLY CLOSE OA DAMPER.
      3. FULLY CLOSE RELIEF AIR DAMPER.
      4. GENERATE ALARM AT FRONT END.
      5. EQUIPMENT RESTART: MANUAL.

I. DUCT HIGH STATIC PRESSURE SENSOR (ALL AHUS)
  1. HARD WIRE HIGH STATIC PRESSURE SENSOR TO EQUIPMENT STARTER.
    a. UPON SIGNAL FROM DUCT HIGH STATIC PRESSURE SENSOR THE BMS SHALL:
      1. SHUT DOWN ALL FANS.
      2. FULLY CLOSE OA DAMPER.
      3. FULLY CLOSE RELIEF AIR DAMPER.
      4. GENERATE ALARM AT FRONT END.
      5. EQUIPMENT RESTART: MANUAL.

J. DUCT LOW STATIC PRESSURE SENSOR (ALL RFS)
  1. HARD WIRE LOW STATIC PRESSURE SENSOR TO EQUIPMENT STARTER.
    a. UPON SIGNAL FROM DUCT HIGH STATIC PRESSURE SENSOR THE BMS SHALL:
      1. SHUT DOWN ALL FANS.
      2. FULLY CLOSE OA DAMPER.
      3. FULLY CLOSE RELIEF AIR DAMPER.
      4. GENERATE ALARM AT FRONT END.
      5. EQUIPMENT RESTART: MANUAL.

K. FREEZE PROTECTION (ALL AHUS)
  1. PROVIDE FREEZSTAT.
  2. HARD WIRE FREEZSTAT TO EQUIPMENT STARTER.
  3. WHENEVER THE MIXING AIR TEMPERATURE FALLS BELOW THE FREEZESTAT SETPOINT 35°F (ADJUSTABLE):
    a. ALL FANS SHALL SHUT DOWN.
    b. FULLY CLOSE OA DAMPER.
    c. FULLY CLOSE RELIEF AIR DAMPER.
    d. HOT WATER CONTROL VALVE SHALL FULLY OPEN
    e. CHILLED WATER CONTROL VALVE SHALL FULLY CLOSE.
    f. GENERATE ALARM AT FRONT END.
    g. EQUIPMENT RESTART: MANUAL.

L. CONDENSATE OVERFLOW MONITORING (ALL AHUS)
  1. UPON SIGNAL FROM CONDENSATE OVERFLOW SWITCH THE BMS SHALL:
    a. SHUT DOWN ALL FANS.
    b. FULLY CLOSE OA DAMPER.
    c. FULLY CLOSE RELIEF AIR DAMPER.
    d. GENERATE ALARM AT FRONT END.
    e. EQUIPMENT RESTART: MANUAL.

M. SUPPLY FAN (ALL AHUS):
  1. SUPPLY FAN (SF) SPEED:
    a. SF VFD SHALL MODULATE SF SPEED BETWEEN 80 – 100% (ADJUSTABLE) DESIGN CAPACITY FOR SPACE TEMPERATURE CONTROL.
    b. MINIMUM AND MAXIMUM SF SPEED SHALL BE DETERMINED IN FIELD WITH ASSISTANCE BY BALANCING CONTRACTOR.

N. RETURN FANS (ALL AHUS):
  1. RETURN FAN (RF) SHALL RUN WHENEVER DEDICATED AHU SUPPLY FAN IS RUNNING.
  2. RF SHALL SHUT DOWN WHENEVER DEDICATED AHU SUPPLY FAN IS SHUT DOWN.
  3. RF SPEED:
    a. RF VFD SHALL MODULATE RETURN FAN SPEED TO PROVIDE RETURN AIR FLOW: RA = SA - OFFSET (FOR PRESSURIZATION) – EXHAUST AIR FLOW FROM AREAS SERVED BY AHU.

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MECHANICAL SEQUENCE OF OPERATIONS

FILE: 2022/3562
DRAWN BY: Author
CHECKED BY: Checker
ISSUE DATE: 11/01/2023
DRAWING NO: **M506**

FIRST FLOOR LEVEL AIR HANDLING UNIT SCHEDULE - BASE BID

TAG	MANUFACTURER	MODEL	SUPPLY FAN		HEATING COIL							COOLING COIL								ELECTRICAL				REMARKS
			AIRFLOW	TOTAL SP	FLUID TYPE	ROWS	MBH	ENTERING FLUID TEMP	LEAVING FLUID TEMP	FLOW RATE	AIR PRESSURE...	FLUID TYPE	ROWS	TOTAL MBH	GPM	SENSIBLE MBH	AIR PRESSURE DROP	FLUID PRESSURE DROP	UNIT VOLTAGE/HZ/PHASE	FLA	MCA	MOP	
			CFM	IN. H20				F	F	GPM	IN. H20						IN. H2O	FT. H20		AMPS	AMPS	AMPS	
AHU-9L	TRANE	UCCAD08A0F0RBL52000000EDV00BA0000000B0B0	4000	2.543	HYDRONIC	1	195	180	163	23.58	0.152	30% PROPYLENE GYCOL CHILLED WATER	6	154	33.66	110	0.768	5.44	208/60/3	22.5	28	50	1,2,3,4,5,6,11
AHU-9R	TRANE	UCCAD08A0F0RBL52000000EDV00BA0000000B0B0	4000	2.543	HYDRONIC	1	195	180	163	23.58	0.152	30% PROPYLENE GYCOL CHILLED WATER	6	154	33.66	110	0.768	5.44	208/60/3	22.5	28	50	1,2,3,4,5,6,11
AHU-11L	TRANE	BCVE090	2000	1.438	HYDRONIC	1	109	180	160	10.9	0.059	30% PROPYLENE GYCOL CHILLED WATER	4	77	16.25	55.12	0.281	6.8	208/60/3	4.6	5.75	15	2,3,5,7,8,9,11
AHU-11R	TRANE	BCVE090	2000	1.438	HYDRONIC	1	109	180	160	10.9	0.059	30% PROPYLENE GYCOL CHILLED WATER	4	77	16.25	55.12	0.281	6.8	208/60/3	4.6	5.75	15	2,3,5,7,8,9,11
MAU-1	TRANE	UCCAA03A0F0RBM72000000CD600AA00000000000	1650	3.032	HYDRONIC	1	106.92	180	180	21.4	0.2	30% PROPYLENE GYCOL CHILLED WATER	6	62.38	13.5	45.47	1.071	9.17	208/60/3	7.3	9	15	1,2,3,4,5,6,11
AHU-14L-1	TRANE	BCHE036	800	1.395	HYDRONIC	1	47.02	180	160	4.7	0.051	30% PROPYLENE GYCOL CHILLED WATER	4	22.5	6	18.84	0.217	7.13	208/60/3	2.4	3	15	2,3,5,7,8,9,10,11
AHU-14L-2	TRANE	BCHE036	800	1.395	HYDRONIC	1	47.02	180	160	4.7	0.051	30% PROPYLENE GYCOL CHILLED WATER	4	22.5	6	18.84	0.217	7.13	208/60/3	2.4	3	15	2,3,5,7,8,9,10,11
AHU-14L-3	TRANE	BCHE036	800	1.395	HYDRONIC	1	47.02	180	160	4.7	0.051	30% PROPYLENE GYCOL CHILLED WATER	4	22.5	6	18.84	0.217	7.13	208/60/3	2.4	3	15	2,3,5,7,8,9,10,11
AHU-14L-5	TRANE	BCHE036	800	1.395	HYDRONIC	1	47.02	180	160	4.7	0.051	30% PROPYLENE GYCOL CHILLED WATER	4	22.5	6	18.84	0.217	7.13	208/60/3	2.4	3	15	2,3,5,7,8,9,10,11

NOTES:
1. PROVIDE REMOTE MOUNTED VARIABLE FREQUENCY DRIVE WITH MANUAL BYPASS (BY ABB, ALLEN BRADLEY OR SCHNEIDER) ON THE SUPPLY FAN.
2. PRE-FILTER SECTION SHALL CONTAIN MERV-8 FILTERS.
3. PROVIDE SINGLE POINT POWER CONNECTION.
4. STAINLESS STEEL DRAIN PAN WITH CONDENSATE OVERFLOW SWITCH.
5. BACnet CONTROLLER. CONTROLS TRANSFORMER.
6. R/A OPENING WITH LOW AIR LEAK MOTORIZED DAMPER SECTION ON TOP, NO O/A DAMPER OPENING ON UNIT.
7. INSULATED ACCESS DOORS.
8. INSULATED ACCESS DOOR FOR FILTER SECTION. POLYMER DRAIN PAN WITH CONDENSATE OVERFLOW SWITCH.
9. ELECTRONICALLY COMMUTATED MOTOR (ECM).
10. PROVIDE SPRING ISOLATOR WITH 1" STATIC DEFLECTION.
11. APPROVED EQUAL MANUFACTURERS: CARRIER AND YORK. APPROVED EQUAL MANUFACTURER SHALL PROVIDE ALL SPECIFIED ITEMS.

INLINE EXHAUST FANS - ADD ALTERNATE #1

TAG	MANUFACTURER	MODEL	LOCATION	FAN				MOTOR		ELECTRICAL		REMARKS
				CFM	STATIC PRESSURE (IN. H20)	DRIVE	RPM	HP	RPM	VOLTS	PHASE	
EX-2	GREENHECK	TDI-3-36-305-A30	ATTIC	11,400	0.5	DIRECT	1670	3	1725	208	3	ALL
EX-3	GREENHECK	TDI-3-30-409-A20	ATTIC	8,000	0.5	DIRECT	1563	2	1725	208	3	ALL
EX-4	GREENHECK	TDI-3-30-409-A20	ATTIC	8,000	0.5	DIRECT	1563	2	1725	208	3	ALL
EX-5	GREENHECK	TDI-3-24-316	ATTIC	5,600	0.51	DIRECT	1564	1	-	208	3	ALL
EX-6	GREENHECK	TDI-3-24-316	ATTIC	5,600	0.51	DIRECT	1564	1	-	208	3	ALL
EX-7	GREENHECK	TDI-3-30-409-A20	ATTIC	8,000	0.5	DIRECT	1563	2	1725	208	3	ALL
EX-8	GREENHECK	TDI-3-30-409-A20	ATTIC	8,000	0.5	DIRECT	1563	2	1725	208	3	ALL

NOTES:
1. FAN CONTROL BASED UPON DESIGNATED AHU OPERATIONS, PROVIDE FAN WITH REMOTE-MOUNTED VFD CONTROLLER WITH MANUAL BYPASS (BY ABB, ALLEN BRADLEY, OR SCHNEDER).
2. PROVIDE SPRING ISOLATORS WITH 2" STATIC DEFLECTION.
3. APPROVED EQUAL MANUFACTURER: LOREN COOK. APPROVED EQUAL MANUFACTURER SHALL PROVIDE ALL SPECIFIED ITEMS.

MEZZANINE AIR CONDITIONING UNIT SCHEDULE - BASE BID

TAG	MANUFACTURER	MODEL	SUPPLY FAN		HEATING COIL		COOLING COIL		ELECTRICAL			WEIGHT (LBS)	EER	REMARKS
			AIRFLOW	ESP	HEATING TYPE	MAXIMUM BTUH	COOLING TYPE	MAXIMUM BTUH	UNIT VOLTAGE/HZ/PHASE	MCA	MOP			
			CFM	IN. H20						AMPS	AMPS			
PK-1	TRANE	4WCC4036A1000A	1200	0.5	HEAT PUMP	34400	DX HEAT PUMP	35200	208/60/1	24.4	40	364	11	ALL
PK-2	TRANE	4WCC4024A1000A	800	0.5	HEAT PUMP	23200	DX HEAT PUMP	23800	208/60/1	20.6	30	328	11	ALL
PK-3	TRANE	4WCC4024A1000A	800	0.5	HEAT PUMP	23200	DX HEAT PUMP	23800	208/60/1	20.6	30	328	11	ALL

NOTES:
1. PROVIE SINGLE POINT POWER CONNECTION.
2. PROVIDE MANUFACTURER'S 18" HIGH EQUIPMENT ISOLATION BASE WITH SPRING ISOLATORS WITH 1" STATIC DEFLECTION. POLYMER DRAIN PAN WITH CONDENSATE OVERFLOW SWITCH.
3. APPROVED EQUAL MANUFACTURER: CARRIER AND YORK. APPROVED EQUAL MANUFACTURER SHALL PROVIDE ALL SPECIFIED ITEMS.

ATTIC AIR HANDLING UNIT SCHEDULE - ADD ALTERNATE #1

TAG	MANUFACTURER	MODEL	OA FLOW		SUPPLY FAN		HEATING COIL					COOLING COIL							ELECTRICAL				REMARKS
			MIN. (CFM)	MAX. (CFM)	AIRFLOW	TOTAL SP	FLUID TYPE	ROWS	MBH	STEAM PRESSURE	AIR PRESSURE DROP	FLUID TYPE	ROWS	TOTAL MBH	GPM	SENSIBLE MBH	AIR PRESSURE DROP	FLUID PRESSURE DROP	UNIT VOLTAGE/HZ/ PHASE	FLA	MCA	MOP	
AHU-2	TRANE	PSCA-28	1200	2400	12000	2.69	STEAM	1	520.56	15	0.099	30% PROPYLENE GYCOL CHILLED WATER	6	450	97.32	330	0.788	12.59	208/60/3	42	52.5	90	ALL
AHU-3	TRANE	UCCAG17A0F0EGM52000000GD881AA00000000001	1000	2000	8500	3.101	STEAM	1	526.5	15	0.181	30% PROPYLENE GYCOL CHILLED WATER	6	321	79.72	235	0.894	18.73	208/60/3	42.5	53	90	ALL
AHU-4	TRANE	UCCAG17A0F0EGM52000000GD881AA00000000001	1000	2000	8500	3.101	STEAM	1	526.5	15	0.181	30% PROPYLENE GYCOL CHILLED WATER	6	321	79.72	235	0.894	18.73	208/60/3	42.5	53	90	ALL
AHU-5	TRANE	UCCAG12A0EGM52000000FD882AA00000000001	800	1600	6000	2.971	STEAM	1	353.01	15	0.215	30% PROPYLENE GYCOL CHILLED WATER	6	225	61.49	165	0.806	13.95	208/60/3	28.5	35.5	60	ALL
AHU-6	TRANE	UCCAG12A0EGM52000000FD882AA00000000001	800	1600	6000	2.971	STEAM	1	353.01	15	0.215	30% PROPYLENE GYCOL CHILLED WATER	6	225	61.49	165	0.806	13.95	208/60/3	28.5	35.5	60	ALL
AHU-7	TRANE	UCCAG17A0F0EGM52000000GD881AA00000000001	1000	2000	8500	3.101	STEAM	1	526.5	15	0.181	30% PROPYLENE GYCOL CHILLED WATER	6	321	79.72	235	0.894	18.73	208/60/3	42.5	53	90	ALL
AHU-8	TRANE	UCCAG17A0F0EGM52000000GD881AA00000000001	1000	2000	8500	3.101	STEAM	1	526.5	15	0.181	30% PROPYLENE GYCOL CHILLED WATER	6	321	79.72	235	0.894	18.73	208/60/3	42.5	53	90	ALL

NOTES:
1. PROVIDE REMOTE MOUNTED VARIABLE FREQUENCY DRIVE WITH MANUAL BYPASS (BY ABB, ALLEN BRADLEY OR SCHNEIDER) ON THE SUPPLY FAN.
2. PRE-FILTER SECTION SHALL CONTAIN MERV-8 FILTERS.
3. PROVIDE SINGLE POINT POWER CONNECTION.
4. STAINLESS STEEL DRAIN PAN WITH CONDENSATE OVERFLOW SWITCH.
5. BACnet CONTROLLER. CONTROLS TRANSFORMER.
6. APPROVED EQUAL MANUFACTURERS: CARRIER AND YORK. APPROVED EQUAL MANUFACTURER SHALL PROVIDE ALL SPECIFIED ITEMS.

AIR COOLED CHILLER SCHEDULE - ADD ALTERNATE #2

TAG	MANUFACTURER	MODEL	NOMINAL TONS	EFFICIENCY		FLUID TYPE	ENTERING WATER TEMP	LEAVING WATER TEMP	DESIGN FLOW RATE	COMPRESSOR DATA			ELECTRICAL			REMARKS
				IPLV	EER		F	F	GPM	QTY	TYPE	REFRIGERANT	UNIT VOLTAGE/HZ /PHASE	MCA	MOP	
														AMPS	AMPS	
CH-4	TRANE	CGAM052F2	52	16.41	10.99	30% PG	54	44	124.2	4	SCROLL	R-454-B	460/60/3	107	150	ALL
CH-5	TRANE	CGAM052F2	52	16.41	10.99	30% PG	54	44	124.2	4	SCROLL	R-454-B	460/60/3	107	150	ALL
CH-6	TRANE	CGAM040F2	40	16.50	11.29	30% PG	54	44	95.1	4	SCROLL	R-454-B	460/60/3	95	125	ALL

NOTES:
1. EQUIPMENT SPECIFIED TO REPLACE EXISTING CHILLERS.
2. PROVIDE FREEZE PROTECTION.
3. PROVIDE SINGLE POINT POWER CONNECTION.
4. SOUND POWER: 89 dBA.
5. BACnet CONTROLLER. CONTROLS TRANSFORMER.
6. UNIT MOUNTED STARTER AND CIRCUIT BREAKER - 65KAIC.
7. FACTORY INSULATED EVAPORATOR AND REFRIGERATION SYSTEM.
8. APPROVED EQUAL MANUFACTURERS: CARRIER AND YORK. APPROVED EQUAL MANUFACTURER SHALL PROVIDE ALL SPECIFIED ITEMS.

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THIS SQUARE APPEARS 1/2"x1/2" ON FULL SIZE SHEETS

NO	DATE	REVISION

STAMP:

PROJECT NAME:
GHTD UNION STATION HVAC UPGRADES

1 UNION PLACE
HARTFORD, CT

DRAWING TITLE:
MECHANICAL SCHEDULES

FILE: 2022/3562
DRAWN BY: AJK
CHECKED BY:AP
ISSUE DATE: 11/01/2023
DRAWING NO: M601

ELECTRICAL ABBREVIATIONS LIST

1P	1 POLE (2P, 3P, 4P, ETC.)
A	AMPERE
AF	AMP FRAME
AFF	ABOVE FINISHED FLOOR
AHU	AIR HANDLING UNIT
AL	ALUMINUM
AMP	AMPERE
AMPL	AMPLIFIER
AT	AMP TRIP
ATS	AUTOMATIC TRANSFER SWITCH
AWG	AMERICAN WIRE GAUGE
BLDG	BUILDING
BMS	BUILDING MANAGEMENT SYSTEM
C	CONDUIT
CB	CIRCUIT BREAKER
CKT	CIRCUIT
CLG	CEILING
CU	COPPER
DEPT	DEPARTMENT
DISC	DISCONNECT
DN	DOWN
DS	SAFETY DISCONNECT SWITCH
DT	DOUBLE THROW
DWG	DRAWING
EC	ELECTRICAL CONTRACTOR
ELEC	ELECTRIC,
ELEV	ELECTRICAL ELEVATOR
EMT	ELECTRICAL METALLIC TUBING
EQUIP	EQUIPMENT
EXIST	EXISTING
EXH	EXHAUST
EXTR	EXISTING TO REMAIN
FA	FIRE ALARM
FABP	FIRE ALARM BOOSTER POWER SUPPLY PANEL
FACP	FIRE ALARM CONTROL PANEL
FCU	FAN COIL UNIT
FU	FUSE
GA	GAUGE
GAL	GALLON
GALV	GALVANIZED
GC	GENERAL CONTRACTOR
GEN	GENERATOR
GFCI	GROUND FAULT CIRCUIT INTERRUPTER
GFP	GROUND FAULT PROTECTOR
GND	GROUND
GRS	GALVANIZED RIGID STEEL (CONDUIT)
HOA	HANDS-OFF-AUTOMATIC SWITCH
HP	HORSEPOWER
HVAC	HEATING, VENTILATING AND AIR CONDITIONING
IC	INTERRUPTING CAPACITY
IMC	INTERMEDIATE METAL CONDUIT
INCAND	INCANDESCENT
IR	INFRARED
I/W	INTERLOCK WITH
J-BOX	JUNCTION BOX
KV	KILOVOLT
KVA	KILOVOLT-AMPERE
KVAR	KILOVOLT-AMPERE REACTIVE
KW	KILOWATT
KWH	KILOWATT HOUR
LTG	LIGHTING
LV	LOW VOLTAGE
MAX	MAXIMUM

MCB	MAIN CIRCUIT BREAKER
MDP	MAIN DISTRIBUTION PANEL
MIN	MINIMUM
MISC	MISCELLANEOUS
MLO	MAIN LUGS ONLY
MSB	MAIN SWITCHBOARD
N.C.	NORMALLY CLOSED
NEC	NATIONAL ELECTRICAL CODE
NEMA	NATIONAL ELECTRICAL MANUFACTURER'S ASSOCIATION
NIC	NOT IN CONTRACT
N.O.	NORMALLY OPEN
NTS	NOT TO SCALE
OL	OVERLOADS
PB	PULL BOX OR PUSHBUTTON
PF	POWER FACTOR
PH	PHASE
PNL	PANEL
PVC	POLYVINYL CHLORIDE (CONDUIT)
PWR	POWER
PWU	PURCHASED WITH UNIT
QUAN	QUANTITY
RCPT	RECEPTACLE
RM	ROOM
RSC	RIGID STEEL CONDUIT
RTU	ROOF TOP UNIT
SEC	SECONDARY
SHT	SHEET
SIM	SIMILAR
S/N	SOLID NEUTRAL
SPEC	SPECIFICATION
SP	SPARE
SR	SURFACE RACEWAY
SS	STAINLESS STEEL
STD	STANDARD
SURF	SURFACE MOUNTED
SW	SWITCH
SWBD	SWITCHBOARD
SYM	SYMMETRICAL
SYS	SYSTEM
TPS	THERMALLY PROTECTED MOTOR CONTROL SWITCH
TYP	TYPICAL
UE	UNDERGROUND ELECTRICAL
UG	UNDERGROUND
UH	UNIT HEATER
UTIL	UTILITY
V	VOLT
VFD	VARIABLE FREQUENCY DRIVE
W	WATT
W/	WITH
WG	WIRE GUARD
W/O	WITHOUT
WP	WEATHERPROOF
XFMR	TRANSFORMER

∠	ANGLE
@	AT
▲	DELTA
'	FEET
"	INCHES
#	NUMBER
Ø	PHASE
C	CENTER LINE
P	PLATE

ELECTRICAL SYMBOL LEGEND

SYMBOL	DESCRIPTION
	JUNCTION BOX
CLNG	CEILING JUNCTION BOX
	COMB. MOTOR STARTER (FUSED)
	SAFETY DISC. SW. (NON-FUSED)
	SAFETY DISC. SW. (FUSED)
	ELECTRICAL PANEL

EXISTING TO REMAIN XX-1 DEMOLISHED XX-1

T	TRANSFORMER
RTS	REMOTE TEST SWITCH
SD	DUCT SMOKE DETECTOR
CO	CARBON MONOXIDE DETECTOR

EXISTING FIRE ALARM CONTROL PANEL IS LOCATED BEHIND THE SECURITY BOOTH AT THE TRANSPORTATION CENTER. COORDINATE PROGRAM OF FIRE ALARM DEVICES WITH KEVIN FROM HARTFORD SPRINKLER COMPANY, INC AT 860-558-9529.

ELECTRICAL SYMBOL NOTES

CONDUIT IN CEILING, FLOOR OR WALL AS REQUIRED BY FIELD CONDITIONS

P4N-102
1, 3, 5

HOME RUN TO BRANCH CIRCUIT PANELBOARD. THE PANELBOARD DESIGNATION IS SHOWN ADJACENT TO THE HOME RUN ARROW AS A NUMERATOR AND THE CIRCUIT DESIGNATION IS SHOWN AS THE DENOMINATOR. CIRCUIT BREAKER SIZES (AMPS/NUMBER OF POLES) ARE SHOWN IN THE PANELBOARD SCHEDULE WITH THE CORRESPONDING PANELBOARD AND CIRCUIT DESIGNATION. EXAMPLE: HOME RUN TO PANELBOARD P4N-102; CIRCUITS 1, 3, 5.

EXISTING TO REMAIN
EXISTING TO BE REMOVED
NEW

ITEM TO BE REMOVED

AREA NOT IN CONTRACT

NUMBER OF DETAIL ON SHEET
NUMBER OF SHEET WHERE DETAIL APPEARS

1 KEYED NOTE (SEE SCHEDULE)

Room 6 ROOM NAME AND NUMBER

ELECTRICAL NOTES

1. ACCESS TO AND CLEARANCES AROUND ELECTRICAL EQUIPMENT SHALL CONFORM TO N.E.C. ARTICLES 110 AND 408. CONSULT ENGINEER WHERE SPACE APPEARS INADEQUATE DUE TO ARCHITECTURAL CHANGES, EQUIPMENT LAYOUT CHANGES, OR FIELD CONDITIONS. DO NOT COVER, OBSCURE OR BLOCK ACCESS TO EQUIPMENT, DATA PLATES, ACCESS PANELS OR MAINTENANCE AREAS WITH THE ELECTRICAL WORK.
2. THIS DRAWING SHOWS EQUIPMENT LOCATIONS ONLY. WIRING SHOWN IS SCHEMATIC IN NATURE. REFER TO RISERS AND DETAILS FOR ALL REQUIRED POWER AND CONTROL WIRING. COORDINATE CONDUIT ROUTE IN FIELD WITH OTHER TRADES, EQUIPMENT AND OWNER. VERIFY ALL MOUNTING HEIGHTS WITH OWNER AND ENGINEER PRIOR TO INSTALLATION.
3. UNLESS NOTED OTHERWISE, ALL WIRING OF CIRCUIT SHALL MATCH HOMERUN WIRING OF CIRCUIT. PROVIDE ADDITIONAL CONDUCTORS AS REQUIRED TO ACCOMPLISH INDICATED WIRING ARRANGEMENT. THIS INCLUDES WIRING AND CONNECTION TO EQUIPMENT PROVIDED BY OTHERS.
4. WIRING OF DIFFERENT VOLTAGES OR TYPES SUCH AS EMERGENCY OR NORMAL, SHALL NOT BE COMBINED IN CONDUITS OR JUNCTIONS BOXES UNLESS OTHERWISE NOTED.

ELECTRICAL DEMOLITION NOTES

1. ALL EXISTING ELECTRICAL INFORMATION WAS OBTAINED FROM LIMITED FIELD WORK. LOCATION AND QUANTITIES OF EQUIPMENT IS BASED ON THE BEST AVAILABLE INFORMATION AT TIME OF DESIGN.
2. DEMOLITION PLANS ARE DIAGRAMMATIC AND DO NOT DEPICT ENTIRE SCOPE OF WORK. ADDITIONAL WORK RELATED TO DEMOLITION MODIFICATIONS SHOULD BE EXPECTED.
3. PRIOR TO BID, CONTRACTOR SHALL VISIT SITE AND IDENTIFY ANY EXISTING CONDITIONS THAT WILL AFFECT THE WORK TO BE PERFORMED.
4. REMOVAL OF ANY ELECTRICAL MATERIAL SHALL INCLUDE THE REMOVAL OF ALL CONDUCTORS AND CONDUIT (WHERE PRACTICAL) ASSOCIATED WITH MATERIALS, UNLESS OTHERWISE NOTED.
5. ELECTRICAL DEMOLITION IS SELECTIVE IN BUILDING. REFER TO DEVICES SHOWN AND NOTES ON SHEETS.
6. REFER TO MECHANICAL PLANS FOR EQUIPMENT TO BE DEMOLISHED. REMOVE ALL STARTERS, DISCONNECTS AND ASSOCIATED WIRING FOR EQUIPMENT TO BE REMOVED.
7. CONTRACTOR TO COORDINATE DEMOLITION WORK WITH OWNER'S HAZMAT REPORTS, AS APPLICABLE.
8. ALL PANELBOARDS ARE EXISTING TO REMAIN UNLESS OTHERWISE NOTED. CONTRACTOR TO VERIFY ALL CIRCUITS FEEDING THE MECHANICAL EQUIPMENT PRIOR TO REMOVAL.
9. VERIFY EXISTING CONDITIONS ON THE JOB SITE BEFORE BEGINNING ANY WORK. COORDINATE DEMOLITION AND NEW CONSTRUCTION WITH THE OWNER PRIOR TO COMMENCEMENT OF WORK.
10. EXECUTE DEMOLITION IN A SAFE MANNER. EGRESS, EXITS AND FIRE PROTECTION OR ALARM EQUIPMENT REQUIREMENTS SHALL BE MAINTAINED. CONTRACTOR SHALL BE RESPONSIBLE FOR ALL DEMOLITION NECESSARY TO COMPLETE WORK.
11. CONTRACTOR SHALL BE RESPONSIBLE FOR ALL REMOVAL AND PROPER DISPOSAL OF DEMOLISHED ITEMS. THIS INCLUDES COSTS FOR RECYCLING OR RECLAMATION OF MATERIALS SUCH AS REFRIGERANT, AS WELL AS HAULING AND DUMPING OF ALL DEMOLISHED MATERIAL

ELECTRICAL GENERAL NOTES

A CONDUCTORS OPERATING AT 50 VOLTS OR GREATER SHALL BE IN RACEWAY. RACEWAY WITHIN THE STRUCTURE ABOVE THE FLOOR SLAB SHALL BE METAL. RACEWAY BELOW THE FLOOR SLAB AND UNDERGROUND RACEWAY OUTSIDE THE STRUCTURE SHALL BE PVC.

B LOW VOLTAGE CABLES OR CONDUCTORS OPERATING AT LESS THAN 50 VOLTS SHALL BE IN METAL RACEWAY WHERE INSTALLED WITHIN WALLS OR INACCESSIBLE SPACES. LOW VOLTAGE CABLES MAY BE RUN IN CABLE TRAY WHERE NOTED. LOW VOLTAGE CABLES MAY BE RUN IN CABLE SUPPORT HOOKS ABOVE ACCESSIBLE CEILINGS WHERE NOTED. LOW VOLTAGE CABLE SHALL BE PLENUM RATED IN PLENUM SPACES.

C LOW VOLTAGE CABLES OR CONDUCTORS OPERATING AT LESS THAN 50 VOLTS SHALL BE IN METAL RACEWAY. LOW VOLTAGE CABLES MAY BE RUN IN CABLE TRAY WHERE NOTED. LOW VOLTAGE CABLE SHALL BE PLENUM RATED IN PLENUM SPACES.

D PROVIDE CABLE OR CONDUIT AND WIRE AS REQUIRED TO ACHIEVE CIRCUITING SHOWN. SIZE CONDUCTORS PER NEC AMPACITY AND WIRE FILL CRITERIA. PROVIDE DEDICATED NEUTRAL AND GROUND CONDUCTORS FOR CIRCUITING ,UNLESS NOTED OTHERWISE. INCREASE BRANCH CIRCUIT AND/OR FEEDER CONDUCTORS INCLUDING EQUIPMENT GROUNDING CONDUCTORS PROPORTIONALLY FOR NO MORE THAN 3% VOLTAGE DROP ON BRANCH CIRCUITS AND 2% ON FEEDERS PER ENERGY CODE.

E IT IS THE RESPONSIBILITY OF THIS CONTRACTOR TO COORDINATE INSTALLATION OF ELECTRICAL SYSTEMS AND THOSE REQUIRING ELECTRICAL CONNECTIONS TO MAINTAIN NEC REQUIRED CLEARANCES, INCLUDED BY NOT LIMITED TO AREAS ABOVE ACCESSIBLE CEILINGS.

F COORDINATE WITH OTHER TRADES FOR PROPER INSTALLATION OF EQUIPMENT. CONSULT THE DRAWINGS OF OTHER TRADES OR CRAFTS TO AVOID CONFLICTS WITH EQUIPMENT, ETC. CONFLICTS SHALL BE RESOLVED PRIOR TO ROUGH-IN AND AT NO ADDITIONAL COST TO THE OWNER.

G LEAVE THE SITE CLEAN AND READY FOR OCCUPANCY. REMOVE DIRT, DEBRIS, EMPTY CARTONS, TOOLS, CONDUIT AND WIRE SCRAPS AND MISCELLANEOUS SPARE EQUIPMENT AND MATERIALS USED IN THIS DIVISION OF THE WORK DURING CONSTRUCTION. COMPONENTS SHALL BE FREE OF DUST, GRIT AND FOREIGN MATERIALS AND LEFT AS NEW BEFORE FINAL ACCEPTANCE OF WORK.

H THE SYMBOLS AND ABBREVIATIONS SHOWN ON THIS SHEET MAY OR MAY NOT BE USED IN THIS SET OF DRAWINGS.

I PERFORM WORK TO COMPLY WITH THE STANDARD PRACTICES FOR GOOD WORKMANSHIP PUBLISHED BY NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA). COMPLY WITH THE LATEST ENFORCED EDITION OF THE NATIONAL ELECTRICAL CODE (NEC), LOCAL CODES, AMENDMENTS, AND ORDINANCES.

J FIELD COORDINATE FINAL MECHANICAL AND EQUIPMENT LOCATIONS ALONG WITH CONNECTION REQUIREMENTS AND CONTROL WIRING PRIOR TO ROUGH-IN. ADJUST CORRESPONDING CIRCUIT BREAKER RATINGS AND BRANCH CIRCUITING ACCORDINGLY.

K ELECTRICAL WORK SHALL BE PERFORMED UNDER THE SUPERVISION OF A LICENSED MASTER ELECTRICIAN. PROCURE PERMITS AND LICENSES AND PAY FEES ASSOCIATED WITH THIS WORK.

L MATERIALS FURNISHED FOR THIS PROJECT SHALL BE NEW, COMMERCIAL GRADE, FREE OF DEFECTS, AND LISTED BY A NATIONALLY RECOGNIZED TESTING LABORATORY UNO.

M PROVIDE COMPLETE OPERATION & MAINTENANCE MANUAL INCLUDING APPROVED SUBMITTAL DRAWINGS, WARRANTY INFORMATION FOR PRODUCT SUPPLIED,AND MANUFACTURES OPERATION AND MAINTENANCE INSTRUCTIONS.

N CONDUIT AND WIRE SHALL NOT BE INSTALLED BELOW FLOOR SLAB UNLESS INDICATED ON PLAN BY DASHED CONDUIT.

INDEX OF ELECTRICAL DRAWINGS

BASE BID

SHALL INCLUDE REPLACEMENT OF THE FOLLOWING EQUIPMENT AND CONTROLS:

1. FOUR AIR HANDLER UNITS: AHU-9L,11L, 9R & 11R.
2. THREE PACKAGE UNITS: PK1, PK2 & PK3.
3. FOUR AIR HANDLERS UNITS (AHU-14-L-1, AHU-14-L-2, AHU-14-L-3, AHU-14-L-5,) SERVING PROPARK (SOUTH WING)
4. ONE MAKEUP AIR UNIT (MAU-1) IN THE TRANSPORTATION CENTER.

ADD ALTERNATE #1

SHALL INCLUDE REPLACEMENT OF THE FOLLOWING EQUIPMENT AND CONTROLS:

1. SEVEN AIR HANDLER UNITS LOCATED IN THE ATTIC: AHU-2,3,4,5,6,7 & 8.
2. SEVEN EXHAUST FANS LOCATED IN THE ATTIC: EX-2,3,4,5,6,7 & 8.
2. A NEW BUILDING MANAGEMENT SYSTEM TO REPLACE THE EXISTING SYSTEM IN PLACE. THE NEW SYSTEM SHALL BE PROVIDED AS DETAILED IN SPECIFICATION 230923. THE EQUIPMENT TO BE INTEGRATED INTO THE NEW SYSTEM SHALL INCLUDE AT MINIMUM:
   - ALL HVAC EQUIPMENT (INCLUDING EXISTING AIR HANDLING EQUIPMENT NOT PART OF PROJECT)
   - ALL CHILLERS
   - ALL PUMPS
   - ALL BOILERS

ADD ALTERNATE #2

SHALL INCLUDE REPLACEMENT OF THE FOLLOWING EQUIPMENT AND CONTROLS:

1. THREE AIR-COOLED CHILLERS LOCATED ON GRADE: CH-4, 5 & 6.

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NO	DATE	REVISION

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PROJECT NAME:
GHTD UNION STATION HVAC UPGRADES

1 UNION PLACE
HARTFORD, CT

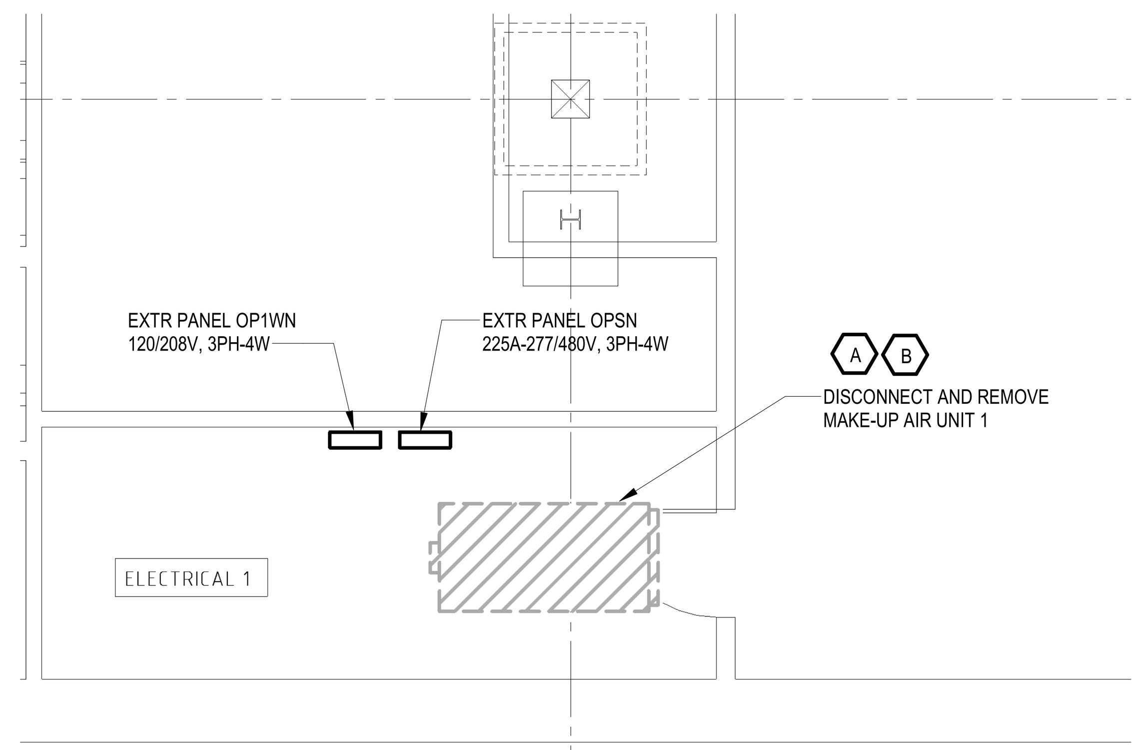
DRAWING TITLE:
ELECTRICAL SYMBOLS, NOTES, AND ABBREVIATIONS

FILE: 2022/3562
DRAWN BY: CSG
CHECKED BY: JP
ISSUE DATE: 11/01/2022
DRAWING NO: E001

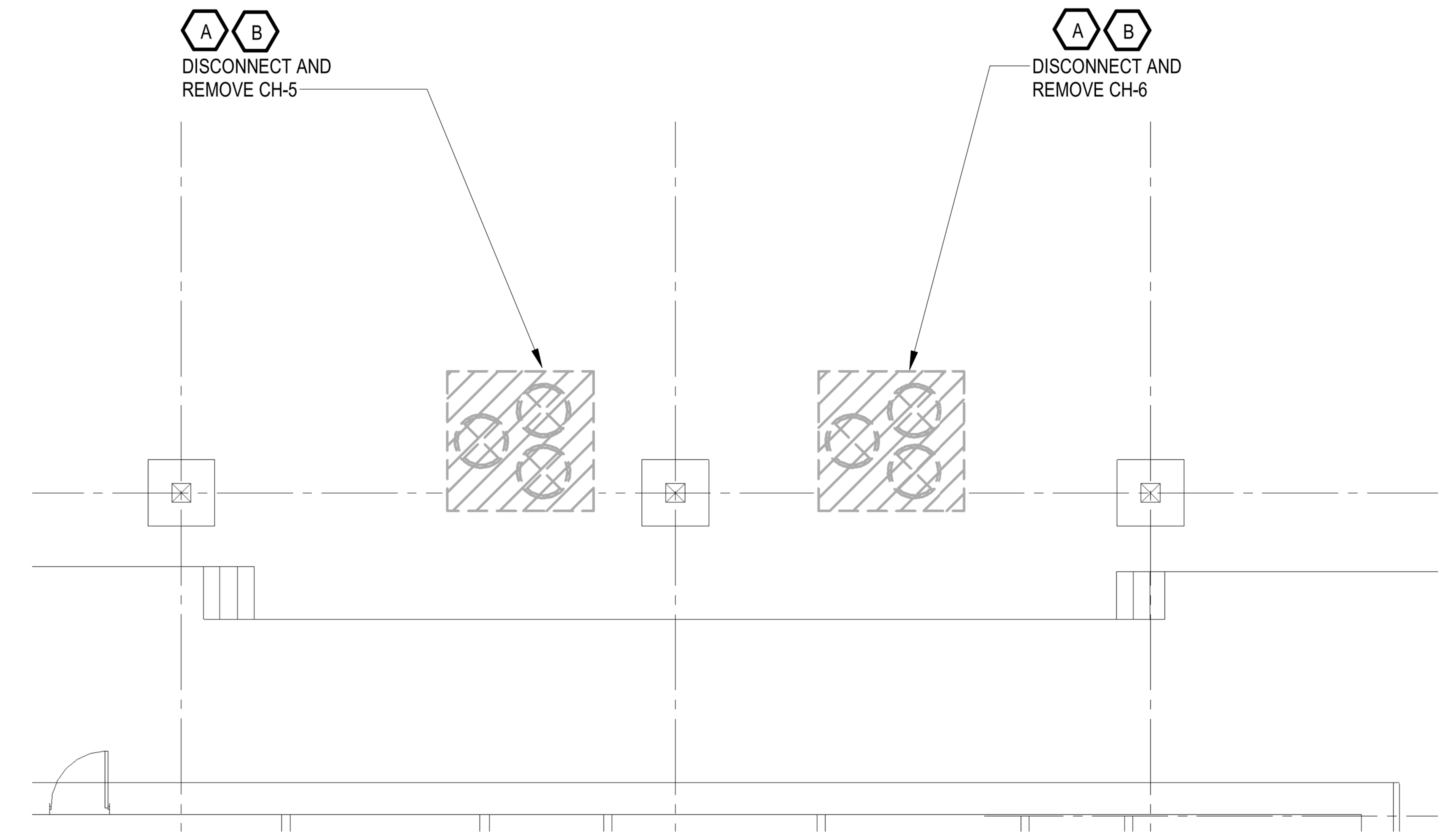
NOTES - ELECTRICAL DEMOLITION

A. REMOVE EXISTING DEDICATED MECHANICAL EQUIPMENT DISCONNECT SWITCH, STARTER AND ASSOCIATED WIRING & CONDUIT BACK TO SOURCE PANELBOARD.

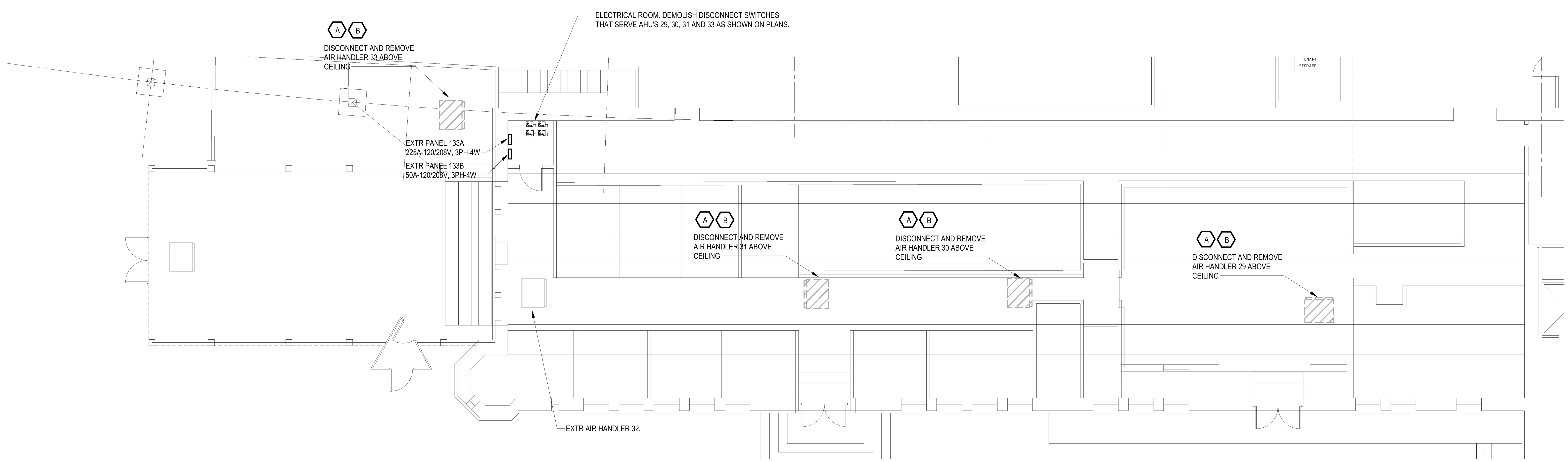
B. THE CONTRACTOR SHALL TRACE OUT CIRCUITS IN THE DEMOLITION PHASE TO CONFIRM PANEL BOARD CIRCUIT FOR NEW HVAC EQUIPMENT.



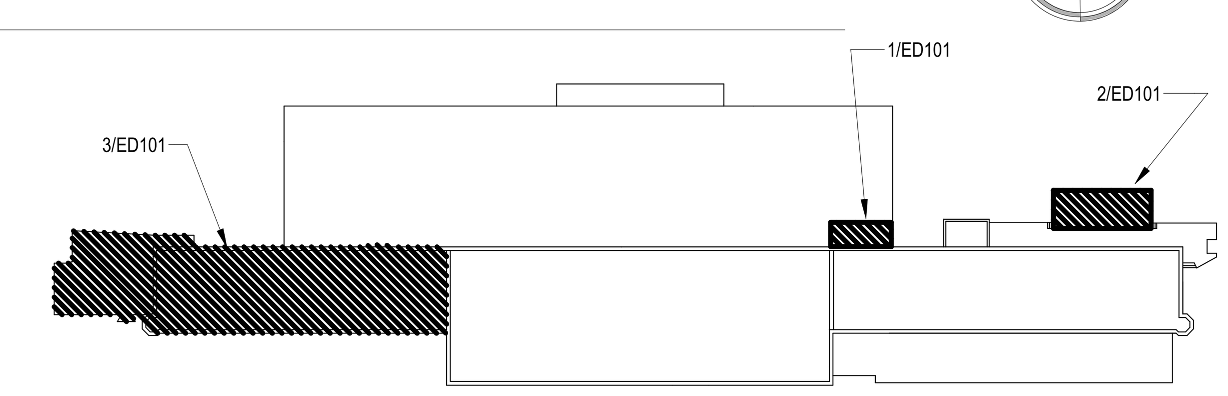
1/ED101 LEVEL 1 ELECTRICAL DEMOLITION PLAN - BASE BID
1/4" = 1'-0"



2/ED101 LEVEL 1 ELECTRICAL DEMOLITION PLAN - ADD ALTERNATE #2
1/8" = 1'-0"



3/ED101 LEVEL 1 ELECTRICAL DEMOLITION PLAN -BASE BID
1/8" = 1'-0"



KEY PLAN

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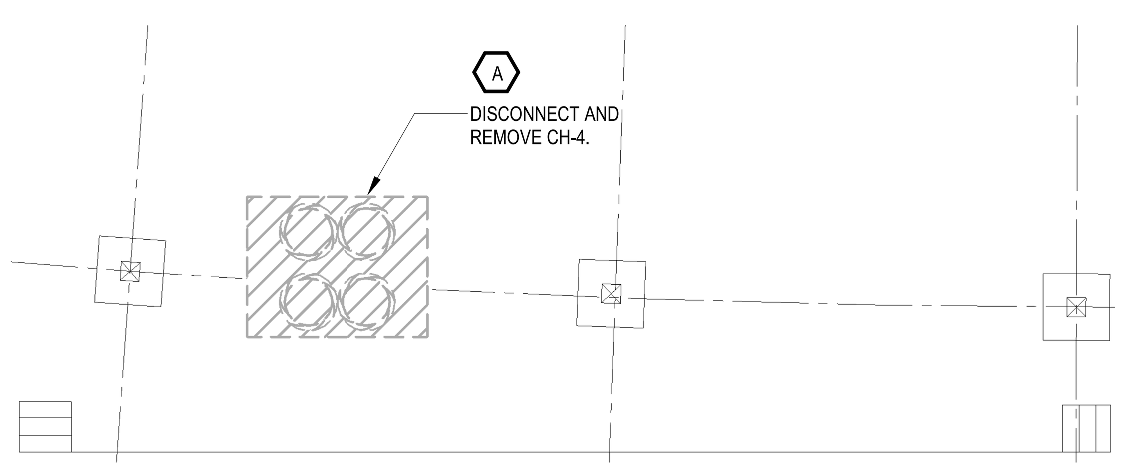
PROJECT NAME:
GHTD UNION STATION HVAC UPGRADES
1 UNION PLACE
HARTFORD, CT

DRAWING TITLE:
LEVEL 1 ELECTRICAL DEMOLITION PLAN

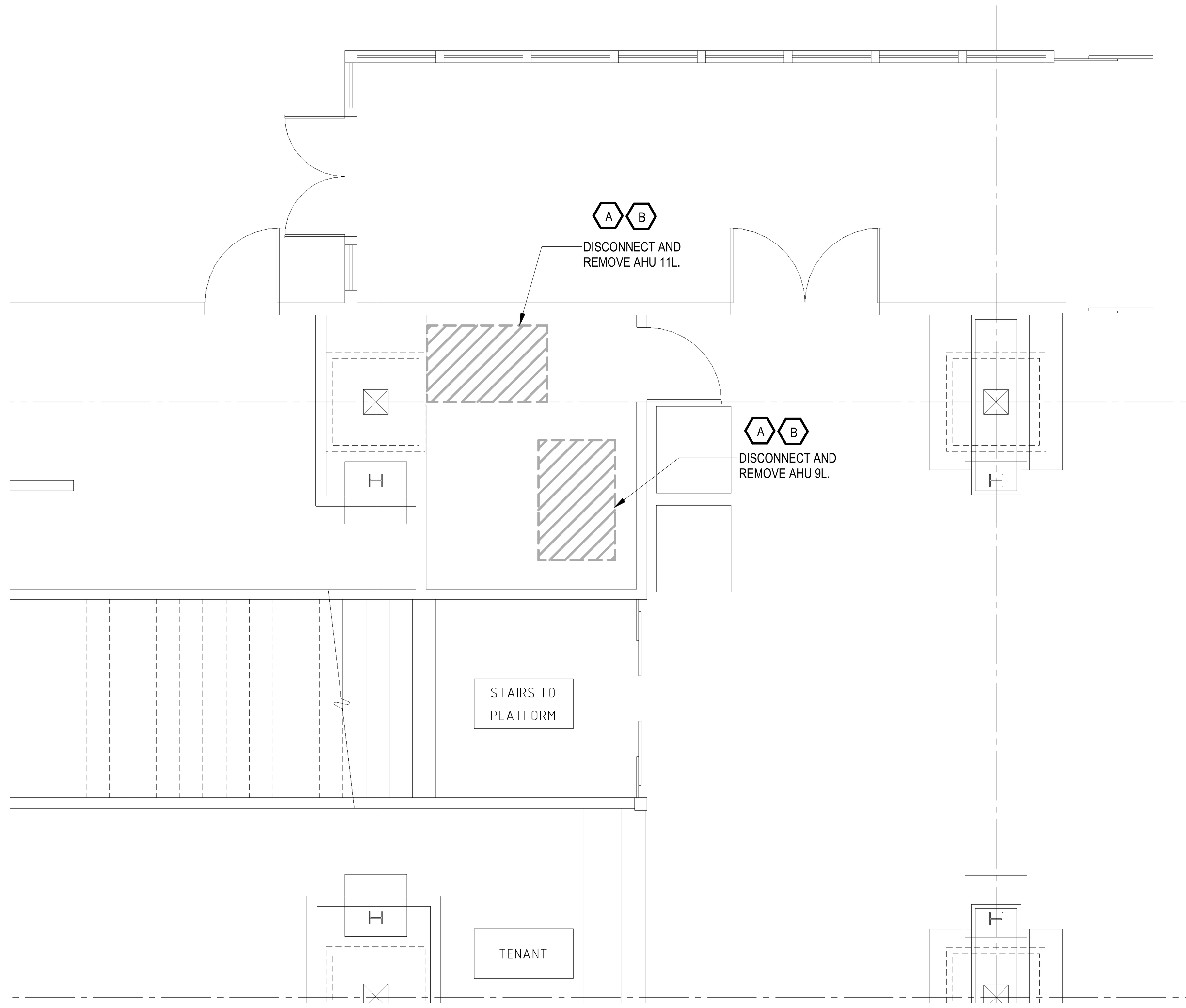
FILE: 2022/3562
DRAWN BY: CSG
CHECKED BY: JP
ISSUE DATE: 11/01/2023
DRAWING NO: **ED101**

NOTES - ELECTRICAL DEMOLITION

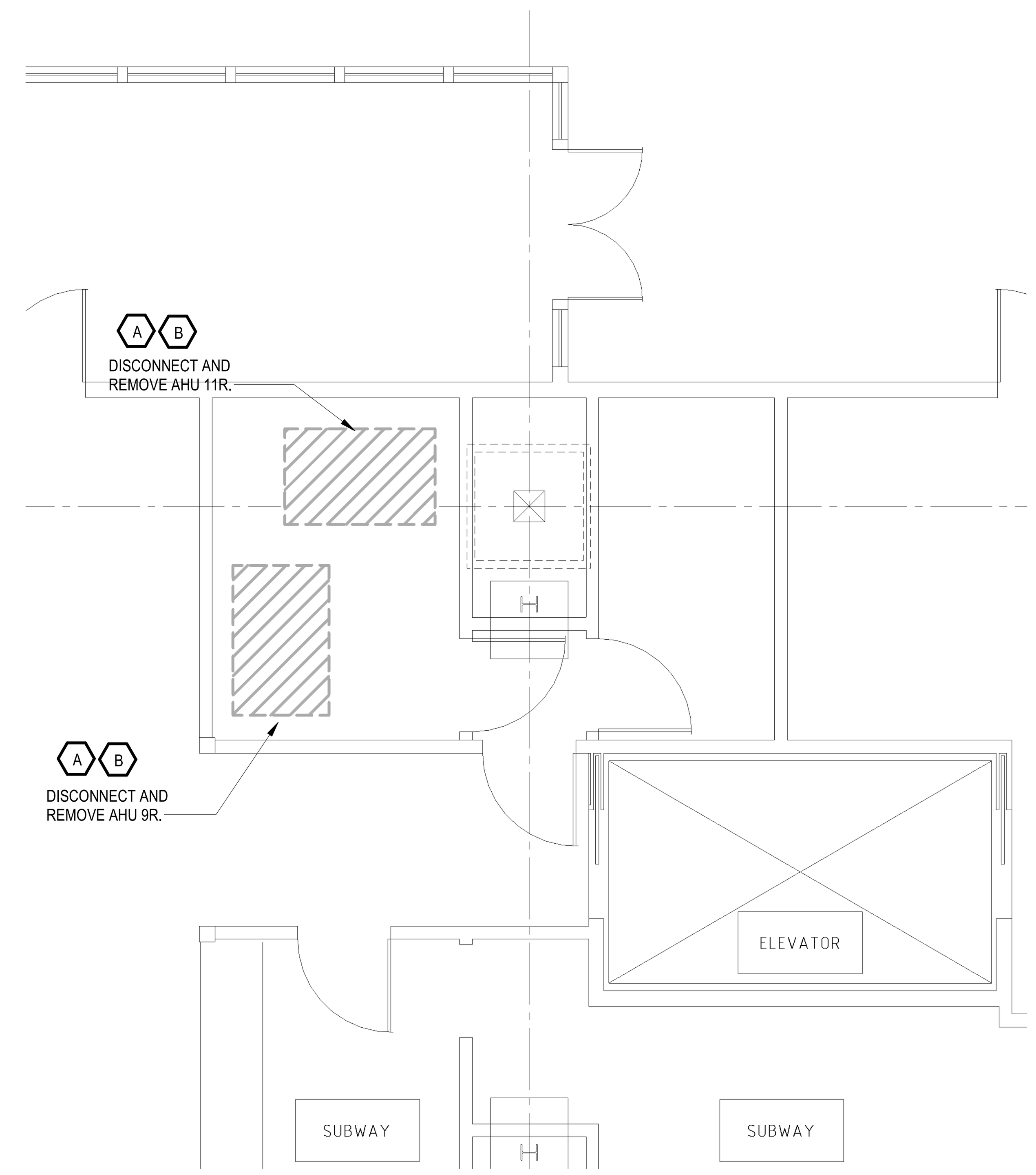
- (A) REMOVE EXISTING DEDICATED MECHANICAL EQUIPMENT DISCONNECT SWITCH, STARTER AND ASSOCIATED WIRING & CONDUIT BACK TO SOURCE PANELBOARD.
- (B) THE CONTRACTOR SHALL TRACE OUT CIRCUITS IN THE DEMOLITION PHASE TO CONFIRM PANEL BOARD CIRCUIT FOR NEW HVAC EQUIPMENT.



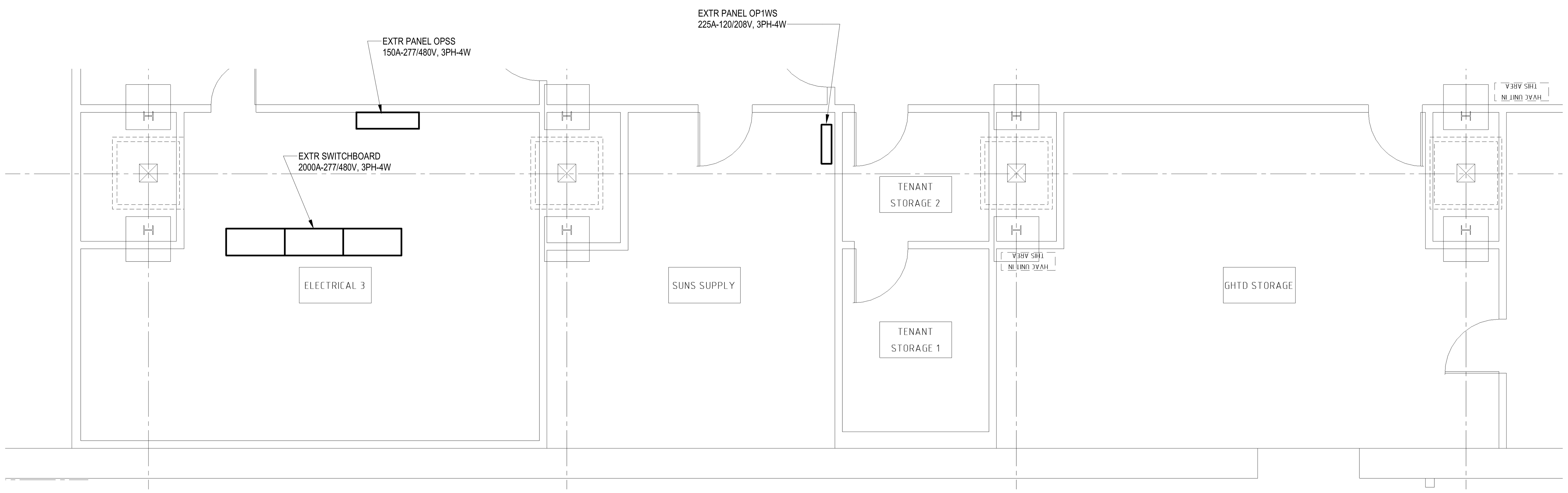
1 ED102 LEVEL 1 ELECTRICAL DEMOLITION PLAN - ADD ALTERNATE #2
1/8" = 1'-0"



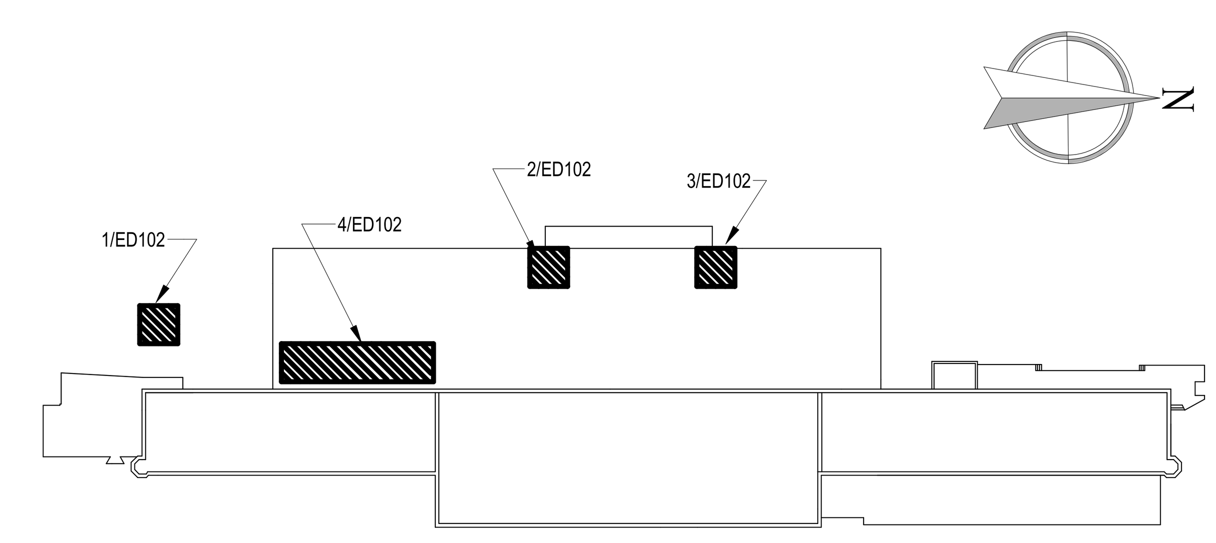
2 ED102 LEVEL 1 ELECTRICAL DEMOLITION PLAN - BASE BID
1/4" = 1'-0"



3 ED102 LEVEL 1 ELECTRICAL DEMOLITION PLAN - BASE BID
1/4" = 1'-0"



4 ED102 ELECTRICAL ROOM LOCATION - BASE BID
1/4" = 1'-0"



KEY PLAN

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Cranston, RI Richmond, VA Exton, PA

CLIENT:
GREATER HARTFORD TRANSIT DISTRICT
1 UNION PLACE
HARTFORD, CT 06103

THIS SQUARE APPEARS 1/2"x1/2" ON FULL SIZE SHEETS

NO	DATE	REVISION

STAMP:

PROJECT NAME:
GHTD UNION STATION
HVAC UPGRADES

1 UNION PLACE
HARTFORD, CT

DRAWING TITLE:
TRANSPORTATION ELECTRICAL DEMOLITION PLAN

FILE: 2022/3562
DRAWN BY: CSG
CHECKED BY: JP
ISSUE DATE: 11/01/2023
DRAWING NO:

ED102

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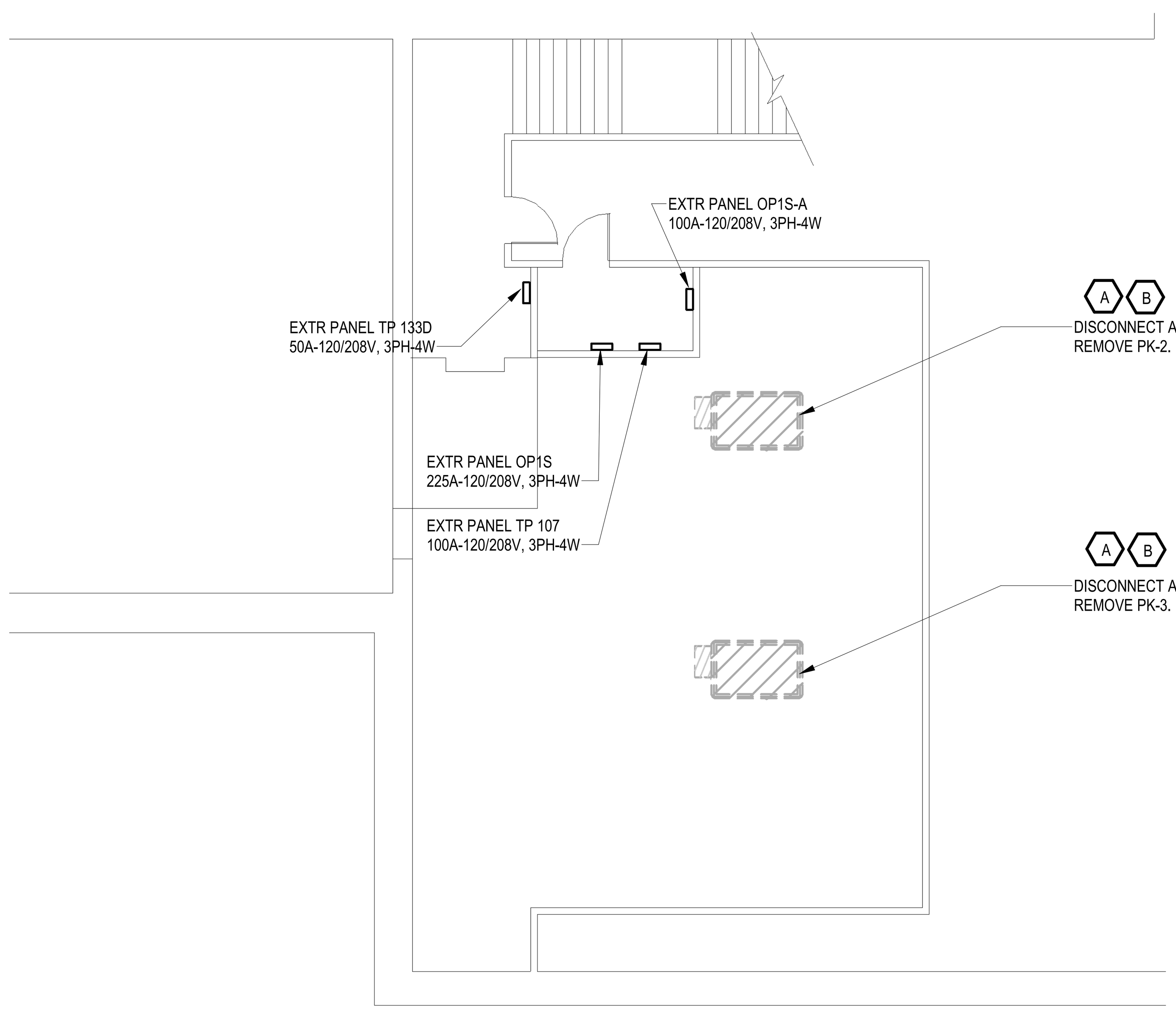
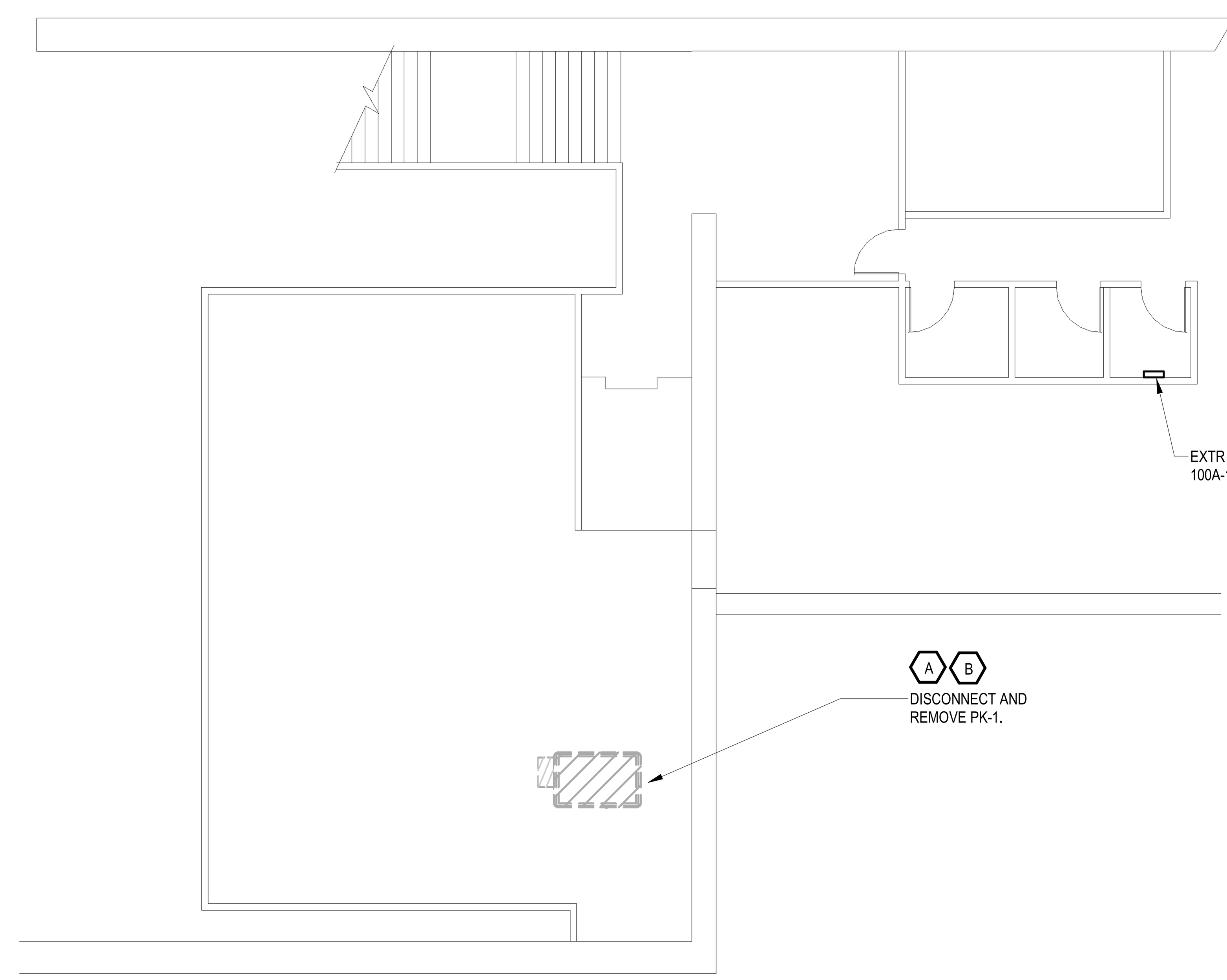
NOTES - ELECTRICAL DEMOLITION

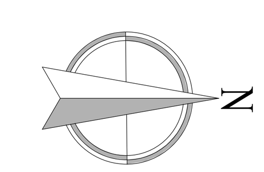
- A: REMOVE EXISTING DEDICATED MECHANICAL EQUIPMENT DISCONNECT SWITCH, STARTER AND ASSOCIATED WIRING & CONDUIT BACK TO SOURCE PANELBOARD.
- B: THE CONTRACTOR SHALL TRACE OUT CIRCUITS IN THE DEMOLITION PHASE TO CONFIRM PANEL BOARD CIRCUIT FOR NEW HVAC EQUIPMENT.

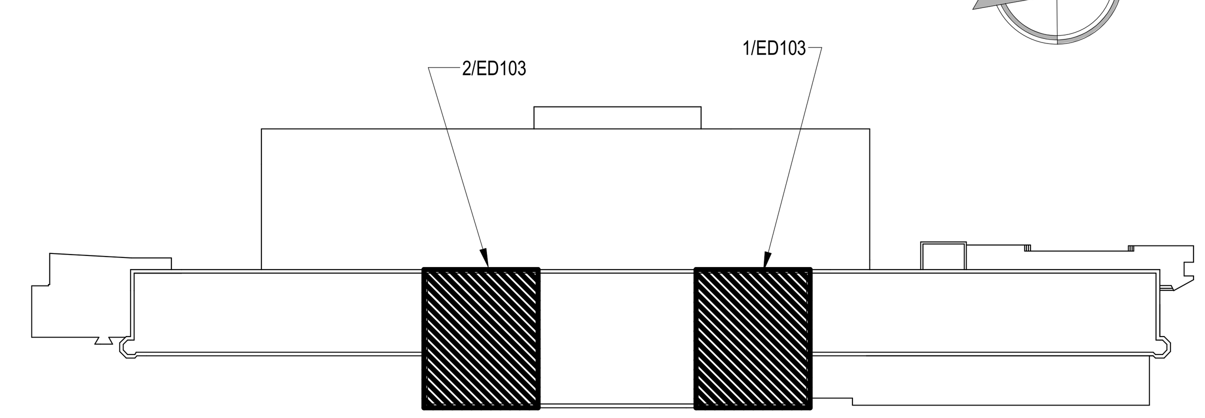


2 / ED103 — SOUTH MEZZANINE ELECTRICAL DEMOLITION PLAN - BASE BID
1/8" = 1'-0"



1 / ED103 — NORTH MEZZANINE ELECTRICAL DEMOLITION PLAN - BASE BID
1/8" = 1'-0"





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HARTFORD, CT 06103

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1 UNION PLACE
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FILE: 2022/3562
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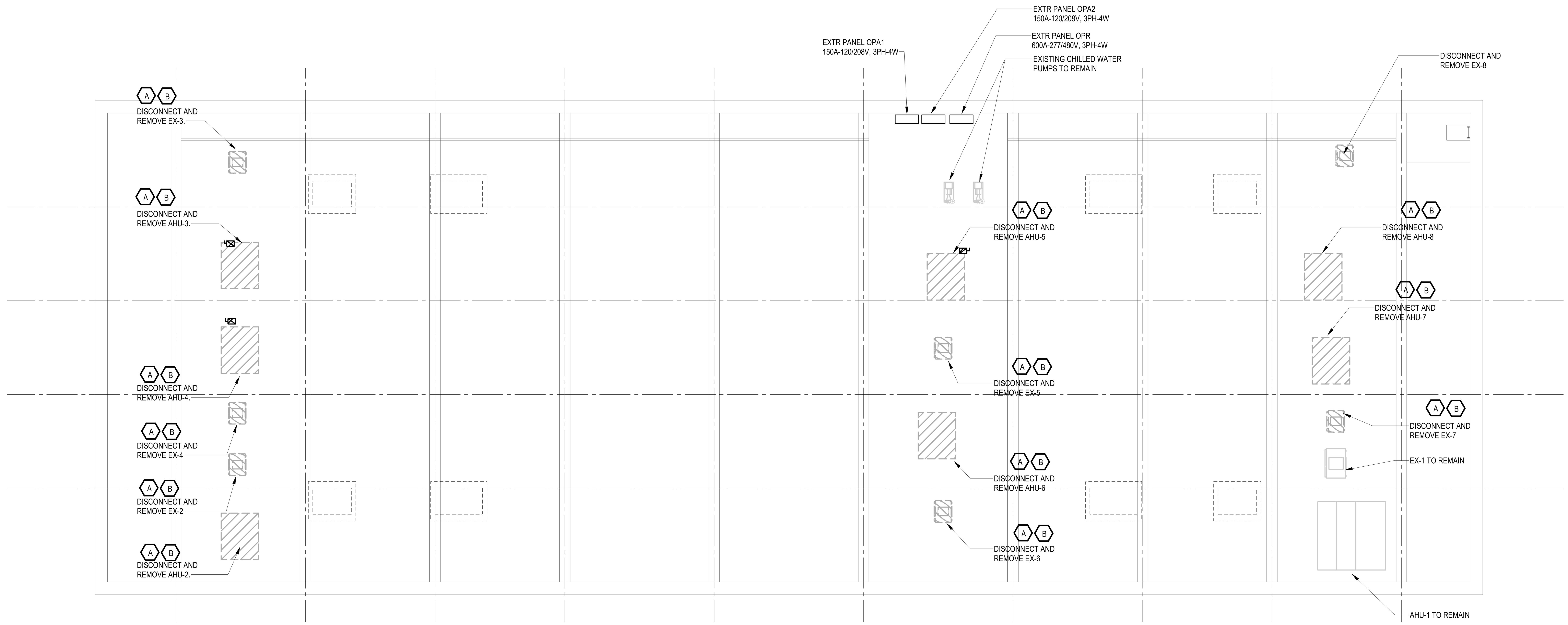
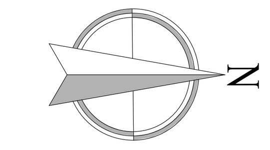
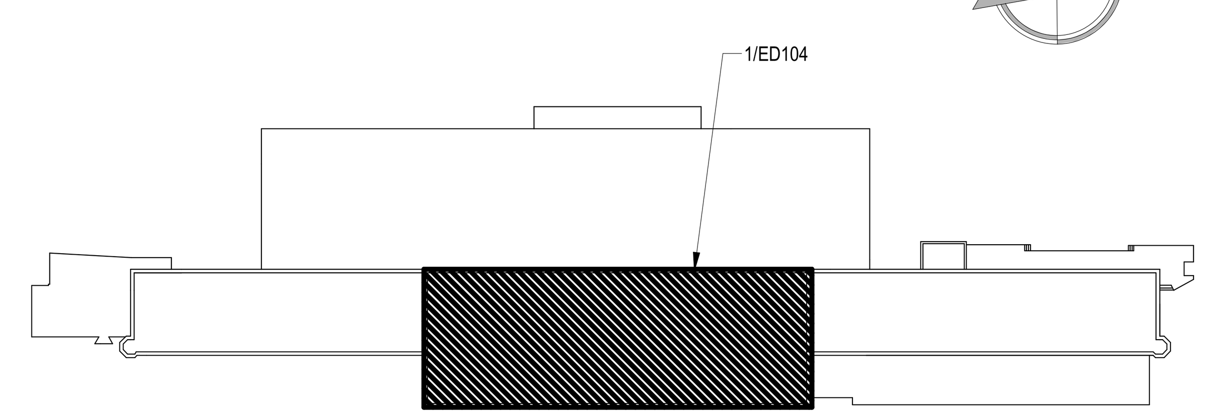
NOTES - ELECTRICAL DEMOLITION

- (A) REMOVE EXISTING DEDICATED MECHANICAL EQUIPMENT DISCONNECT SWITCH, STARTER AND ASSOCIATED WIRING & CONDUIT BACK TO SOURCE PANELBOARD.
- (B) THE CONTRACTOR SHALL TRACE OUT CIRCUITS IN THE DEMOLITION PHASE TO CONFIRM PANEL BOARD CIRCUIT FOR NEW HVAC EQUIPMENT.



1 ED104 ATTIC ELECTRICAL DEMOLITION PLAN - ADD ALTERNATE #1
1/8" = 1'-0"





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ATTIC ELECTRICAL DEMOLITION PLAN

FILE: 2022/3562
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CHECKED BY: JP
ISSUE DATE: 11/01/2023
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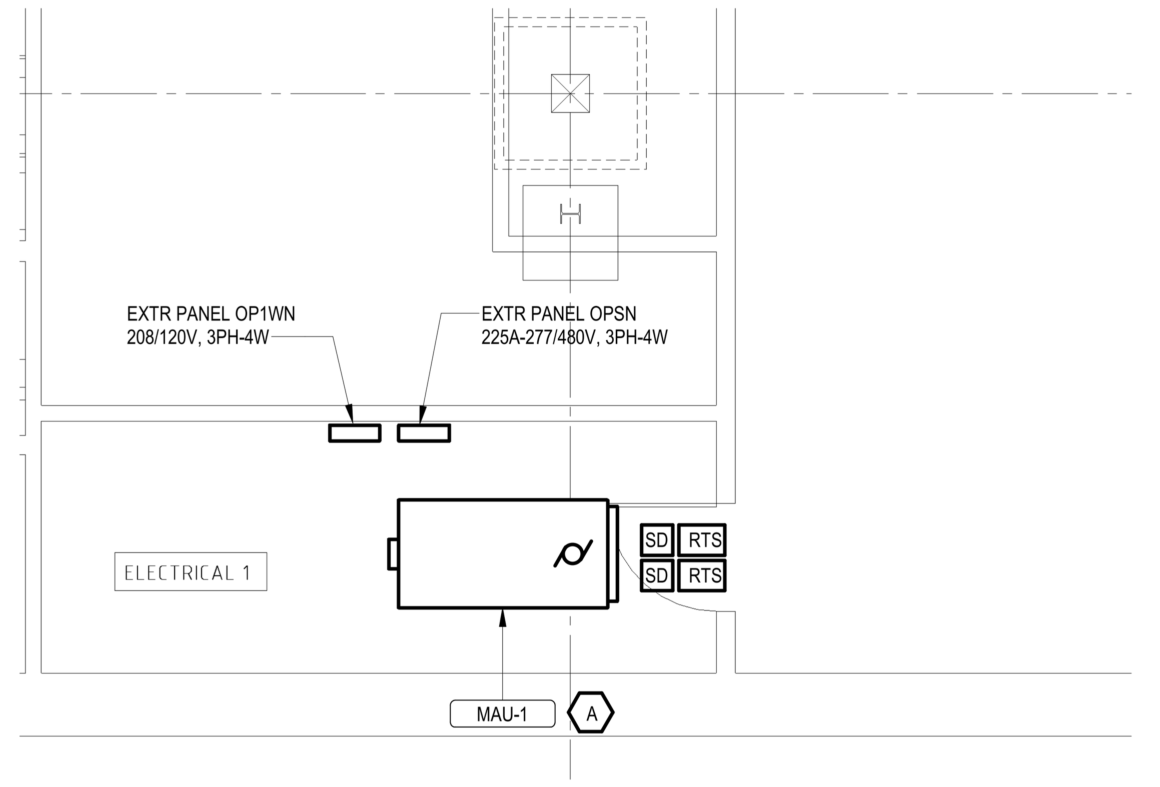
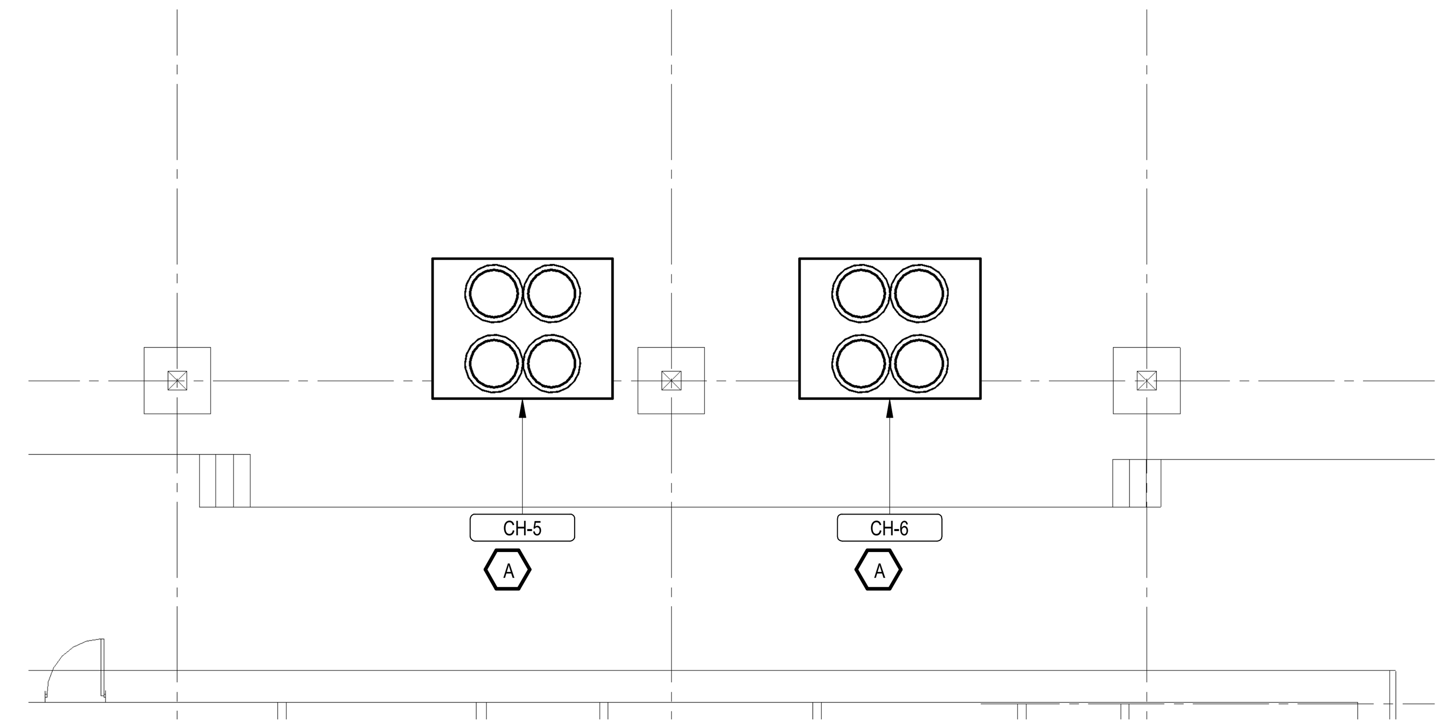
NOTES - ELECTRICAL NEW WORK

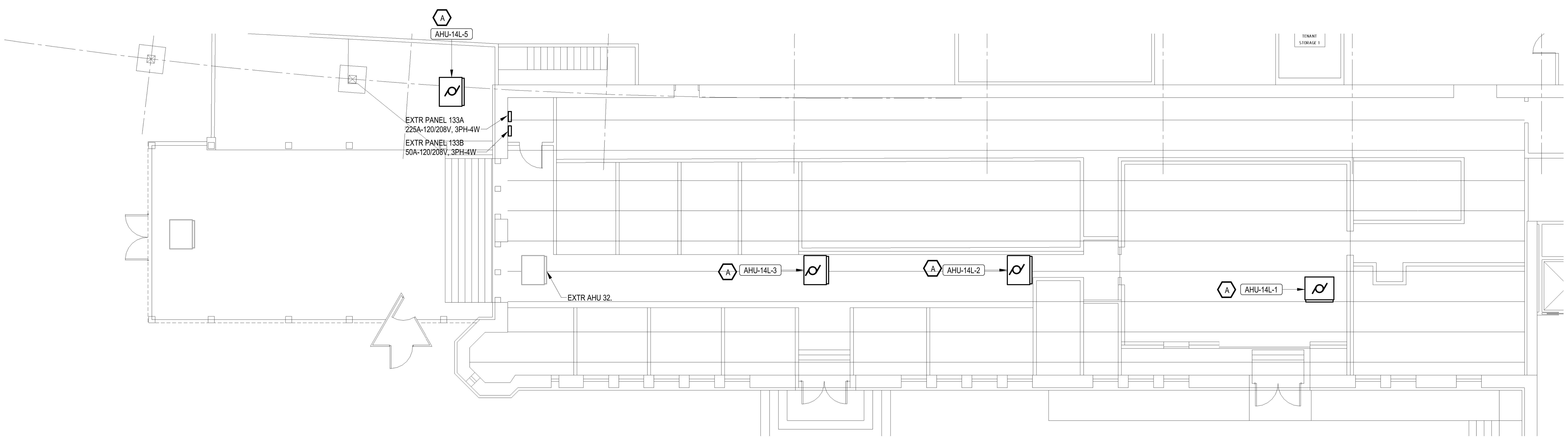
(A) PROVIDE NEW WIRE AND CONDUIT. PROVIDE NEW CIRCUIT BREAKER TO EXISTING PANEL. LABEL CIRCUIT AT THE EQUIPMENT DISCONNECT AND THE UPDATED PANEL BOARD SCHEDULE. REFER TO SCHEDULE ON E601 FOR ADDITIONAL INFORMATION.



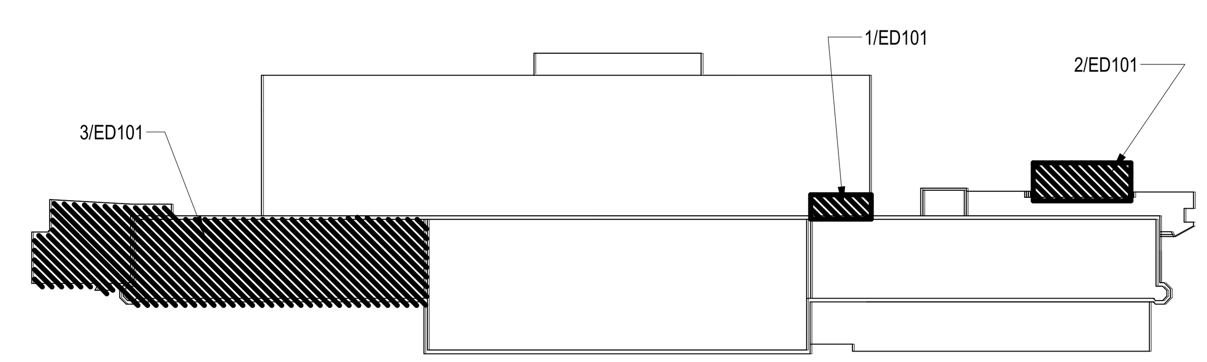
1 E101 LEVEL 1 MAKE-UP AIR UNIT POWER PLAN - BASE BID
1/4" = 1'-0"



2 E101 LEVEL 1 CHILLERS 5 AND 6 POWER PLAN - ADD ALTERNATE #2
1/8" = 1'-0"



3 E101 LEVEL 1 PROPARK SOUTH POWER PLAN - BASE BID
1/8" = 1'-0"



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1 UNION PLACE
HARTFORD, CT

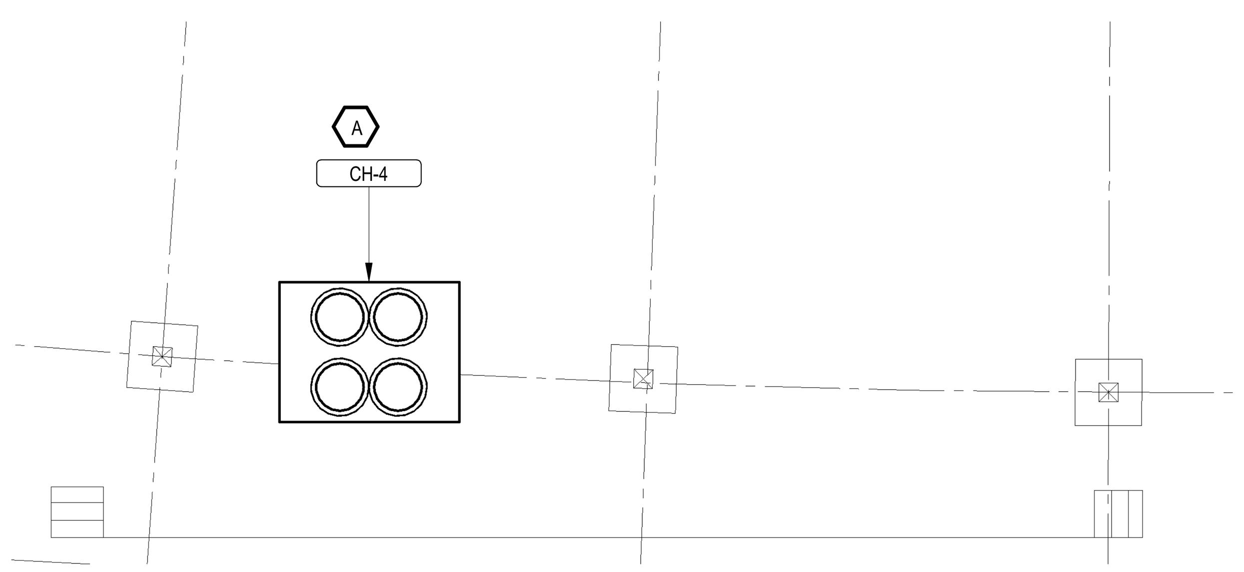
DRAWING TITLE:
LEVEL 1 POWER PLAN

FILE: 2022/3562
DRAWN BY: CSG
CHECKED BY: JP
ISSUE DATE: 11/01/2023
DRAWING NO: **E101**

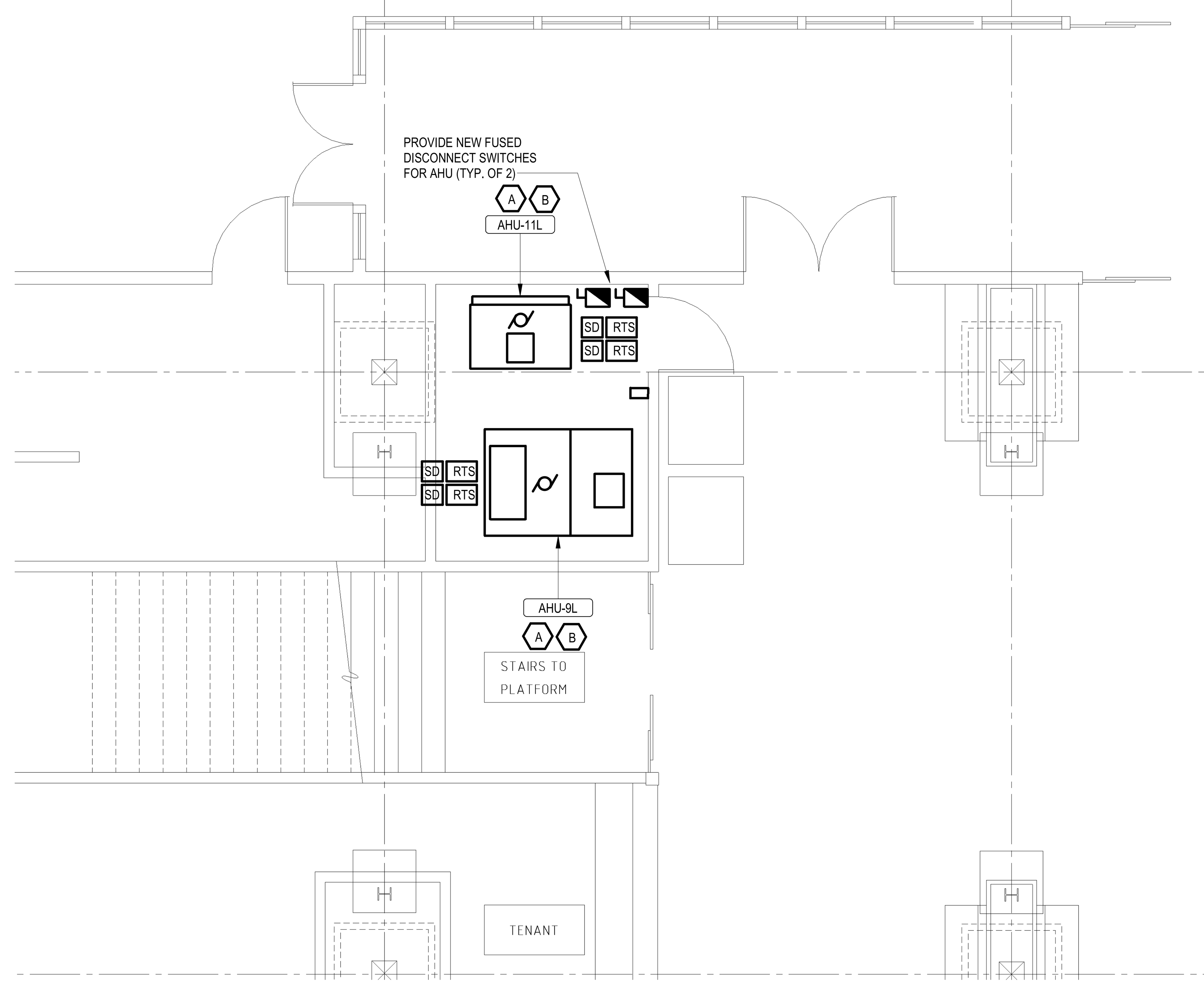
NOTES - ELECTRICAL NEW WORK

(A) PROVIDE NEW WIRE AND CONDUIT. PROVIDE NEW CIRCUIT BREAKER TO EXISTING PANEL. LABEL CIRCUIT AT THE EQUIPMENT DISCONNECT AND THE UPDATED PANEL BOARD SCHEDULE. REFER TO SCHEDULE ON E601 FOR ADDITIONAL INFORMATION.

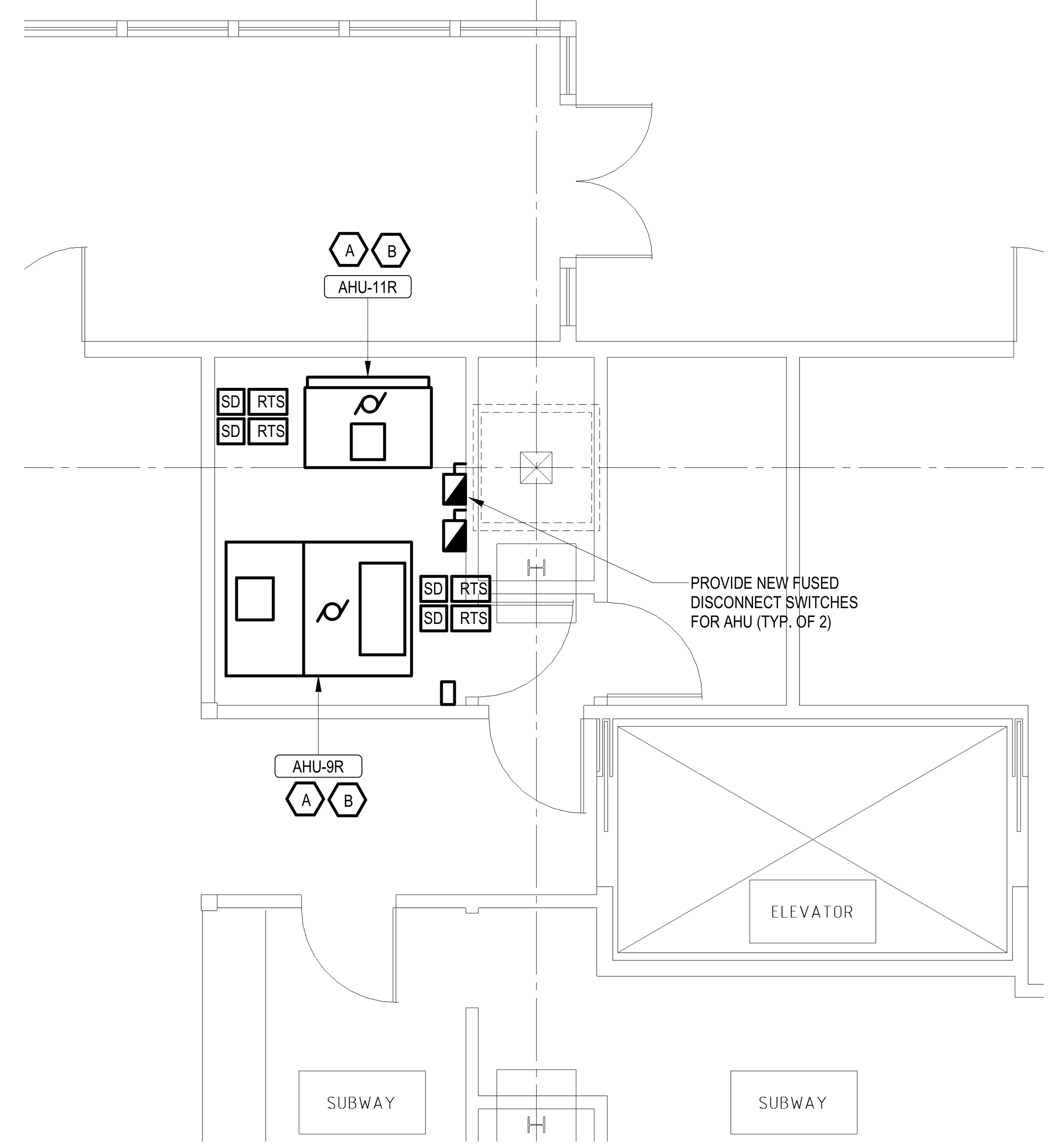
(B) PROVIDE DUCT SMOKE DETECTOR AND REMOTE TEST SWITCH. LOCATE EXISTING INITIATING FIRE ALARM LOOP AND EXTEND TO DEVICES WITH 3/4"C. COORDINATE PROGRAM OF FIRE ALARM DEVICES WITH KEVIN FROM HARTFORD SPRINKLER COMPANY, INC AT 860-558-9529.



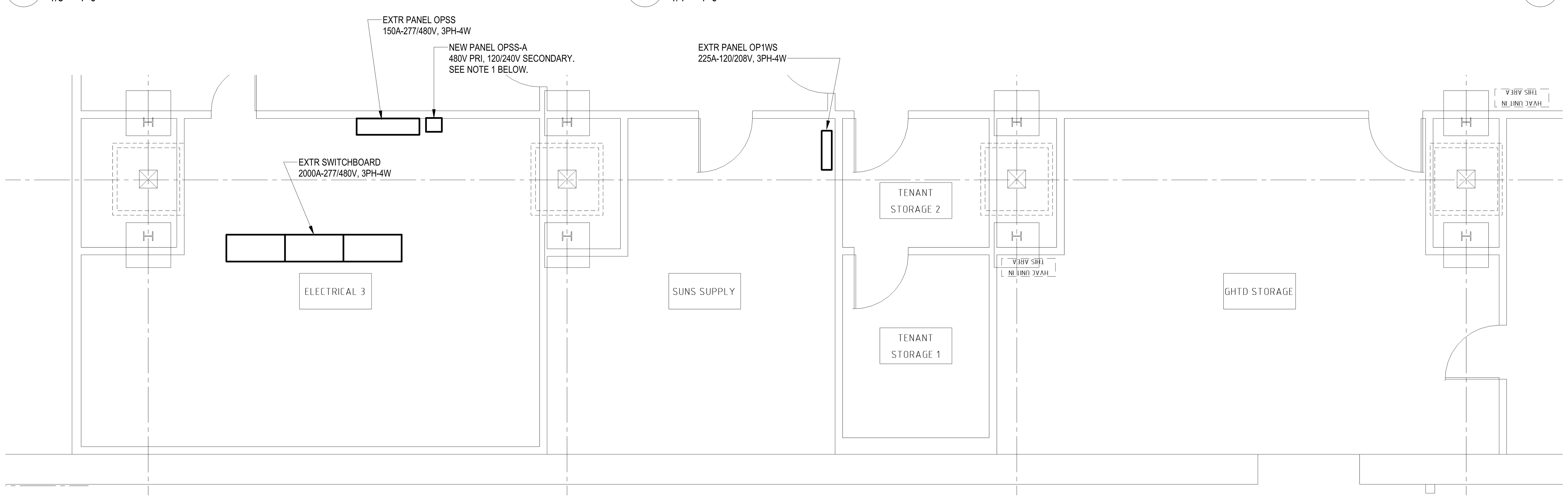
1 E102 LEVEL 1 CHILLER 4 POWER PLAN - ADD ALTERNATE #2
1/8" = 1'-0"



2 E102 SOUTH MECHANICAL ROOM POWER PLAN UNIT 9L AND 11L - BASE BID
1/4" = 1'-0"

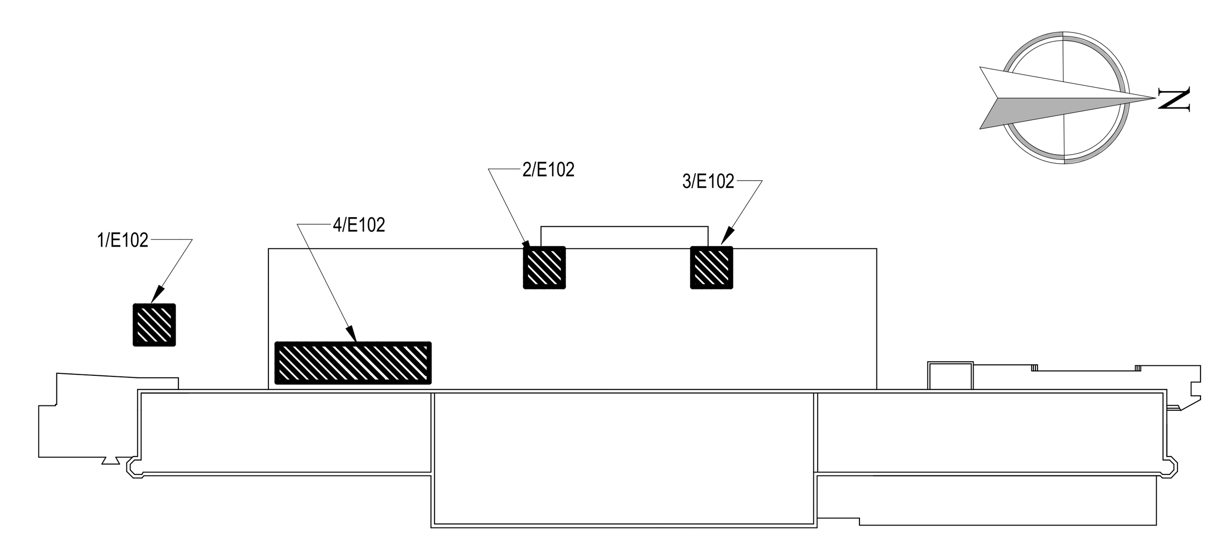


3 E102 NORTH MECHANICAL ROOM POWER PLAN UNIT 9R AND 11R - BASE BID
1/4" = 1'-0"



NOTE:
1. PROVIDE NEW 5KVA MINI SUBSTATION AND NAME IT PANEL OPSS-A AND FED FROM EXTR PANEL OPSS WITH 15A-2P C/B. THE PANEL SHALL BE SIMILAR TO SQUARE D MINI POWER ZONE LV SUBSTATION AND WILL BE 480V PRIMARY, 120/240V SECONDARY. SEE SCHEDULE ON E601 FOR ADDITIONAL INFORMATION.

4 E102 ELECTRICAL ROOM LOCATION - BASE BID
1/4" = 1'-0"



KEY PLAN

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1 UNION PLACE
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TRANSPORTATION MECHANICAL ROOM POWER PLAN

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E102

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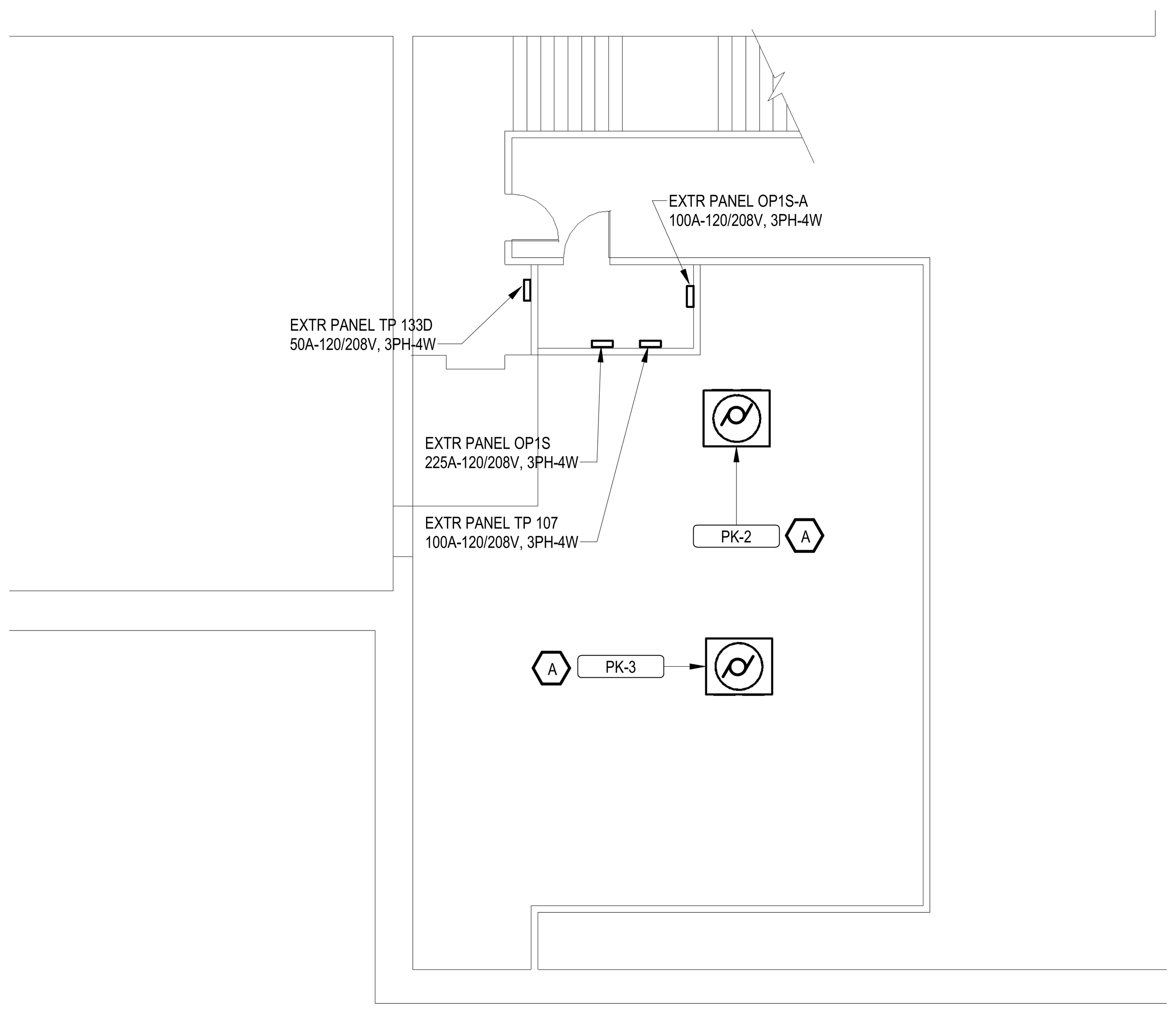
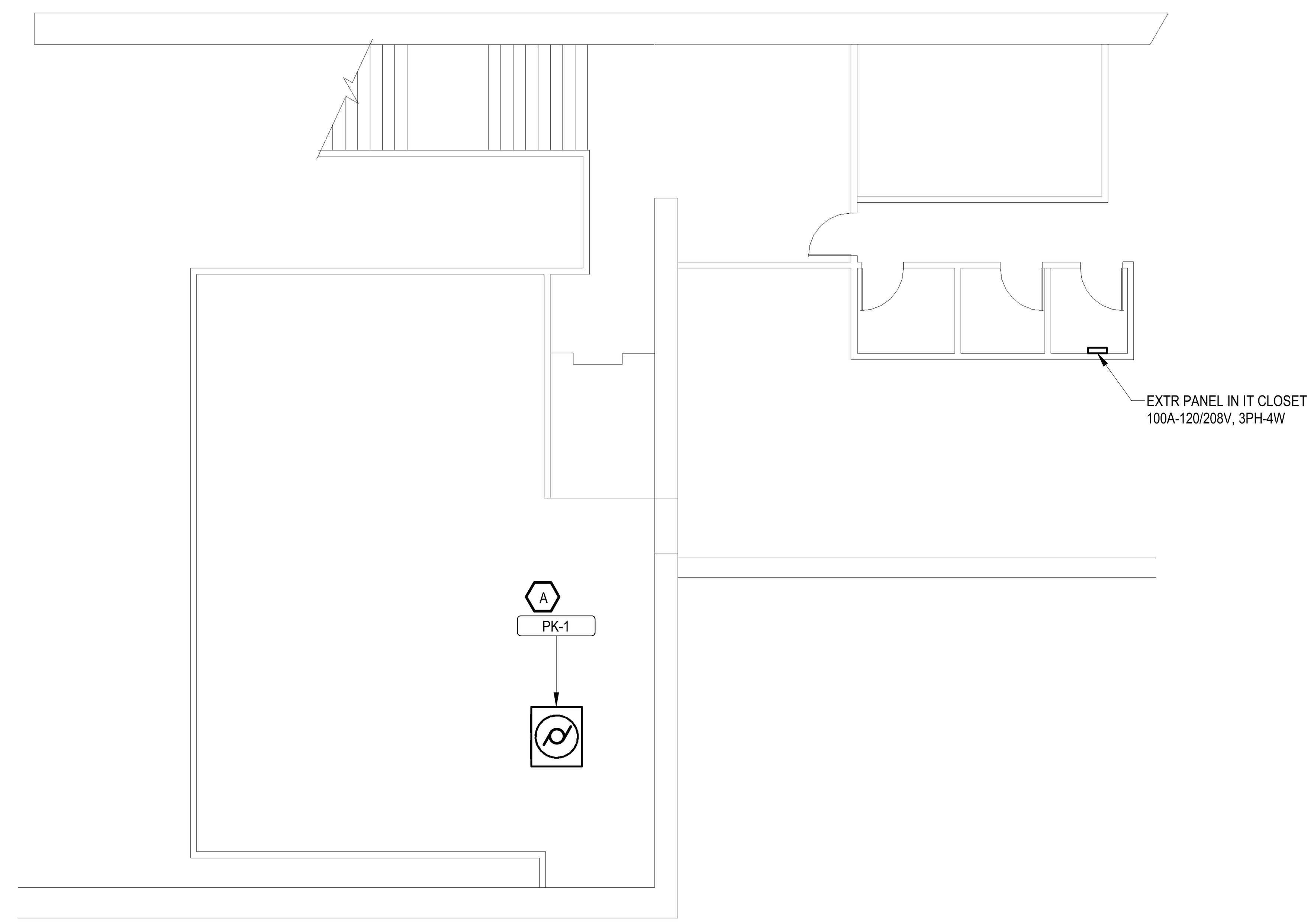
NOTES - ELECTRICAL NEW WORK

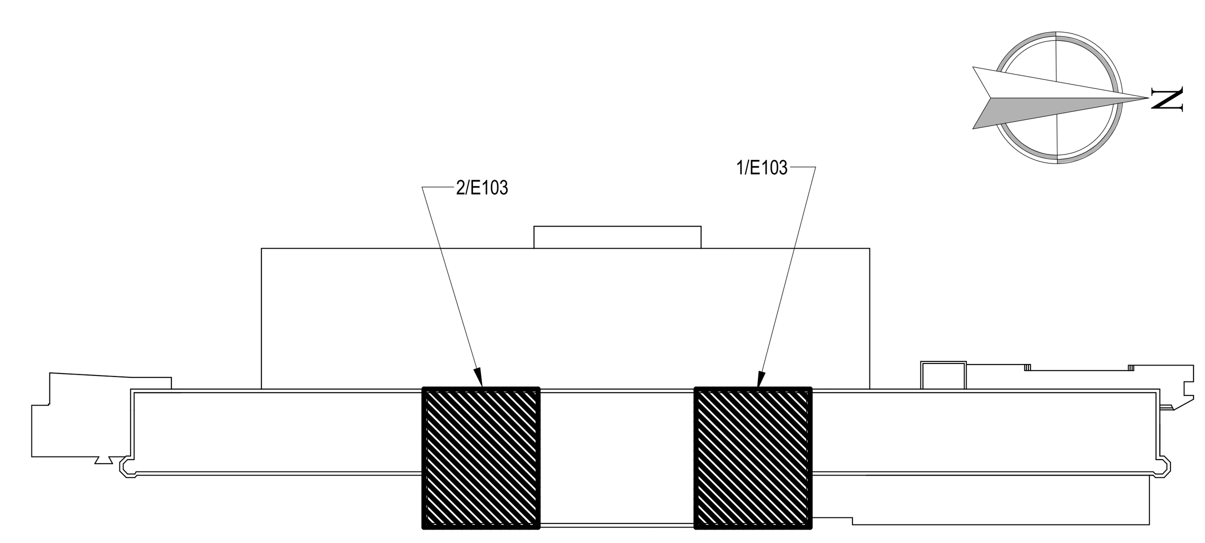
(A) PROVIDE NEW WIRE AND CONDUIT. PROVIDE NEW CIRCUIT BREAKER TO EXISTING PANEL. LABEL CIRCUIT AT THE EQUIPMENT DISCONNECT AND THE UPDATED PANEL BOARD SCHEDULE. REFER TO SCHEDULE ON E601 FOR ADDITIONAL INFORMATION.



2 E103 SOUTH MEZZANINE POWER PLAN - BASE BID
1/8" = 1'-0"



1 E103 NORTH MEZZANINE POWER PLAN - BASE BID
1/8" = 1'-0"



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CLIENT:
GREATER HARTFORD TRANSIT DISTRICT
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HARTFORD, CT 06103

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1 UNION PLACE
HARTFORD, CT

DRAWING TITLE:
MEZZANINE POWER PLAN

FILE: 2022/3562
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E103

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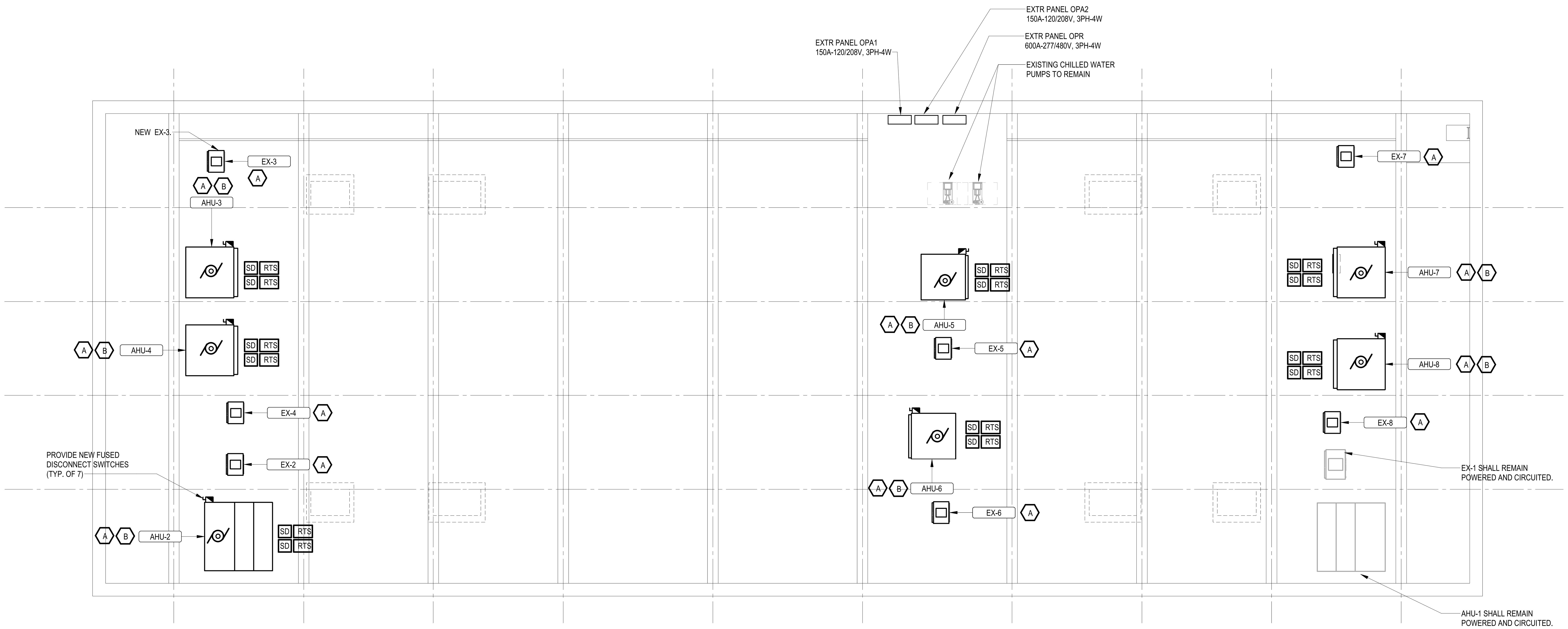
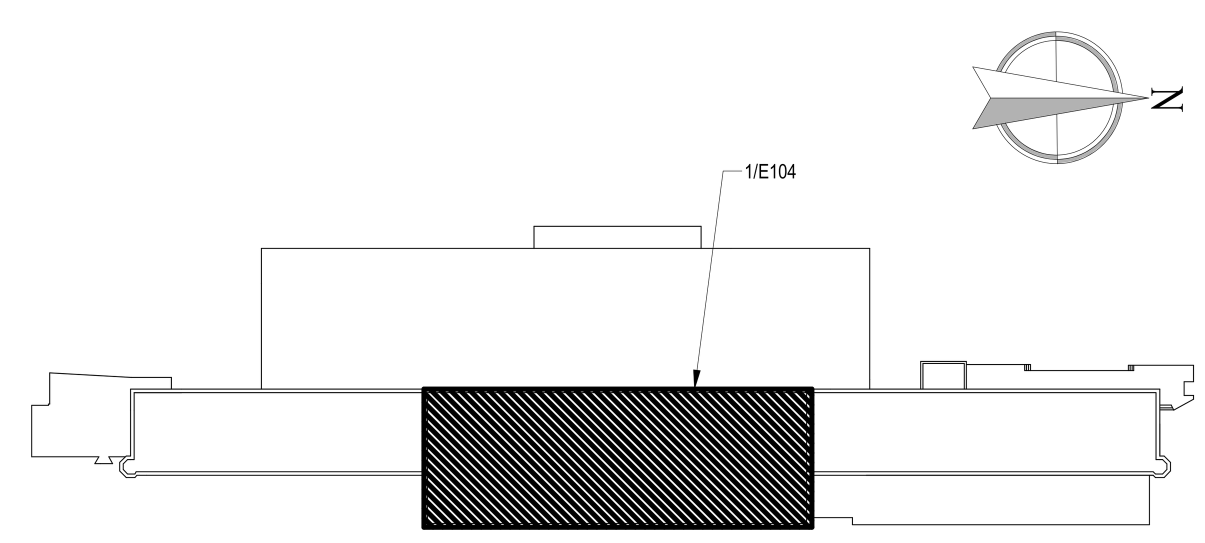
NOTES - ELECTRICAL NEW WORK

A. PROVIDE NEW WIRE AND CONDUIT. PROVIDE NEW CIRCUIT BREAKER TO EXISTING PANEL. LABEL CIRCUIT AT THE EQUIPMENT DISCONNECT AND THE UPDATED PANEL BOARD SCHEDULE. REFER TO SCHEDULE ON E601 FOR ADDITIONAL INFORMATION.

B. PROVIDE DUCT SMOKE DETECTOR AND REMOTE TEST SWITCH. LOCATE EXISTING INITIATING FIRE ALARM LOOP AND EXTEND TO DEVICES WITH 3/4"C. COORDINATE PROGRAM OF FIRE ALARM DEVICES WITH KEVIN FROM HARTFORD SPRINKLER COMPANY, INC AT 860-558-9529.



1/E104 ATTIC POWER PLAN - ADD ALTERNATE #1
1/8" = 1'-0"



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HARTFORD, CT

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ATTIC POWER PLAN

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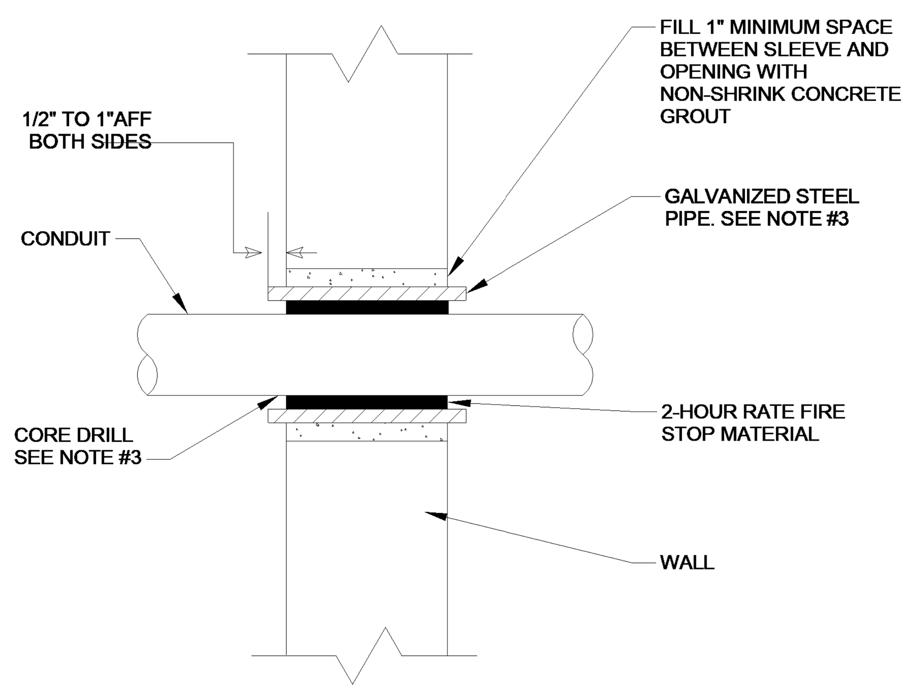
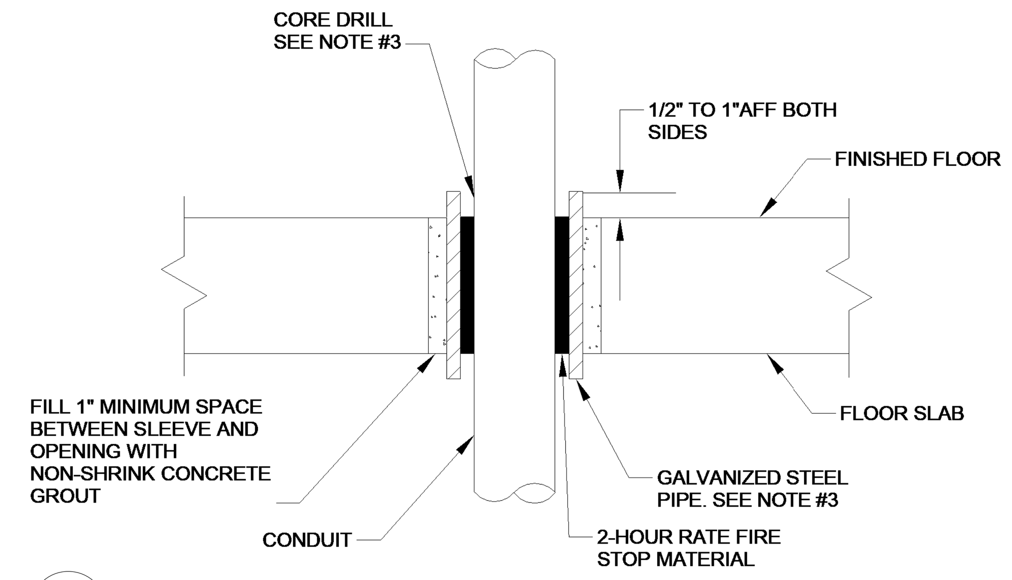
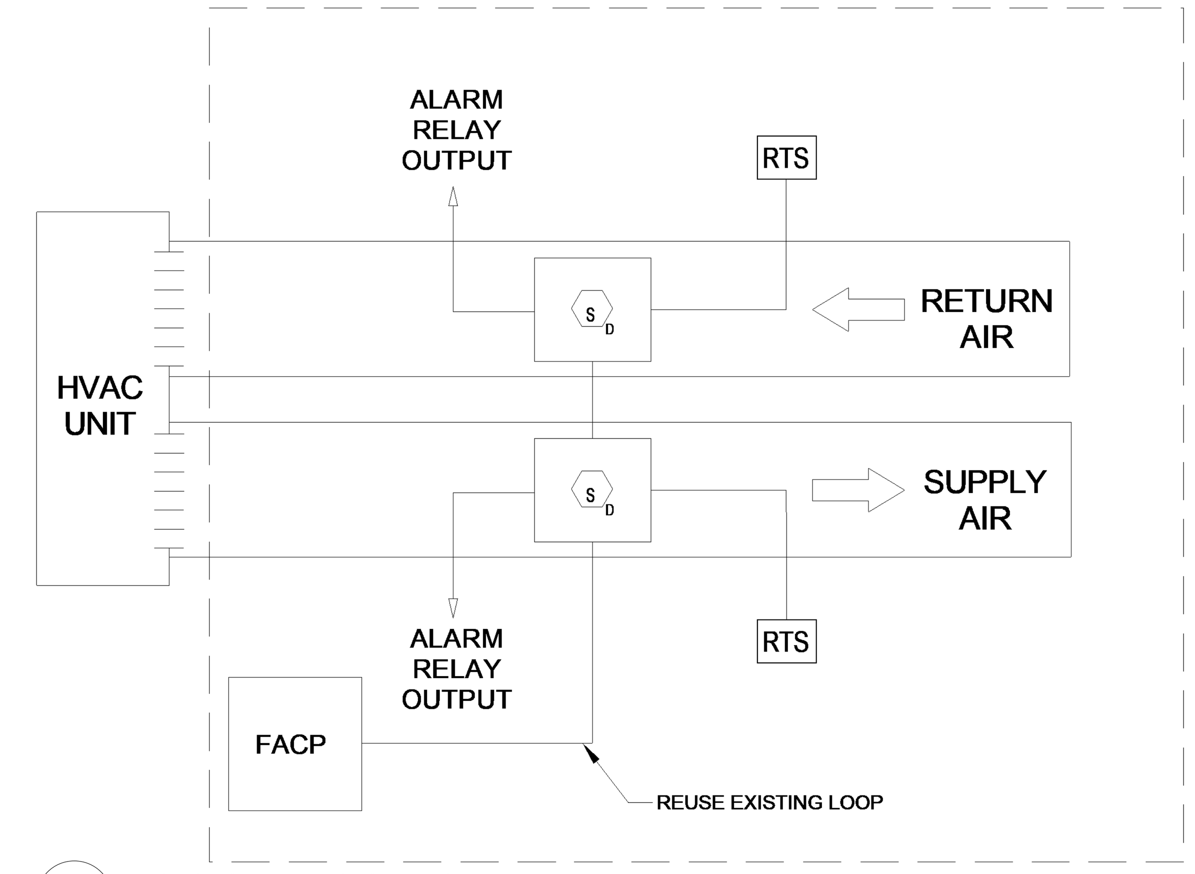


1 E501 CONDUIT PENETRATION DETAIL THROUGH MASONRY WALL
NOT TO SCALE



2 E501 CONDUIT PENETRATION DETAIL THROUGH MASONRY FLOOR
NOT TO SCALE



3 E501 DUCT SMOKE DETECTOR DIAGRAM
NOT TO SCALE

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DRAWING TITLE:
ELECTRICAL DETAILS

FILE: 2022/3562
DRAWN BY: CSG
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FEEDER SIZE SCHEDULE (3-PHASE AND 1-PHASE, COPPER CONDUCTORS)

CIRCUIT OR OVERCURRENT DEVICE RATING	1-PHASE, 3-WIRE CONDUCTOR AND GROUND*	CONDUIT SIZE (MINIMUM)	3-PHASE, 3-WIRE CONDUCTOR AND GROUND*	CONDUIT SIZE (MINIMUM)	3-PHASE, 4-WIRE CONDUCTOR AND GROUND*	CONDUIT SIZE (MINIMUM)
15A	2#12, 1#12G	3/4"C	3#12, 1#12G	3/4"C	4#12, 1#12G	3/4"C
20A	2#12, 1#12G	3/4"C	3#12, 1#12G	3/4"C	4#12, 1#12G	3/4"C
25A	2#10, 1#10G	3/4"C	3#10, 1#10G	3/4"C	4#10, 1#10G	3/4"C
30A	2#10, 1#10G	3/4"C	3#10, 1#10G	3/4"C	4#10, 1#10G	3/4"C
35A	2#8, 1#10G	3/4"C	3#8, 1#10G	3/4"C	4#8, 1#10G	1"C
40A	2#8, 1#10G	3/4"C	3#8, 1#10G	3/4"C	4#8, 1#10G	1"C
45A	2#6, 1#10G	1"C	3#6, 1#10G	1"C	4#6, 1#10G	1"C
50A	2#6, 1#10G	1"C	3#6, 1#10G	1"C	4#6, 1#10G	1"C
60A	2#4, 1#10G	1"C	3#4, 1#10G	1"C	4#4, 1#10G	1-1/4"C
70A	2#4, 1#8G	1"C	3#4, 1#8G	1-1/4"C	4#4, 1#8G	1-1/4"C
80A	2#3, 1#8G	1"C	3#3, 1#8G	1-1/4"C	4#3, 1#8G	1-1/4"C
90A	2#2, 1#8G	1-1/4"C	3#2, 1#8G	1-1/4"C	4#2, 1#8G	1-1/2"C
100A	2#1, 1#8G	1-1/4"C	3#1, 1#8G	1-1/2"C	4#1, 1#8G	2"C
110A	---	---	3#1, 1#6G	1-1/2"C	4#1, 1#6G	2"C
125A	---	---	3#1/0, 1#6G	2"C	4#1/0, 1#6G	2"C
150A	---	---	3#1/0, 1#6G	2"C	4#1/0, 1#6G	2"C
175A	---	---	3#1/0, 1#6G	2"C	4#2/0, 1#6G	2"C
200A	---	---	3#3/0, 1#6G	2"C	4#3/0, 1#6G	2-1/2"C
225A	---	---	3#4/0, 1#4G	2-1/2"C	4#4/0, 1#4G	2-1/2"C
250A	---	---	3#250, 1#4G	2-1/2"C	4#250, 1#4G	3"C
300A	---	---	3#350, 1#4G	3"C	4#350, 1#4G	3"C
350A	---	---	3#500, 1#3G	3-1/2"C	4#500, 1#3G	4"C
400A	---	---	3#600, 1#3G	3-1/2"C	4#600, 1#3G	4"C
500A	---	---	6#250, 2#2G	(2) 2-1/2"C	8#250, 2#2G	(2) 3"C
600A	---	---	6#350, 2#1G	(2) 3"C	8#350, 2#1G	(2) 3"C

* CONDUCTOR SIZES ARE BASED ON 60°C TEMPERATURE RATING FOR OVERCURRENT DEVICES 100A AND SMALLER AND 75°C TEMPERATURE RATING FOR OVERCURRENT DEVICES LARGER THAN 100A. NOT MORE THAN THREE CURRENT CARRYING CONDUCTORS SHALL BE PROVIDED IN RACEWAY, CABLE OR EARTH (DIRECT BURY), BASED ON AMBIENT TEMPERATURE OF 30°C, UNLESS OTHERWISE NOTED.

FEEDER SIZE SCHEDULE NOTES:

1. FEEDER SIZES ARE BASED ON COPPER CONDUCTORS (TYPE THHN/THWN FOR CONDUCTORS SMALLER THAN #3, AND TYPE XHHW FOR CONDUCTORS #3 AND LARGER).
2. PROVIDE 4-WIRE FEEDER UNLESS DEVICE SERVED DOES NOT HAVE PROVISIONS FOR A NEUTRAL CONNECTION.
3. REFER TO MOTOR CIRCUIT SCHEDULE FOR MOTOR LOAD CONDUCTOR AND CONDUIT SIZE REQUIREMENTS.

MOTOR CIRCUIT SCHEDULE

TAG	SOURCE PANEL	OCP DEVICE	FEEDER SIZE	APPROX. FEEDER LENGTH IN FT.	LOCAL FUSED DISCONNECT SWITCH	MOTOR STARTER	LOAD						KEY NOTES
						TYPE	MCA	MOCP	HP	FLA	VOLTS	PHASE	
CH-4	PANEL OPSS	150A-3P	3-1/0+1#6G, 2"C	155	200A/150A	N/A	107	150	---	---	480	3	A
CH-4 HEAT	NEW PANEL OPSS-A	15A-1P	2#12+1#12G, 3/4"C	155	30A/15A	N/A	---	---	---	10	120	1	A
CH-5	PANEL OPSN	150A-3P	3-1/0+1#6G, 2"C	100	200A/150A	N/A	107	150	---	---	480	3	A
CH-5 HEAT	PANEL OP1WN	15A-1P	2#12+1#12G, 3/4"C	100	30A/15A	N/A	---	---	---	10	120	1	A
CH-6	PANEL OPSN	125A-3P	3-1/0+1#6G, 2"C	100	200A/125A	N/A	95	125	---	---	480	3	A
CH-6 HEAT	PANEL OP1WN	15A-1P	2#12+1#12G, 3/4"C	100	30A/15A	N/A	---	---	---	10	120	1	A
AHU-2	PANEL OPA1	90A-3P	3#6+1#8G, 1"C	165	100A/90A	BY DIV. 23 - VFD	52.5	90	(4) 3	42	208	3	A
AHU-3	PANEL OPA1	90A-3P	3#6+1#8G, 1"C	115	100A/90A	BY DIV. 23 - VFD	53	90	10	42.5	208	3	A
AHU-4	PANEL OPA1	90A-3P	3#6+1#8G, 1"C	125	100A/90A	BY DIV. 23 - VFD	53	90	10	42.5	208	3	A
AHU-5	PANEL OPA1	60A-3P	3#8+1#10G, 3/4"C	65	100A/60A	BY DIV. 23 - VFD	35.5	60	7.5	28.5	208	3	A
AHU-6	PANELOPA1	60A-3P	3#8+1#10G, 3/4"C	65	100A/60A	BY DIV. 23 - VFD	35.5	60	7.5	28.5	208	3	A
AHU-7	PANEL OPA1	90A-3P	3#6+1#8G, 1"C	125	100A/90A	BY DIV. 23 - VFD	53	90	10	42.5	208	3	A
AHU-8	PANEL OPA1	90A-3P	3#6+1#8G, 1"C	115	100A/90A	BY DIV. 23 - VFD	53	90	10	42.5	208	3	A
AHU-9L	PANEL OP1WS	50A-3P	3#10+1#10G, 3/4"C	120	60A/50A	BY DIV. 23 - VFD	28	50	5	22.5	208	3	A
AHU-9R	PANEL NOT IDENTIFIED	50A-3P	3#10+1#10G, 3/4"C	120	60A/50A	BY DIV. 23 - VFD	28	50	5	22.5	208	3	A
AHU-11L	PANEL OP1WS	15A-3P	3#12+1#12G, 3/4"C	120	BY DIV. 23	N/A	5.75	15	1	4.6	208	3	A,C
AHU-11R	PANEL NOT IDENTIFIED	15A-3P	3#12+1#12G, 3/4"C	120	BY DIV. 23	N/A	5.75	15	1	4.6	208	3	A,C
MAU-1	PANEL OP1WN	15A-3P	3#12+1#12G, 3/4"C	50	30A/15A	BY DIV. 23 - VFD	9	15	2	7.3	208	3	A
AHU-14L-1	PANEL 133A/B	15A-3P	3#12+1#12G, 3/4"C	150	BY DIV. 23	N/A	3	15	0.5	2.4	208	3	A,C
AHU-14L-2	PANEL 133A/B	15A-3P	3#12+1#12G, 3/4"C	150	BY DIV. 23	N/A	3	15	0.5	2.4	208	3	A,C
AHU-14L-3	PANEL 133A/B	15A-3P	3#12+1#12G, 3/4"C	150	BY DIV. 23	N/A	3	15	0.5	2.4	208	3	A,C
AHU-14L-5	PANEL 133A/B	15A-3P	3#12+1#12G, 3/4"C	150	BY DIV. 23	N/A	3	15	0.5	2.4	208	3	A,C
PK-1	PANEL LOCATED IN IT CLOSET	40A-2P	2#10+1#10G, 3/4"C	115	60A/40A	BY DIV. 23	24.4	40	0.5	4.1	208	1	A
PK-2	PANEL TP 107 IN ELEC CLOSET	30A-2P	2#10+1#10G, 3/4"C	120	30A/30A	BY DIV. 23	20.6	30	0.5	4.1	208	1	A
PK-3	PANEL TP 107 IN ELEC CLOSET	30A-2P	2#10+1#10G, 3/4"C	120	30A/30A	BY DIV. 23	20.6	30	0.5	4.1	208	1	A
EX-2	PANEL OPA2	30A-3P	3#12+1#12G, 3/4"C	165	30A/20A	BY DIV. 23 - VFD	---	---	3	---	208	3	A
EX-3	PANEL OPA2	15A-3P	3#12+1#12G, 3/4"C	100	30A/15A	BY DIV. 23 - VFD	---	---	2	---	208	3	A
EX-4	PANEL OPA2	15A-3P	3#12+1#12G, 3/4"C	165	30A/15A	BY DIV. 23 - VFD	---	---	2	---	208	3	A
EX-5	PANEL OPA2	15A-3P	3#12+1#12G, 3/4"C	65	30A/15A	BY DIV. 23 - VFD	---	---	1	---	208	3	A
EX-6	PANEL OPA2	15A-3P	3#12+1#12G, 3/4"C	65	30A/15A	BY DIV. 23 - VFD	---	---	1	---	208	3	A
EX-7	PANEL OPA2	15A-3P	3#12+1#12G, 3/4"C	125	30A/15A	BY DIV. 23 - VFD	---	---	2	---	208	3	A
EX-8	PANEL OPA2	15A-3P	3#12+1#12G, 3/4"C	115	30A/15A	BY DIV. 23 - VFD	---	---	2	---	208	3	A

General Notes:

1) OCP DEVICES AND LOCAL DISC. SWITCHES, FVNR STARTERS, WIRING AND CONDUIT SHALL BE NEW(FURNISHED AND INSTALLED BY DIVISION 26) FROM SOURCE TO EQUIPMENT.
2) ALL VFD's SHALL BE FURNISHED AND INSTALLED BY DIVISION 23 AND WIRED BY DIV. 26. POWER WIRING FROM SOURCE TO VFD BY DIV. 26. POWER WIRING BETWEEN VFD/STARTERS AND MOTORS BY DIV. 26. CONTROL WIRING BY DIVISION 23.

KEY NOTES:

A THE "OCP DEVICE" SHALL BE A CIRCUIT BREAKER.
B THE "OCP DEVICE" SHALL BE FUSED DISCONNECT SWITCH.
C LOCAL DISCONNECT SWITCHES FURNISHED BY DIVISION 23 SHALL BE AN INTEGRAL COMPONENT OF THE EQUIPMENT.

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CLIENT:
GREATER HARTFORD TRANSIT DISTRICT
1 UNION PLACE
HARTFORD, CT 06103

THIS SQUARE APPEARS 1/2"x1/2" ON FULL SIZE SHEETS

NO	DATE	REVISION

STAMP:

PROJECT NAME:
GHTD UNION STATION HVAC UPGRADES

1 UNION PLACE
HARTFORD, CT

DRAWING TITLE:
ELECTRICAL SCHEDULES

FILE: 2022/3562
DRAWN BY: Author
CHECKED BY:Checker
ISSUE DATE: 11/01/2023
DRAWING NO: **E601**

EAGLE Environmental, Inc.

- Industrial Hygiene / IAQ
- Hazardous Building Materials
- Environmental Assessments
- Laboratory Services & Training

October 28, 2022

Mr. Tony Punzalan, PE
Senior Director of Facilities Engineering
AI Engineers
919 Middle Street
Middletown, Connecticut 06457

RE: Pre-Renovation Hazardous Building Materials Inspection Report
Greater Hartford Transit District – HVAC Upgrades
Union Station
1 Union Place
Hartford, Connecticut
Eagle Project No. 22-187.10T1

Dear Mr. Punzalan:

Please find the report for the hazardous building materials inspection conducted at the Greater Hartford Transit District Union Station located at 1 Union Place in Hartford, Connecticut. The scope of services included an asbestos-containing materials inspection, lead-based paint screen and an inspection for universal waste materials. The inspection was performed to support upgrades to Heating, Ventilation, and Air Conditioning (HVAC) equipment throughout the building.

Please do not hesitate to contact us if you have any questions regarding the contents of this report.

Sincerely,
Eagle Environmental, Inc.

Peter J. Folino
President

Z:\2022 Files\2022 Reports\AI Engineers\1 Union Place - Union Station\1 Union Pl - Pre-Reno Haz Inspection Report.doc

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APPENDICES

1. INTRODUCTION

On October 25, 2022, Eagle Environmental, Inc. (Eagle) conducted a hazardous building materials inspection of HVAC equipment within the Greater Hartford Transit District Union Station located at 1 Union Place in Hartford, Connecticut (Site). The scope of the hazardous building material inspection included an asbestos-containing materials inspection, a lead-based paint screen, and an inspection for universal waste materials. The inspection was performed to support HVAC upgrades within the Site building.

1.1 Inspection Area Description

Eagle performed a hazardous building materials inspection of HVAC equipment within several areas of the Site building. The inspection focused on the HVAC equipment and building materials that may potentially be disturbed by the HVAC upgrade work. Eagle was accompanied by an AI Engineers representative during the inspection. The areas inspected are identified on attached Floor Plans FP-1 through FP-4. Eagle reviewed mechanical demolition plans MD101, MD102, MD103, and MD104 to determine locations and extent of mechanical demolition. The following locations contained mechanical equipment scheduled for demolition and were included within the scope of the inspection:

<u>Located on FP-1</u>

- Level 1 Electrical Room
- Level 1 Exterior Parking Area
- Level 1 Office Space Above Ceilings (Inaccessible due to occupancy during inspection)

<u>Located on FP-2</u>

- Level 1 Transportation Center Left
- Level 1 Transportation Center Right

<u>Located on FP-3</u>

- South Mezzanine
- North Mezzanine

<u>Located on FP-4</u>

- Attic Space

2. SCOPE OF INSPECTION

2.1 Asbestos Containing Materials

The asbestos inspection was conducted in order to satisfy the United States Environmental Protection Agency (USEPA) National Emission Standard for Hazardous Air Pollutants Act (NESHAP) as amended November 20, 1990. The USEPA NESHAP final rule requires the identification and removal of all regulated ACM in an area of renovation prior to renovating the area if the renovation work will impact the ACM.

The asbestos inspection was performed by Peter J. Folino; a CT DPH licensed Asbestos Inspector/Management Planner (license #000184).

2.2 Lead-based Paint

2.2.1 X-Ray Fluorescence Screen

The lead-based paint (LBP) screen was performed in accordance with the requirements of the State of Connecticut, Department of Energy and Environmental Protection (DEEP), Guidance for the Management and Disposal of Lead Contaminated Materials Generated in the Lead Abatement, Renovation and Demolition Industries. The DEEP regulates the disposal of hazardous lead waste in the State of Connecticut. Lead-contaminated debris, not contaminated with other hazardous materials, is classified either as hazardous lead waste or as non-hazardous solid waste.

Additionally, the U.S. Department of Labor Occupational Safety and Health Administration (OSHA) regulates lead dust exposure to workers in the construction industry under 29 CFR 1926.62 Lead in Construction.

The lead-based paint screen was performed by Jonathan Vargas; a CT DPH licensed Lead Inspector (license #002270).

2.3 Universal Waste Materials and Other Environmental Concerns

2.3.1 Polychlorinated Biphenyls (PCB) and Di-ethylhexlpthalate (DEHP) Containing Items

PCB and DEHP lighting ballasts and electrical equipment, including capacitors and switches that contain PCBs, are regulated under the Toxic Substances Control Act of 1976 (TSCA) which bans the manufacturing and distribution of PCBs and regulates their storage and disposal.

PCBs and DEHP can be found in a number of items, including lighting ballast and electrical equipment, including capacitors and switches. DEHP and PCB-containing items such as these must be managed and disposed of in accordance with special requirements. A visual inspection for PCB and DEHP containing items was performed at the Site building.

2.3.2 Mercury Containing Items

Fluorescent lamps, thermostats, mercury switches, manometers, natural gas meters and other items can contain enough mercury to be classified as a special waste, and therefore may not be disposed of as regular construction debris. The mercury and mercury vapors associated with these products must be reclaimed prior to disposal or recycling of the products. A visual inspection for the presence of fluorescent lamps, thermostats and switches potentially containing mercury was performed at the Site building.

3. INSPECTION PROTOCOLS

3.1 Asbestos Containing Materials

3.1.1 Inspection

The asbestos-containing materials (ACM) inspection included the accessible areas of the mechanical spaces and accessible materials associated with the mechanical equipment. The scope of mechanical demolition generally included the one-for-one replacement of Air Handling Units (AHUs), Exhaust Fans (EFs) and localized piping and duct work servicing the units. The mechanical equipment was operational at the time of the inspection. Panels on the mechanical equipment were not opened if the mechanical equipment was operational. Interior of duct work was inspected to the best extent possible.

During the inspection, suspect materials are located, sampled, quantified and the friability of the material is determined. Friable materials are those materials that hand pressure can crumble, pulverize or reduce to powder when dry. An estimated quantity of identified ACM is provided for positive materials only. The materials are quantified in linear or square feet, depending on the nature of the material.

3.1.2 Bulk Sampling

During the sampling process, suspect ACM is separated into three (3) USEPA categories. These categories are: Thermal System Insulation (TSI), Surfacing Materials (SURF) and Miscellaneous materials (MISC). TSI includes all materials used to prevent heat loss or gain or water condensation on mechanical systems. Examples of TSI are pipe covering, boiler insulation, duct wrap and mudpack fitting cement. Surfacing ACM includes all ACM that is sprayed, toweled or otherwise applied to an existing surface. These applications are most commonly used in fireproofing, decorative and acoustical applications. Miscellaneous materials include all ACM not listed in thermal or surfacing, such as linoleum, vinyl asbestos flooring and ceiling tile.

Bulk sampling was performed in a random method. Bulk sampling methods and number of samples collected meets or exceeds the USEPA requirements.

3.1.3 Bulk Sample Analysis

The samples of the suspect asbestos containing materials were sent to a CT DPH approved laboratory for analysis by Polarized Light Microscopy (PLM). PLM is the USEPA accepted method of analysis for identification of asbestos in bulk matrices. Samples are collected individually or in sets. When sets of samples are collected, each set is systematically analyzed until one sample is determined to contain asbestos. Upon the determination of the presence of asbestos in one sample in the set, analysis of the remaining samples in the set is discontinued. If no asbestos is observed during analysis of the set of samples, the suspect material is determined to be negative for asbestos content.

Sample analysis results are reported in percentage of asbestos and non-asbestos components. The USEPA defines any material that contains greater than one percent asbestos, utilizing PLM, as being an asbestos-containing material (ACM). The State of Connecticut defines any material that contains equal to or greater than one percent asbestos, utilizing PLM, as being an asbestos-containing material (ACM). Suspect materials containing greater than one percent (>1%) asbestos utilizing the PLM Point Count Method or the NOB TEM method are also considered to be asbestos-containing. Materials determined to contain equal to or greater than one percent (>1%) asbestos are regulated by the USEPA, CT DPH and DEEP and the United States Department of Labor. Sample results indicating “no asbestos detected” (NAD) are specified as non-asbestos containing materials. Samples results indicating “Did Not Analyze” (DNA) are not analyzed due to the stop on first positive request to the laboratory.

3.1.3.1 Friable ACM Analysis

Certain samples of friable materials shown to contain less than ten percent (<10%) asbestos are analyzed further by the "Point Count Method". This procedure is recommended by the United States Environmental Protection Agency to confirm friable bulk samples shown to have less than ten percent (<10%) asbestos by PLM to be definitively negative or positive for asbestos. This method is accepted as providing statistically reliable results when analyzing bulk samples with very low asbestos concentrations. Friable materials containing "Trace" or "less than one percent (<1%)" asbestos must be analyzed by the PLM Point Count Method. None of the samples were further analyzed by the PLM Point Count Method.

3.1.3.2 Non Friable ACM Analysis

Certain samples of organically bound non-friable materials shown to contain "less than 1% asbestos", "TRACE" or "NAD" are recommended for analyses by the "NOB TEM ELAP 198.4 Method". This procedure is recommended by the United States Environmental Protection Agency to further evaluate non-friable organically bound materials for asbestos. Suspect materials confirmed by NOB TEM to be "less than one percent (<1%) asbestos", "TRACE" or "NAD" are considered non-asbestos containing. None of the samples were further analyzed by the NOB TEM Method.

3.2 Lead-based Paint

3.2.1 X-Ray Fluorescence Screen

The lead-based paint screen was performed utilizing an X-Ray Fluorescence (XRF) Radiation Monitoring Device (RMD) Lead Paint Analyzer (LPA 1), serial number 2753 within the limits of the inspection area(s). The screen included testing mechanical equipment, supports and ancillary piping and duct for lead.

The data is presented on computer generated Lead Inspection Reports contained in Appendix C. The Summary Report provides an inventory of each surface coating that contains lead at or above 1.0 mg/cm². The Detailed Report is an inventory of each tested surface on a room-by-room basis.

For the purpose of this report, the XRF results are separated into two (2) categories; high levels of lead (≥1.0 mg/cm²) and low levels of lead (<1.0 mg/cm²). Building materials containing high levels of lead have a greater probability of creating worker exposures during construction than do building materials with low levels of lead. Additionally, lead waste characterization sampling is required for building materials containing high levels of lead (≥1.0 mg/cm²) and will become a waste product as a result of demolition or renovation activities.

OSHA regulates lead dust exposure to workers in the construction industry under 29 CRF 1926.62 Lead Exposure in Construction; Interim Final Rule. Currently, OSHA does not define a threshold level of lead in paint that may cause worker exposure. Any detectable level of lead in paint (>0.0 mg/cm² +/- 0.3 mg/cm² by XRF or ≥0.01 % by AAS) requires task specific exposure monitoring.

3.3 Universal Waste Materials and Other Environmental Concerns

3.3.1 PCB and Di-ethylhexlpthalate (DEHP) Containing Items

A visual inspection for the presence of lighting ballasts and electrical equipment potentially containing PCB's or DEHP was performed within the inspection areas. Lighting ballasts and oil-filled capacitor manufactured after 1979 may have "NO PCB's" stamped on its casing. These are filled with oil which does not contain PCB's but may contain DEHP. Lighting ballasts and Capacitors with date stamps prior to 1979 or no date stamps are assumed to contain PCB's. Lighting ballasts and capacitors labeled as "No PCB's" are assumed to contain DEHP if the date stamp is illegible or non-existent. Electronic ballasts are not assumed to contain PCB's or DEHP.

3.3.2 Mercury Containing Items

During the visual inspection process, fluorescent, metal halide and sodium lamps are assumed to contain mercury vapors. Thermostatic controls, switches, manometers, capacitors and other used electronic components are inventoried during the inspection process.

4. INSPECTION RESULTS

4.1 Asbestos Containing Materials

During the course of the building inspection thirty-four (34) bulk samples of suspect ACM were collected and analyzed by PLM analysis. From the thirty-four (34) samples analyzed, all suspect materials were confirmed to be non-ACM.

The summary of non-asbestos materials is presented in Table II. The asbestos analysis laboratory reports are provided in Appendix B.

Any suspect material not specifically identified in this report as non-ACM should be assumed to contain asbestos unless sample results prove otherwise. Eagle recommends that a project specification for asbestos abatement be prepared to further clarify the type, location and quantity of ACM requiring abatement. This report is not intended to serve as a scope of work or technical specification for asbestos abatement.

4.2 Lead-based Paint

4.2.1 X-Ray Fluorescence Screen

A total of forty-six (46) XRF readings were collected during the lead-based paint screen of the building, including instrument calibration readings. From the forty-six (46) readings, no surfaces or components were found to contain high levels of lead. Two (2) surfaces were found to contain low levels of lead including the painted wallboard (0.1 mg/cm^2) in the Transportation Center Left Mechanical Room and the stone wall (0.2 mg/cm^2) in the Level 1 Electrical Room.

OSHA regulates lead dust exposure to workers in the construction industry under 29 CFR 1926.62 Lead Exposure in Construction; Interim Final Rule. Currently, OSHA does not define a threshold level of lead in paint that may cause worker exposure. Any detectable level of lead in paint (>0.0 mg/cm^2 +/- 0.3 mg/cm^2 by XRF or >0.01 % by AAS) requires task specific exposure monitoring. This "initial exposure assessment" must be conducted by trained workers utilizing appropriate personal protective equipment. Exposure assessments must be conducted for each task where painted surfaces or components are disturbed.

A complete inventory of tested building materials is presented in Detailed Reports contained Appendix C.

4.3 Universal Waste Materials and Other Environmental Concerns

4.3.1 PCB and Di-ethylhexlpthalate (DEHP) Containing Items

No PCB containing lighting ballasts or capacitors were identified. The AHU's contain electric motors, which may have a running capacitor within the motor housing. The motor housing units were not removed for inspection. The motors may be reused or recycled but should not be placed in a municipal or solid waste landfill.

4.3.2 Mercury Containing Items

No switches or controls were identified, which may contain Mercury. The controls associated with the equipment appeared to be pneumatic.

TABLE I

ASBESTOS CONTAINING MATERIALS SUMMARY TABLE

KEY FOR TABLES I and II

*** Please utilize the following key for abbreviations used in Tables I and II**

KEY		ANALYTICAL METHODS
DNA = DID NOT ANALYZE	SF = SQUARE FEET	PLM PC = EPA 600/R-93/116 QUANTITATION 400 POINT COUNT
NAD = NO ASBESTOS DETECTED	LF = LINEAR FEET	TEM NOB = NEW YORK ELAP 198.4 METHOD
F = FRIABLE	Chrys = Chrysotile	PLM = EPA 600/R-93/116
NF = NON-FRIABLE	Amos = Amosite	PS = Previously Sampled
TSI = THERMAL SYSTEMS INSULATION	Anth = Anthophylite	EA = Each
SURF = SURFACING MATERIAL	Trem = Tremolite	IM = Insufficient Material
MISC = MISCELLANEOUS MATERIAL	Croc = Crocidolite	NQ = Not Quantifiable
BOLD TEXT IN "LOCATION" COLUMN INDICATES SAMPLE LOCATION		

TABLE I
ASBESTOS CONTAINING MATERIALS
SUMMARY TABLE
GREATER HARTFORD TRANSIT DISTRICT
UNION STATION
1 UNION PLACE
HARTFORD, CONNECTICUT

LOCATION(S)	MATERIAL TYPE	SAMPLE NUMBER	CATEGORY	BULK SAMPLE ANALYSIS RESULTS				ESTIMATED QUANTITY	F/NF
				PLM	PLM PC	TEM NOB	ACM		
NO ASBESTOS CONTAINING MATERIALS WERE IDENTIFIED DURING THIS INSPECTION									

TABLE II

NON-ASBESTOS-CONTAINING MATERIALS SUMMARY TABLE

KEY FOR TABLES I and II

*** Please utilize the following key for abbreviations used in Tables I and II**

KEY		ANALYTICAL METHODS
DNA = DID NOT ANALYZE	SF = SQUARE FEET	PLM PC = EPA 600/R-93/116 QUANTITATION 400 POINT COUNT
NAD = NO ASBESTOS DETECTED	LF = LINEAR FEET	TEM NOB = NEW YORK ELAP 198.4 METHOD
F = FRIABLE	Chrys = Chrysotile	PLM = EPA 600/R-93/116
NF = NON-FRIABLE	Amos = Amosite	PS = Previously Sampled
TSI = THERMAL SYSTEMS INSULATION	Anth = Anthophylite	EA = Each
SURF = SURFACING MATERIAL	Trem = Tremolite	IM = Insufficient Material
MISC = MISCELLANEOUS MATERIAL	Croc = Crocidolite	NQ = Not Quantifiable
BOLD TEXT IN "LOCATION" COLUMN INDICATES SAMPLE LOCATION		

TABLE II
NON - ASBESTOS CONTAINING MATERIALS
SUMMARY TABLE
GREATER HARTFORD TRANSIT DISTRICT
UNION STATION
1 UNION PLACE
HARTFORD, CONNECTICUT

SAMPLE LOCATION(S)	MATERIAL TYPE	SAMPLE NUMBER	CATEGORY	BULK SAMPLE ANALYSIS RESULTS			
				PLM	PLM PC	TEM NOB	ACM
Transporation Center Mechanical Rooms - Left & Right (Units 9L & 11L)	Flex connector - black	10-25-PF-01A	MISC	NAD			NO
		10-25-PF-01B		NAD			
		10-25-PF-01C		NAD			
Transporation Center Mechanical Room-Left	Joint compound - white	10-25-PF-02A	MISC	NAD			NO
		10-25-PF-02B		NAD			
Transporation Center Mechancial Rooms - Left & Right	Fiberglass endcap sealant - white	10-25-PF-03A	MISC	NAD			NO
		10-25-PF-03B		NAD			
		10-25-PF-03C		NAD			
Transporation Center Mechanical Room-Left	Sheetrock - white	10-25-PF-04A	MISC	NAD			NO
		10-25-PF-04B		NAD			
Trans Center Mechanical Room-Right	Condesation repair tape - black	10-25-PF-05A	MISC	NAD			NO
		10-25-PF-05B		NAD			
Electrical Room	Spray-applied fire proofing - tan	10-25-PF-06A	TSI	NAD			NO
		10-25-PF-06B		NAD			
		10-25-PF-06C		NAD			
Exterior Parking Area - Level 1 (Chiller 6)	Seam caulk on aluminum pipe cover	10-25-PF-07A	MISC	NAD			NO
		10-25-PF-07B		NAD			
Exterior Parking Area - Level 1 (Chillers 5 & 6)	Fiberglass insulation	10-25-PF-08A	MISC	NAD			NO
		10-25-PF-08B		NAD			
		10-25-PF-08C		NAD			
Office Mezzannine PK 1 - North Side	White debris on duct	10-25-PF-09A	MISC	NAD			NO
		10-25-PF-09B		NAD			

TABLE II
NON - ASBESTOS CONTAINING MATERIALS
SUMMARY TABLE
GREATER HARTFORD TRANSIT DISTRICT
UNION STATION
1 UNION PLACE
HARTFORD, CONNECTICUT

SAMPLE LOCATION(S)	MATERIAL TYPE	SAMPLE NUMBER	CATEGORY	BULK SAMPLE ANALYSIS RESULTS			
				PLM	PLM PC	TEM NOB	ACM
Exhaust Fan 3, Exhaust Fan 5 (Attic)	Flex connector - black round duct	10-25-PF-10A	MISC	NAD			NO
		10-25-PF-10B		NAD			
Exhaust Fan 4 (Attic)	Fiberglass gasket in square exhaust vent	10-25-PF-11A	MISC	NAD			NO
		10-25-PF-11B		NAD			
Air Handling Units 6, 7 & 8 (Attic)	Fiberglass endcap sealant	10-25-PF-12A	MISC	NAD			NO
		10-25-PF-12B		NAD			
		10-25-PF-12C		NAD			
Ceiling Throughout (Attic)	Gypcrete ceiling deck - white/brown	10-25-PF-13A	MISC	NAD			NO
		10-25-PF-13B		NAD			
		10-25-PF-13C		NAD			
Exhaust Fan 8 (Attic)	Duct sealant - tan/gold	10-25-PF-14A	MISC	NAD			NO
		10-25-PF-14B		NAD			

APPENDIX A

FLOOR PLANS WITH SAMPLE LOCATION DIAGRAMS

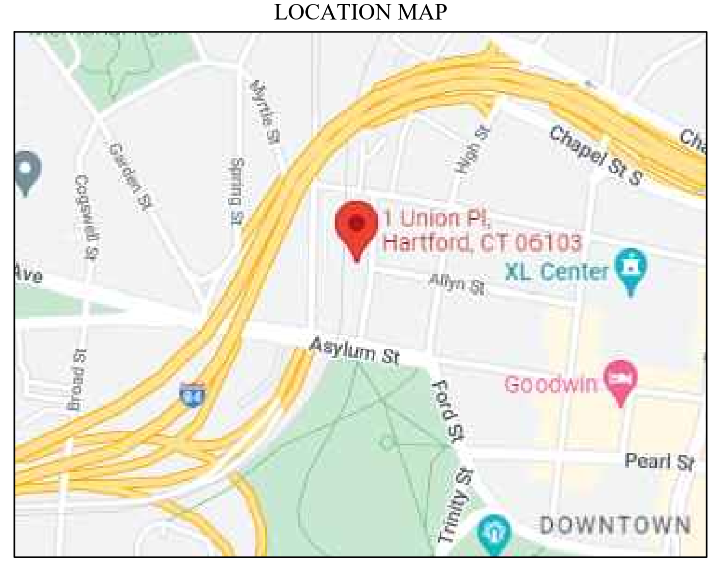
AI ENGINEERS
G.H.T.D. UNION STATION

1 UNION PLACE
HARTFORD, CONNECTICUT

EAGLE PROJECT NUMBER: 22-187.10T1

INDEX OF DRAWINGS

LOCATION MAP



OCTOBER 28, 2022

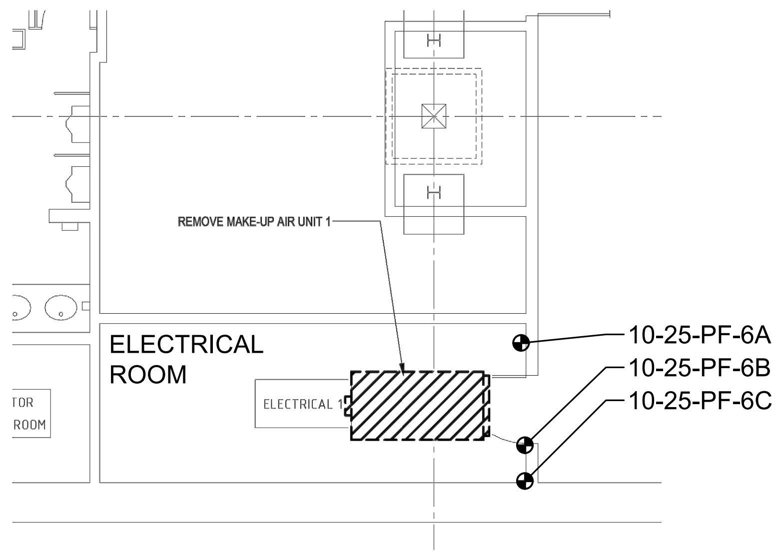
EAGLE Environmental, Inc.
8 SOUTH MAIN STREET, SUITE 3
TERRYVILLE, CONNECTICUT 06786
860-589-8257

Z:\2022 Files\2022 AutoCAD\AI Engineers\Union Station\HBM\CAD\1 Union Place - Union Station.dwg

SAMPLE KEY:

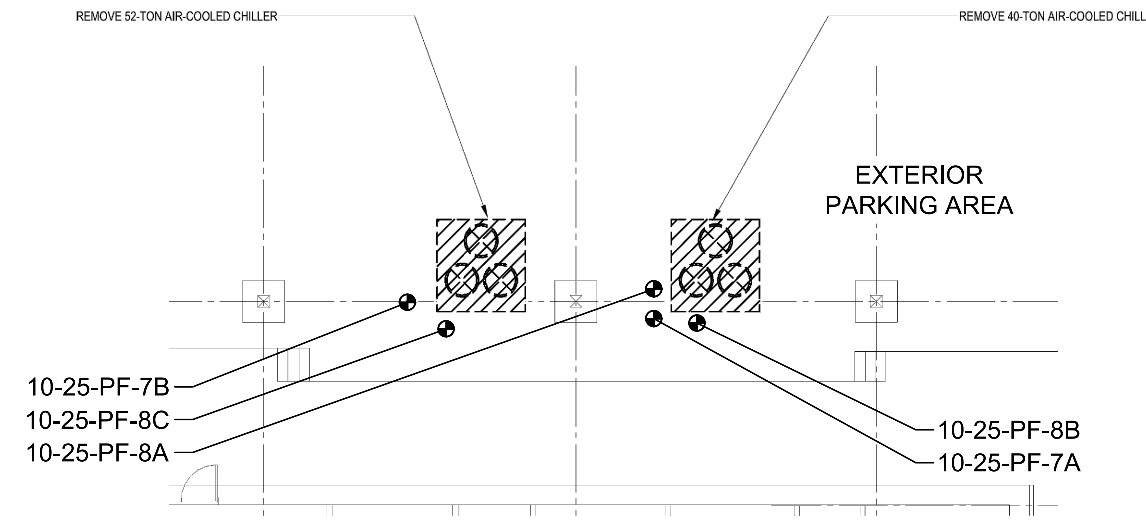
10-25-PF-## = ASBESTOS SAMPLE LOCATION AND NUMBER

BOLDED SAMPLE NUMBERS INDICATE PRESENCE OF ASBESTOS IN CONCENTRATIONS GREATER THAN 1% WITHIN SAMPLE SET.



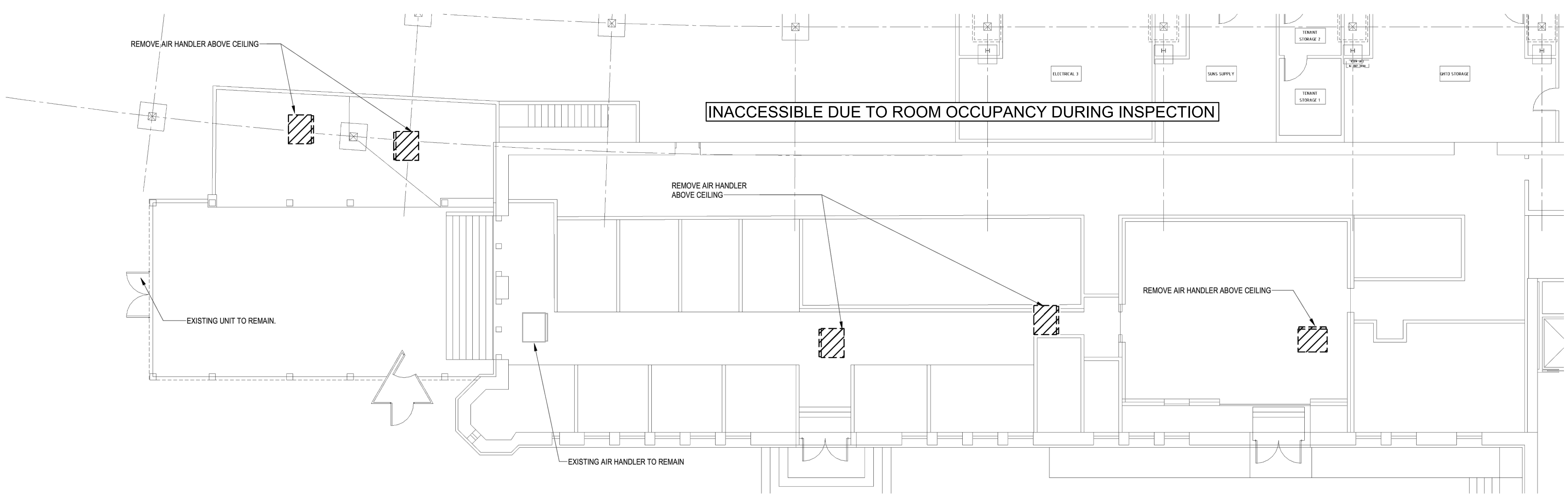
LEVEL 1 - ELECTRICAL ROOM

NOT TO SCALE



LEVEL 1 - EXTERIOR PARKING AREA

NOT TO SCALE



LEVEL 1 - OFFICE SPACE

NOT TO SCALE

PROJECT NO.: 22-187.10T1
DATE: 10/28/2022
DRAWN BY: BB
REVIEWED BY: PF

HAZARDOUS BUILDING MATERIALS INSPECTION
AI ENGINEERS
G.H.T.D. UNION STATION
1 UNION STATION
BRISTOL, CONNECTICUT

EAGLE Environmental, Inc.
8 SOUTH MAIN STREET, SUITE 3
TERRYVILLE, CONNECTICUT 06786
860-589-8257

SHEET NO.

FP-1

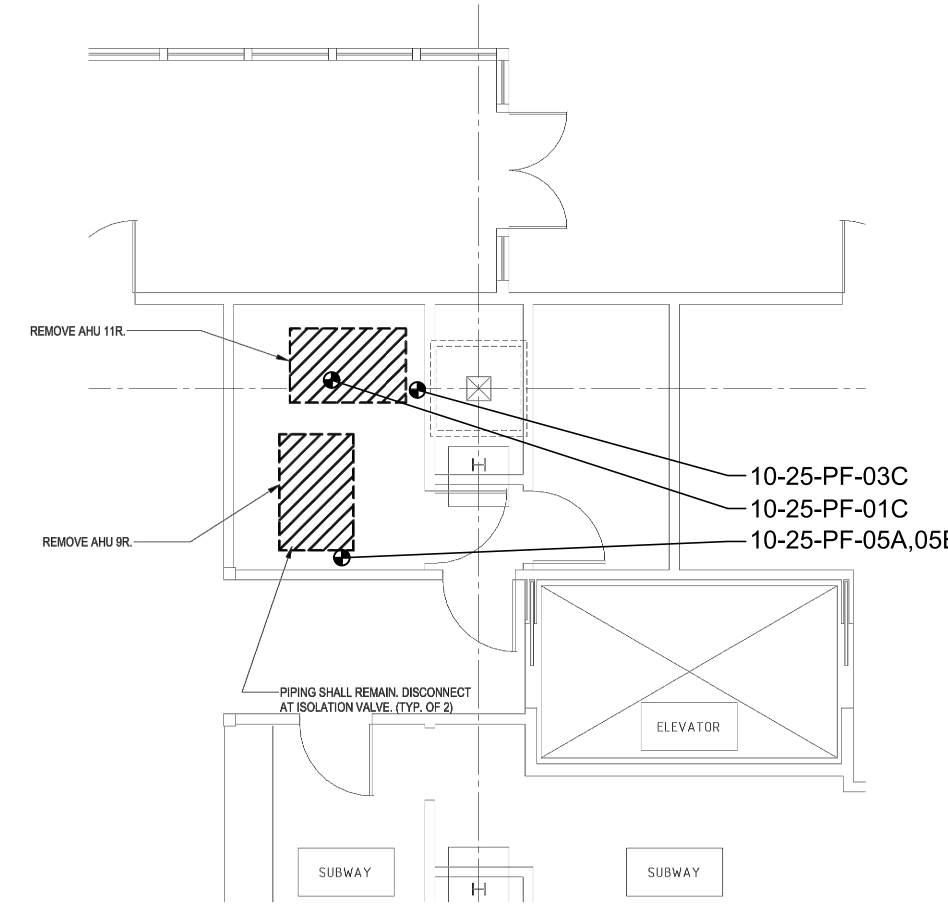
SHEET 1 OF 4

Z:\2022 Files\2022 AutoCAD\AI Engineers\Union Station\HBMI\CAD\1 Union Place - Union Station.dwg

SAMPLE KEY:

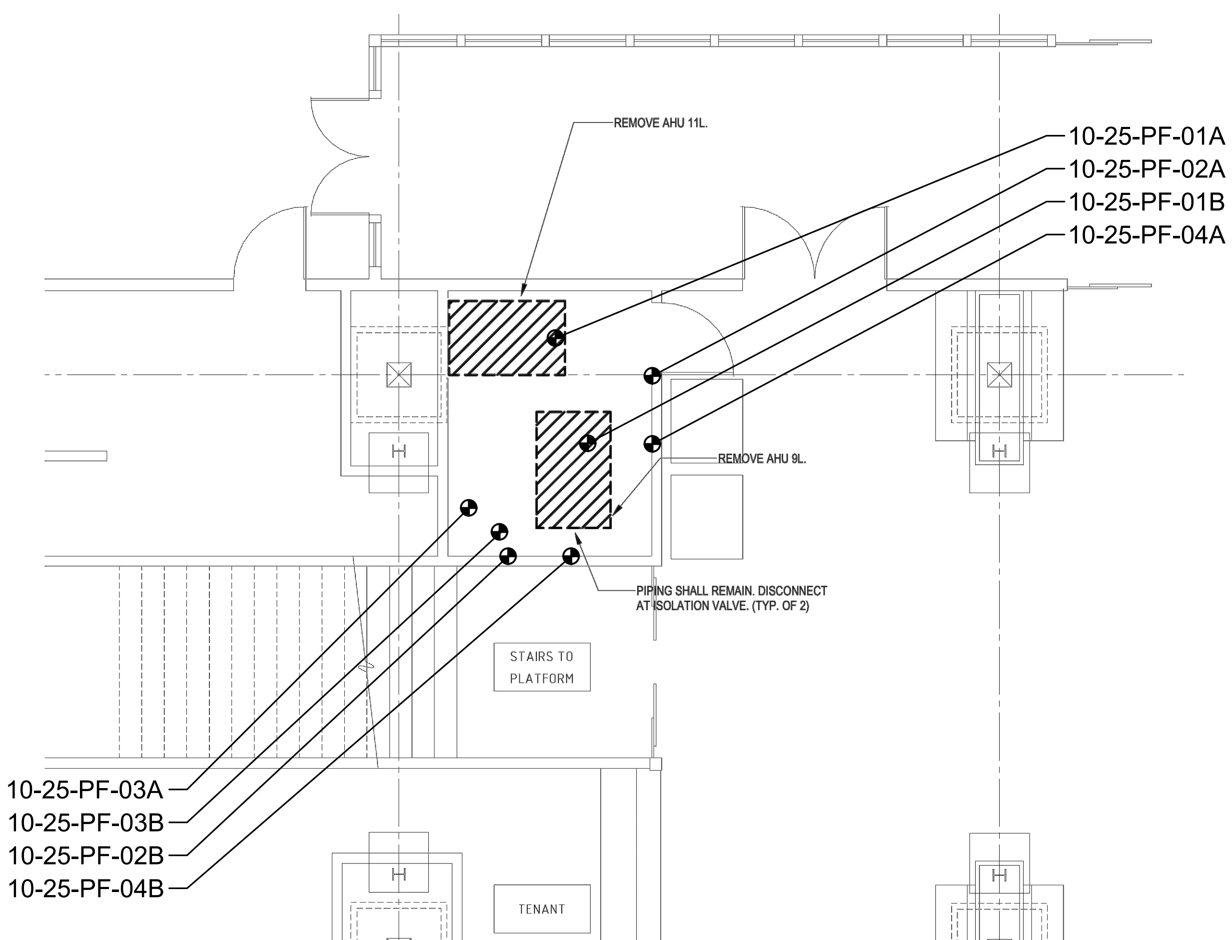
10-25-PF-## = ASBESTOS SAMPLE LOCATION AND NUMBER

BOLDED SAMPLE NUMBERS INDICATE PRESENCE OF ASBESTOS IN CONCENTRATIONS GREATER THAN 1% WITHIN SAMPLE SET.



LEVEL 1 - TRANSPORTATION CENTER (RIGHT)

NOT TO SCALE



LEVEL 1 - TRANSPORTATION CENTER (LEFT)

NOT TO SCALE

PROJECT NO.: 22-187.10T1
DATE: 10/28/2022
DRAWN BY: BB
REVIEWED BY: PF

HAZARDOUS BUILDING MATERIALS INSPECTION
AI ENGINEERS
G.H.T.D. UNION STATION
1 UNION STATION
BRISTOL, CONNECTICUT

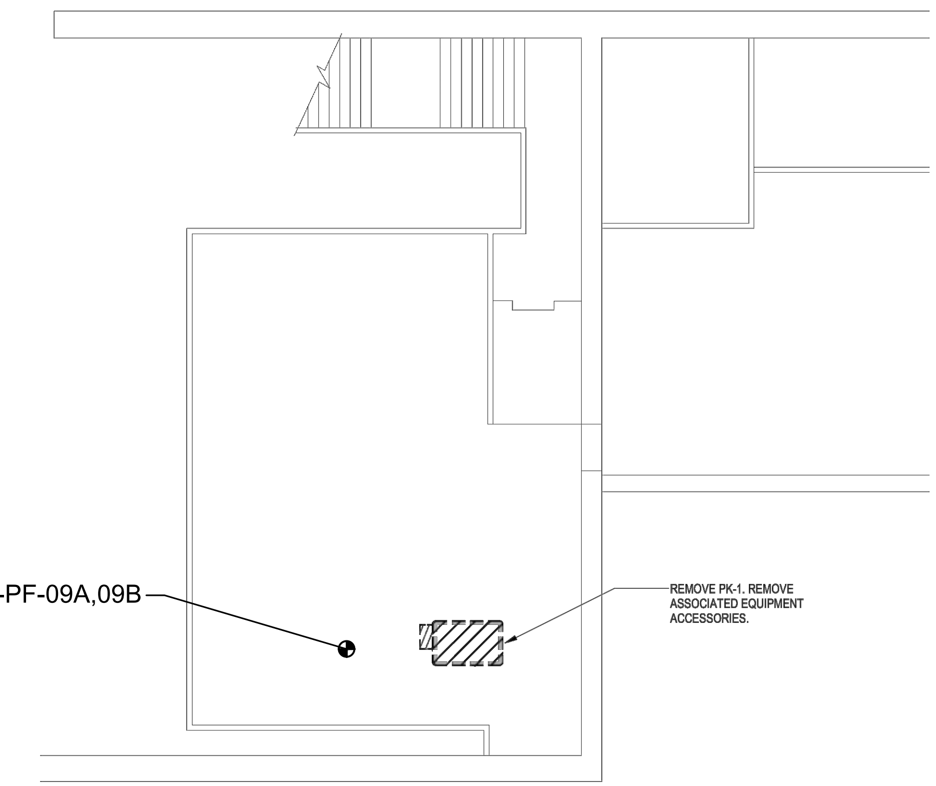
EAGLE Environmental, Inc.
8 SOUTH MAIN STREET, SUITE 3
TERRYVILLE, CONNECTICUT 06786
860-589-8257

SHEET NO.
FP-2
SHEET 2 OF 4

SAMPLE KEY:

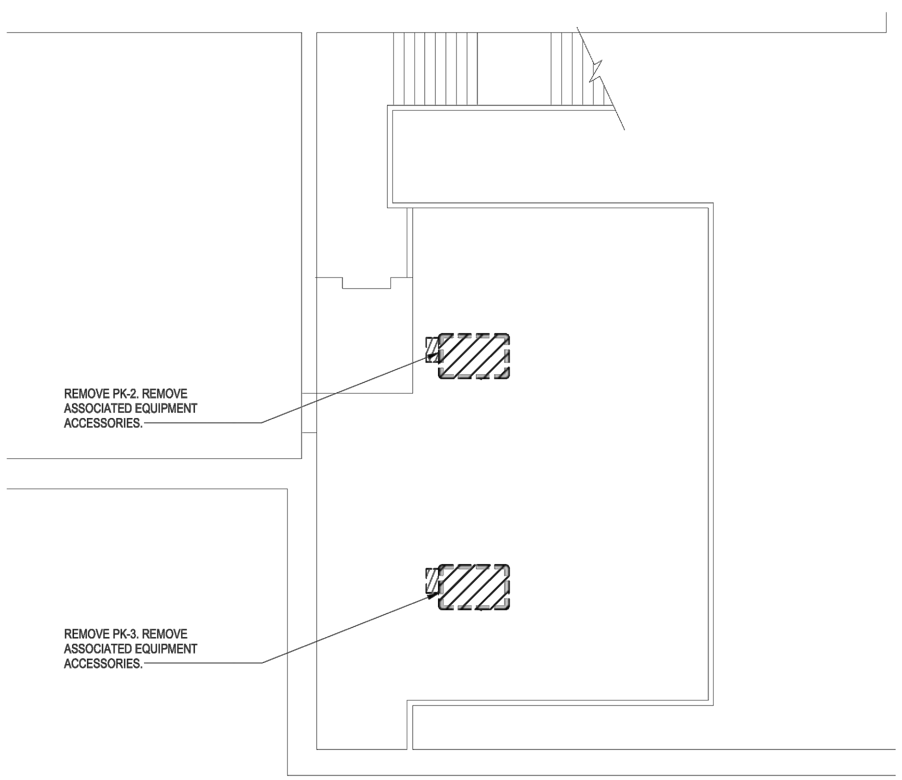
10-25-PF-## = ASBESTOS SAMPLE LOCATION AND NUMBER

BOLDED SAMPLE NUMBERS INDICATE PRESENCE OF ASBESTOS IN CONCENTRATIONS GREATER THAN 1% WITHIN SAMPLE SET.



NORTH MEZZANINE

NOT TO SCALE



SOUTH MEZZANINE

NOT TO SCALE

PROJECT NO.: 22-187.10T1
DATE: 10/28/2022
DRAWN BY: BB
REVIEWED BY: PF

HAZARDOUS BUILDING MATERIALS INSPECTION
AI ENGINEERS
G.H.T.D. UNION STATION
1 UNION STATION
BRISTOL, CONNECTICUT

EAGLE Environmental, Inc.
8 SOUTH MAIN STREET, SUITE 3
TERRYVILLE, CONNECTICUT 06786
860-589-8257

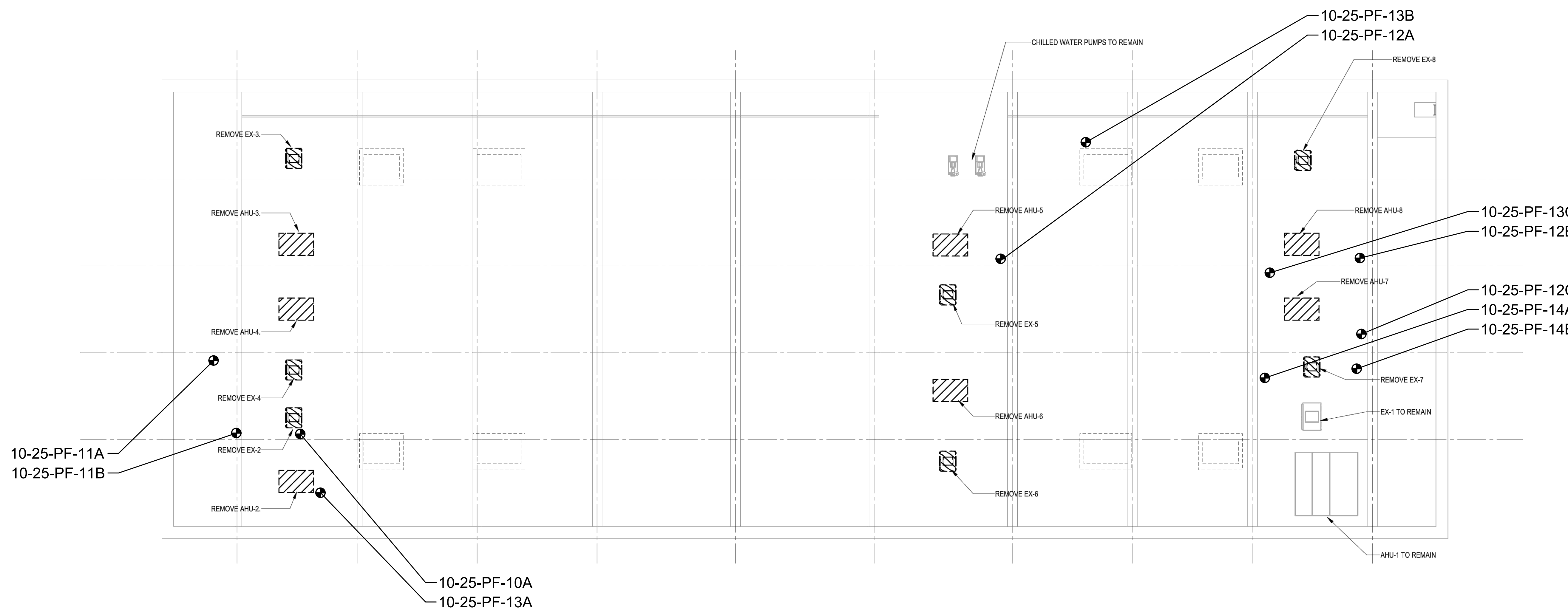
SHEET NO.

FP-3

SAMPLE KEY:

10-25-PF-## = ASBESTOS SAMPLE LOCATION AND NUMBER

BOLDED SAMPLE NUMBERS INDICATE PRESENCE OF ASBESTOS IN CONCENTRATIONS GREATER THAN 1% WITHIN SAMPLE SET.



ATTIC

NOT TO SCALE

PROJECT NO.: 22-187.10T1
DATE: 10/28/2022
DRAWN BY: BB
REVIEWED BY: PF

HAZARDOUS BUILDING MATERIALS INSPECTION
AI ENGINEERS
G.H.T.D. UNION STATION
1 UNION STATION
BRISTOL, CONNECTICUT

EAGLE Environmental, Inc.
8 SOUTH MAIN STREET, SUITE 3
TERRYVILLE, CONNECTICUT 06786
860-589-8257

SHEET NO.

FP-4

SHEET 4 OF 4

Z:\2022 Files\2022 AutoCAD\AI Engineers\Union Station\HBMI\CAD\1 Union Place - Union Station.dwg

APPENDIX B

ASBESTOS BULK SAMPLE LABORATORY REPORTS

Bulk Asbestos Analysis

By Polarized Light Microscopy
EPA Method: 600/R-93/116 and
40 CFR, Part 763, Subpart E, App.E

NVLAP LAB CODE 200664-0

Lab ID # 173190

Customer: Eagle Environmental, Inc
8 South Main Street Suite 3
Terryville, CT 06786

Attn: Victoria Farkas
Brandy LeBlanc-Christen
Aaron Hatcher

Lab Order ID: 10008775
Analysis: PLM
Date Received: 10/26/2022
Date Reported: 10/27/2022

Project: AI Engineers - 1 Union Place Hartford

Sample ID / *Lab Sample ID*	Description / *Lab Notes*	Asbestos	Fibrous Components	Non-Fibrous Components	Attributes / Treatment
10-25-PF-01A	Flex Connector - Black	None Detected	60% Fiber Glass	40% Other	Gray, Black Fibrous Heterogeneous
10008775_0001					Ashed
10-25-PF-01B	Flex Connector - Black	None Detected	40% Fiber Glass	60% Other	Black, Gray Fibrous Heterogeneous
10008775_0002					Ashed
10-25-PF-01C	Flex Connector - Black	None Detected	40% Fiber Glass	60% Other	Black, Gray Fibrous Heterogeneous
10008775_0003					Ashed
10-25-PF-02A	Joint Compound - White	None Detected		100% Other	White Non-Fibrous Homogeneous
10008775_0004	*small sample mostly paint*				Teased
10-25-PF-02B	Joint Compound - White	None Detected		100% Other	White Non-Fibrous Homogeneous
10008775_0005					Teased
10-25-PF-03A	Fiberglass Endcap Sealant - White	None Detected	20% Cellulose	80% Other	White Non-Fibrous Heterogeneous
10008775_0006					Dissolved
10-25-PF-03B	Fiberglass Endcap Sealant - White	None Detected	20% Cellulose	80% Other	White Non-Fibrous Heterogeneous
10008775_0007					Dissolved
10-25-PF-03C	Fiberglass Endcap Sealant - White	None Detected	20% Cellulose	80% Other	White Non-Fibrous Heterogeneous
10008775_0008					Dissolved

Byron Stroble (34)

Analyst

Nathaniel Durham

Approved Signatory

Bulk Asbestos Analysis

By Polarized Light Microscopy
EPA Method: 600/R-93/116 and
40 CFR, Part 763, Subpart E, App.E

NVLAP LAB CODE 200664-0

Lab ID # 173190

Customer: Eagle Environmental, Inc
8 South Main Street Suite 3
Terryville, CT 06786

Attn: Victoria Farkas
Brandy LeBlanc-Christen
Aaron Hatcher

Lab Order ID: 10008775
Analysis: PLM
Date Received: 10/26/2022
Date Reported: 10/27/2022

Project: AI Engineers - 1 Union Place Hartford

Sample ID / *Lab Sample ID*	Description / *Lab Notes*	Asbestos	Fibrous Components	Non-Fibrous Components	Attributes / Treatment
10-25-PF-04A	Sheetrock - White	None Detected	10% Cellulose	90% Other	White Non-Fibrous Homogeneous
10008775_0009					Teased
10-25-PF-04B	Sheetrock - White	None Detected	10% Cellulose	90% Other	White Non-Fibrous Homogeneous
10008775_0010					Teased
10-25-PF-05A	Condesation Repair Tape - Black	None Detected		100% Other	Black Non-Fibrous Homogeneous
10008775_0011					Ashed
10-25-PF-05B	Condesation Repair Tape - Black	None Detected		100% Other	Black Non-Fibrous Homogeneous
10008775_0012					Ashed
10-25-PF-06A	Spray-Applied Fire Proofing - Tan	None Detected	15% Cellulose	70% Other 15% Vermiculite	Brown Non-Fibrous Homogeneous
10008775_0013					Teased
10-25-PF-06B	Spray-Applied Fire Proofing - Tan	None Detected	15% Cellulose	70% Other 15% Vermiculite	Brown Non-Fibrous Homogeneous
10008775_0014					Teased
10-25-PF-06C	Spray-Applied Fire Proofing - Tan	None Detected	15% Cellulose	70% Other 15% Vermiculite	Brown Non-Fibrous Homogeneous
10008775_0015					Teased
10-25-PF-07A	Seam Caulk on Aluminum Pipe Cover	None Detected		100% Other	Gray Non-Fibrous Homogeneous
10008775_0016					Ashed

Byron Stroble (34)
Analyst

Nathaniel Durham
Approved Signatory

Bulk Asbestos Analysis

By Polarized Light Microscopy
EPA Method: 600/R-93/116 and
40 CFR, Part 763, Subpart E, App.E

NVLAP LAB CODE 200664-0

Lab ID # 173190

Customer: Eagle Environmental, Inc
8 South Main Street Suite 3
Terryville, CT 06786

Attn: Victoria Farkas
Brandy LeBlanc-Christen
Aaron Hatcher

Project: AI Engineers - 1 Union Place Hartford

Lab Order ID: **10008775**
Analysis: PLM
Date Received: 10/26/2022
Date Reported: 10/27/2022

Sample ID / *Lab Sample ID*	Description / *Lab Notes*	Asbestos	Fibrous Components	Non-Fibrous Components	Attributes / Treatment
10-25-PF-07B	Seam Caulk on Aluminum Pipe Cover	**None Detected**		**100% Other**	Gray Non-Fibrous Homogeneous
10008775_0017					Ashed
10-25-PF-08A	Fiberglass Insulation	**None Detected**	**80% Fiber Glass 10% Cellulose**	**10% Other**	White Fibrous Homogeneous
10008775_0018					Teased
10-25-PF-08B	Fiberglass Insulation	**None Detected**	**80% Fiber Glass 10% Cellulose**	**10% Other**	White Fibrous Homogeneous
10008775_0019					Teased
10-25-PF-08C	Fiberglass Insulation	**None Detected**	**80% Fiber Glass 10% Cellulose**	**10% Other**	White Fibrous Homogeneous
10008775_0020					Teased
10-25-PF-09A	White Debris on Duct	**None Detected**		**100% Other**	White Non-Fibrous Homogeneous
10008775_0021					Crushed
10-25-PF-09B	White Debris on Duct	**None Detected**		**100% Other**	White Non-Fibrous Homogeneous
10008775_0022					Crushed
10-25-PF-10A	Flex Connector - Black Round Duct	**None Detected**	**40% Fiber Glass**	**60% Other**	Black, White Non-Fibrous Homogeneous
10008775_0023					Ashed
10-25-PF-10B	Flex Connector - Black Round Duct	**None Detected**	**40% Fiber Glass**	**60% Other**	Black, White Non-Fibrous Homogeneous
10008775_0024					Ashed

Byron Stroble (34)

Analyst

Nathaniel Durham

Approved Signatory

Bulk Asbestos Analysis

By Polarized Light Microscopy
EPA Method: 600/R-93/116 and
40 CFR, Part 763, Subpart E, App.E

NVLAP LAB CODE 200664-0

Lab ID # 173190

Customer: Eagle Environmental, Inc
8 South Main Street Suite 3
Terryville, CT 06786

Attn: Victoria Farkas
Brandy LeBlanc-Christen
Aaron Hatcher

Project: AI Engineers - 1 Union Place Hartford

Lab Order ID: 10008775
Analysis: PLM
Date Received: 10/26/2022
Date Reported: 10/27/2022

Sample ID / *Lab Sample ID*	Description / *Lab Notes*	Asbestos	Fibrous Components	Non-Fibrous Components	Attributes / Treatment
10-25-PF-11A	Fiberglass Gasket in Square Exhaust Vent	**None Detected**	**90% Fiber Glass**	**10% Other**	Gray Fibrous Homogeneous
10008775_0025					Teased
10-25-PF-11B	Fiberglass Gasket in Square Exhaust Vent	**None Detected**	**90% Fiber Glass**	**10% Other**	Gray Fibrous Homogeneous
10008775_0026					Teased
10-25-PF-12A	Fiberglass Endcap Sealant	**None Detected**	**30% Cellulose**	**70% Other**	White Non-Fibrous Heterogeneous
10008775_0027					Dissolved
10-25-PF-12B	Fiberglass Endcap Sealant	**None Detected**	**30% Cellulose**	**70% Other**	White Non-Fibrous Heterogeneous
10008775_0028					Dissolved
10-25-PF-12C	Fiberglass Endcap Sealant	**None Detected**	**30% Cellulose**	**70% Other**	White Non-Fibrous Heterogeneous
10008775_0029					Dissolved
10-25-PF-13A	Gypcrete Ceiling Deck - White/Brown	**None Detected**	**10% Cellulose**	**90% Other**	Brown, White Non-Fibrous Heterogeneous
10008775_0030					Crushed
10-25-PF-13B	Gypcrete Ceiling Deck - White/Brown	**None Detected**	**10% Cellulose**	**90% Other**	Brown, White Non-Fibrous Heterogeneous
10008775_0031					Crushed
10-25-PF-13C	Gypcrete Ceiling Deck - White/Brown	**None Detected**	**10% Cellulose**	**90% Other**	Brown, White Non-Fibrous Heterogeneous
10008775_0032					Crushed

Byron Stroble (34)
Analyst

Nathaniel Durham
Approved Signatory

Bulk Asbestos Analysis

By Polarized Light Microscopy
EPA Method: 600/R-93/116 and
40 CFR, Part 763, Subpart E, App.E

NVLAP LAB CODE 200664-0

Lab ID # 173190

Customer: Eagle Environmental, Inc
8 South Main Street Suite 3
Terryville, CT 06786

Attn: Victoria Farkas
Brandy LeBlanc-Christen
Aaron Hatcher

Project: AI Engineers - 1 Union Place Hartford

Lab Order ID: **10008775**
Analysis: PLM
Date Received: 10/26/2022
Date Reported: 10/27/2022

Sample ID / *Lab Sample ID*	Description / *Lab Notes*	Asbestos	Fibrous Components	Non-Fibrous Components	Attributes / Treatment
10-25-PF-14A	Duct Sealant - Tan/Gold	**None Detected**		**100% Other**	Tan Non-Fibrous Homogeneous
10008775_0033					Dissolved
10-25-PF-14B	Duct Sealant - Tan/Gold	**None Detected**		**100% Other**	Tan Non-Fibrous Homogeneous
10008775_0034					Dissolved

Byron Stroble (34)

Analyst **Approved Signatory**

10068775

Client:	Eagle Environmental, Inc.
Contact:	Victoria Farkas, Brandy Christen
Address:	8 South Main Street, Terryville, CT
Phone:	860-589-8257
Fax:	860-585-7034
Email:	vfarkas@eagleenviro.com bleblanc@eagleenviro.com ahatcher@eagleenviro.com
Project:	AI Engineers - 1 Union Place Hartford
Client Notes:	Please stop on first positive in sets Please do not split samples
P.O. #.	22-187.10T1
Date Submitted:	10/25/2022 0:00
Analysis:	PLM Bulk:EPA 600/R-93/116
TurnAroundTime:	24 Hour

**Instructions:*
Use Column "B" for your contact info

To See an Example Click the bottom Example Tab.

Enter samples between "<<" and ">>"
Begin Samples with a "<< "above the first sample and end with a ">>" below the last sample.
Only Enter your data on the first sheet "Sheet1"

Note: Data 1 and Data 2 are optional fields that do not show up on the official report, however they will be included in the electronic data returned to you to facilitate your reintegration of the report data.

Scientific Analytical Institute

4604 Dundas Drive
Greensboro, NC 27407
Phone: 336.292.3888
Fax: 336.292.3313
Email: lab@sailab.com

Sample Number	Data 1	Sample Description	Data 2
<<			
10-25-PF-01A	Unit 9L	Flex Connector - Black	Transporation Center Mech.Room- Le
10-25-PF-01B	Unit 11L	Flex Connector - Black	Transporation Center Mech.Room- Le
10-25-PF-01C		Flex Connector - Black	Trans Center Mech.Room-Right
10-25-PF-02A		Joint Compound - White	Transporation Center Mech.Room- Le
10-25-PF-02B		Joint Compound - White	Transporation Center Mech.Room- Le
10-25-PF-03A		Fiberglass Endcap Sealant - White	Transporation Center Mech.Room- Le
10-25-PF-03B		Fiberglass Endcap Sealant - White	Transporation Center Mech.Room- Le
10-25-PF-03C		Fiberglass Endcap Sealant - White	Trans Center Mech.Room-Right
10-25-PF-04A		Sheetrock - White	Transporation Center Mech.Room- Le
10-25-PF-04B		Sheetrock - White	Transporation Center Mech.Room- Le
10-25-PF-05A		Condesation Repair Tape - Black	Trans Center Mech.Room-Right
10-25-PF-05B		Condesation Repair Tape - Black	Trans Center Mech.Room-Right
10-25-PF-06A		Spray-Applied Fire Proofing - Tan	Electrical Room
10-25-PF-06B		Spray-Applied Fire Proofing - Tan	Electrical Room
10-25-PF-06C		Spray-Applied Fire Proofing - Tan	Electrical Room
>>			

Accepted ☒

Rejected ☐

Relinquished By [signature]

Received By [signature] 10/26 1030A

10008776

10-25-PF-07A	Chiler 6	Seam Caulk on Aluminum Pipe Cover	Exterior Parking Area - Level 1
10-25-PF-07B	Chiler 6	Seam Caulk on Aluminum Pipe Cover	Exterior Parking Area - Level 1
10-25-PF-08A	Chiler 6	Fiberglass Insulation	Exterior Parking Area - Level 1
10-25-PF-08B	Chiler 6	Fiberglass Insulation	Exterior Parking Area - Level 1
10-25-PF-08C	Chiller 5	Fiberglass Insulation	Exterior Parking Area - Level 1
10-25-PF-09A		White Debris on Duct	Office Mezzannine PK 1 - North Side
10-25-PF-09B		White Debris on Duct	Office Mezzannine PK 1 - North Side
10-25-PF-10A	Attic	Flex Connector - Black Round Duct	Exhaust Fan 3
10-25-PF-10B	Attic	Flex Connector - Black Round Duct	Exhaust Fan 5
10-25-PF-11A	Attic	Fiberglass Gasket in Square Exhaust Vent	Exhaust Fan 4
10-25-PF-11B	Attic	Fiberglass Gasket in Square Exhaust Vent	Exhaust Fan 4
10-25-PF-12A	Attic	Fiberglass Endcap Sealant	Air Handling Unit 6
10-25-PF-12B	Attic	Fiberglass Endcap Sealant	Air Handling Unit 7
10-25-PF-12C	Attic	Fiberglass Endcap Sealant	Air Handling Unit 8
10-25-PF-13A	Attic	Gypcrete Ceiling Deck - White/Brown	Ceiling Throughout
10-25-PF-13B	Attic	Gypcrete Ceiling Deck - White/Brown	Ceiling Throughout
10-25-PF-13C	Attic	Gypcrete Ceiling Deck - White/Brown	Ceiling Throughout
10-25-PF-14A	Attic	Duct Sealant - Tan/Gold	Exhaust Fan 8
10-25-PF-14B	Attic	Duct Sealant - Tan/Gold	Exhaust Fan 8

Relinquished By

Received By

APPENDIX C

XRF LEAD-BASED PAINT INSPECTION REPORTS

LEAD PAINT INSPECTION REPORT

REPORT NUMBER: S#02753 - 10/25/22 09:24

INSPECTION FOR: Mr. Tony Punzalan
AI Engineers
919 Middle Street
Middletown, Connecticut 06457

PERFORMED AT: 1 Union Place
Interiors and Exteriors
Air Handling Units
Hartford, CT

INSPECTION DATE: 10/25/22

INSTRUMENT TYPE: R M D
MODEL LPA-1
XRF TYPE ANALYZER
Serial Number: 02753

ACTION LEVEL: 1.0 mg/cm²

OPERATOR LICENSE: 002270

Screened Lead Based Paint Inspection (Air handling units & Exhaust fan units)

SIGNED: ______________________ Date: 10/25/22

Jonathan R. Vargas
Lead Inspector
Eagle Environmental, Inc
8 South Main Street, Suite #3
Terryville, CT 06786

SUMMARY REPORT OF LEAD PAINT INSPECTION FOR: Mr. Tony Punzalan

Inspection Date:	10/25/22	1 Union Place
Report Date:	10/25/2022	Interiors and Exteriors
Abatement Level:	1.0	Air Handling Units
Report No.	S#02753 - 10/25/22 09:24	Hartford, CT
Total Readings:	46 Actionable: 0	
Job Started:	10/25/22 09:24	
Job Finished:	10/25/22 14:19	

Reading No.	Wall	Structure	Location	Member	Paint Cond	Substrate	Color	Lead (mg/cm²)	Mode

Calibration Readings

---- End of Readings ----

DETAILED REPORT OF LEAD PAINT INSPECTION FOR: Mr. Tony Punzalan

Inspection Date:	10/25/22	1 Union Place
Report Date:	10/25/2022	Interiors and Exteriors
Abatement Level:	1.0	Air Handling Units
Report No.	S#02753 - 10/25/22 09:24	Hartford, CT
Total Readings:	46	
Job Started:	10/25/22 09:24	
Job Finished:	10/25/22 14:19	

Reading No.	Wall	Structure	Location	Member	Paint Cond	Substrate	Color	Lead (mg/cm²)	Mode
Interior Room 001 Tr Center L									
002								0.9	TC
003								0.9	TC
008	-	Unit 9L	-		I	Metal	grey	-0.2	QM
009	-	Unit 11L	-		I	Metal	grey	-0.1	QM
004	A	Wall	-	-	I	Dry wall	white	-0.2	QM
010	B	Vent base	-		I	Aluminum	grey	-0.2	QM
011	B	Vent	-		I	Aluminum	white	-0.7	QM
005	B	Wall	-	-	I	Dry wall	white	-0.3	QM
006	C	Wall	-	-	I	Dry wall	white	-0.3	QM
007	D	Wall	-	-	I	Dry wall	white	-0.2	QM
Interior Room 002 Tr Center R									
017	-	Unit 9R	-		I	Metal	grey	-0.2	QM
018	-	Unit 9R	-	Vent	I	Metal	white	-0.2	QM
019	-	Unit 11R	-		I	Metal	grey	-0.4	QM
012	A	Wall	-	-	I	Dry wall	white	-0.2	QM
013	B	Wall	-	-	I	Dry wall	white	0.1	QM
014	C	Wall	-	-	I	Dry wall	white	-0.4	QM
016	D	Elec Panel	-		I	Metal	grey	-0.2	QM
015	D	Wall	-	-	I	Dry wall	white	-0.1	QM
Interior Room 003 Elec room									
024	-	Unit 1	-		I	Metal	grey	-0.3	QM
020	A	Wall	-	-	I	Stone	black	0.2	QM
021	B	Wall	-	-	I	Dry wall	white	-0.3	QM
022	C	Wall	-	-	I	Wood	grey	-0.2	QM
023	D	Wall	-	-	I	Dry wall	white	-0.2	QM
Interior Room 004 Chiller 6									
025	B	Unit	-		I	Metal	grey	-0.4	QM
026	C	Unit	-	Plate	I	Metal	grey	-0.2	QM
027	D	Unit	-	-	I	Metal	grey	-0.2	QM
Interior Room 005 Chiller 5									
028	B	Unit	-	-	I	Metal	grey	-0.2	QM
029	C	Unit	-	-	I	Metal	grey	-0.3	QM
030	D	Unit	-	-	I	Metal	grey	-0.2	QM
Interior Room 006 Attic									
031	-	EF 3	-		I	Metal	grey	-0.1	QM
033	-	Unit AHU 3	-		I	Metal	grey	-0.3	QM

DETAILED REPORT OF LEAD PAINT INSPECTION FOR: Mr. Tony Punzalan

Reading No.	Wall	Structure	Location	Member	Paint Cond	Substrate	Color	Lead (mg/cm²)	Mode
034	-	Unit AHU 4	-		I	Metal	grey	-0.2	QM
035	-	Unit AHU 2	-		I	Metal	grey	-0.1	QM
036	-	Unit AHU 5	-		I	Metal	grey	-0.2	QM
037	-	EF 5	-		I	Metal	grey	-0.1	QM
038	-	Unit AHU 6	-		I	Metal	grey	-0.1	QM
039	-	EF 6	-		I	Metal	grey	-0.2	QM
040	-	EF 7	-		I	Metal	grey	-0.2	QM
041	-	Unit AHU 7	-		I	Metal	grey	0.0	QM
042	-	Unit AHU 8	-		I	Metal	grey	-0.2	QM
043	-	EF 8	-		I	Metal	grey	-0.2	QM
032	C	Mechanical	-	Railing	I	Metal	grey	-0.3	QM

Calibration Readings

001	0.9	TC
044	0.9	TC
045	1.0	TC
046	0.9	TC

---- End of Readings ----

APPENDIX D

EAGLE ENVIRONMENTAL INC. LICENSES AND LABORATORY CERTIFICATES

STATE OF CONNECTICUT

DEPARTMENT OF PUBLIC HEALTH

PURSUANT TO THE PROVISIONS OF THE GENERAL STATUTES OF CONNECTICUT

THE INDIVIDUAL NAMED BELOW IS LICENSED
BY THIS DEPARTMENT AS A

LEAD CONSULTANT CONTRACTOR

EAGLE ENVIRONMENTAL INC.

LICENSE NO.
001723

CURRENT THROUGH
04/30/23

VALIDATION NO.
03-954732

SIGNATURE

COMMISSIONER

CERT#: L-302-312

CHEMSCOPE TRAINING DIVISION

LEAD INSPECTOR INITIAL

24HOUR TRAINING CERTIFICATE

Jonathan R. Vargas

8 South Main Street, Suite 3, Terryville CT

Has attended a 24hour course on the subject discipline in English on

12/14/2021-12/16/2021 and has passed a written examination.

The above individual has successfully completed the above training course approved in accordance with the Department of Public Health Standards established pursuant to Section 20-477 of the Connecticut General Statutes.

Course syllabus includes all required topics of State of Connecticut DPH and EPA.

Under civil and criminal penalties of law for the making or submission of false or fraudulent statements or representations (U.S.C. 1001 and 15 U.S. C. 2615), I certify that this training complies with all applicable requirements of Title IV of TSCA, 40 CFR part 745 and any other applicable Federal, State or local requirements.

Examination Score: 90%
Exam Date: 12/16/2021
Expiration Date: 12/16/2022

Daniel Sullivan
Training Manager

Chem Scope, Inc.
15 Moulthrop Street
North Haven CT 06473
Phone: 203.865.5605
www.chem-scope.com

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STATE OF CONNECTICUT

DEPARTMENT OF PUBLIC HEALTH

PURSUANT TO THE PROVISIONS OF THE GENERAL STATUTES OF CONNECTICUT

THE INDIVIDUAL NAMED BELOW IS CERTIFIED
BY THIS DEPARTMENT AS A

LEAD INSPECTOR

JONATHAN R VARGAS

CERTIFICATE NO.
002270

CURRENT THROUGH
06/30/23

VALIDATION NO.
03-965272

SIGNATURE

COMMISSIONER

CERT#: A-508-Virtual.628

CHEMSCOPE TRAINING DIVISION

ASBESTOS INSPECTOR/MANAGEMENT PLANNER REFRESHER

8-HOUR TRAINING CERTIFICATE

Peter J. Folino

8 South Main Street, Suite 3, Terryville CT

Has attended an 8-hour course on the subject discipline on

09/02/2022 and has passed a written examination.

"The person receiving this certificate has completed the requisite training required for asbestos accreditation as an inspector/management planner under TSCA Title II"

Course topics include a review and update on asbestos health hazards, functions of inspectors and management planners, building systems, planning, inspecting for asbestos, sampling and analysis, respiratory protection, government regulations and preparing the inspection report.

The training course has been accredited by the State of Connecticut.

Examination 1 Score: 98%
Examination 2 Score: 98%
Exam Date: 09/02/2022
Expiration Date: 09/02/2023

Daniel Sullivan
Training Manager

Chem Scope, Inc.
15 Moulthrop Street
North Haven CT 06473
Phone: 203.865.5605
www.chem-scope.com

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STATE OF CONNECTICUT

DEPARTMENT OF PUBLIC HEALTH

PURSUANT TO THE PROVISIONS OF THE GENERAL STATUTES OF CONNECTICUT

THE INDIVIDUAL NAMED BELOW IS CERTIFIED
BY THIS DEPARTMENT AS A

ASBESTOS CONSULTANT-INSP/MGMT PLANNER

PETER J. FOLINO

CERTIFICATE NO.
000184

CURRENT THROUGH
05/31/23

VALIDATION NO.
03-958963

SIGNATURE

COMMISSIONER

State of Connecticut, Department of Public Health

Approved Environmental Laboratory

THIS IS TO CERTIFY THAT THE LABORATORY DESCRIBED BELOW HAS BEEN APPROVED BY THE STATE DEPARTMENT OF PUBLIC HEALTH PURSUANT TO APPLICABLE PROVISIONS OF THE PUBLIC HEALTH CODE AND GENERAL STATUTES OF CONNECTICUT, FOR MAKING THE EXAMINATIONS, DETERMINATIONS OR TESTS SPECIFIED BELOW WHICH HAVE BEEN AUTHORIZED IN WRITING BY THAT DEPARTMENT.

SCIENTIFIC ANALYTICAL INSTITUTE, INC.

LOCATED AT 4604 DUNDAS DRIVE **IN** GREENSBORO, NC 27407

AND REGISTERED IN THE NAME OF NATHANIEL DURHAM

THIS CERTIFICATE IS ISSUED IN THE NAME OF NATHANIEL DURHAM **WHO HAS BEEN DESIGNATED BY THE REGISTERED OWNER/AUTHORIZED AGENT TO BE IN CHARGE OF THE LABORATORY WORK COVERED BY THIS CERTIFICATE OF APPROVAL AS FOLLOWS:**

DRINKING WATER
Examination For:
ASBESTOS

ENVIRONMENTAL HEALTH & HOUSING
LEAD IN PAINT
LEAD (PAINT) IN SOIL
LEAD IN DUST WIPES

BUILDING MATERIALS
Examination For:
ASBESTOS FIBERS – PCM. TEM
ASBESTOS IN BULK – PLM, TEM

SEE COMPUTER PRINT-OUT FOR SPECIFIC TESTS APPROVED

EFFECTIVE RENEWAL DATE JANUARY 1, 2022

THIS CERTIFICATE EXPIRES DECEMBER 31, 2023 **AND IS REVOCABLE FOR CAUSE BY THE STATE DEPARTMENT OF PUBLIC HEALTH**

DATED AT HARTFORD, CONNECTICUT, THIS 1st **DAY OF** November, 2021

Registration No.

PH–0336

Lori J. Mathieu '21

Lori J. Mathieu
Public Health Branch Chief