



REQUEST

FOR

BIDS

BOILER & MECHANICAL EQUIPMENT REPLACEMENT

at

MANCHESTER COMMUNITY COLLEGE

1066 Front Street, Manchester, NH

A COMPONENT OF THE

Community College System of New Hampshire

26 College Drive, Concord, NH

Project# MCC19-04

May 19, 2020

DOCUMENT 00015

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END OF SECTION

SECTION 00010 - INVITATION TO BID – CCSNH

Electronic Bids per the Project Manual Technical Specifications will be accepted by email to Matthew Moore, Director of Capital Planning and Development at memoore@ccsnh.edu until **Tuesday, June 9th 2020 at 2:00pm** for the following project:

**Boiler & Mechanical Equipment Replacement
at Manchester Community College
1066 Front Street, Manchester, NH
a Component of the Community College System of New Hampshire
26 College Drive, Concord, NH
Project # MCC19-04**

Description: This project consists of Boiler & Mechanical Equipment Replacement. Provide labor, materials, accessories, and other related items as required to complete operations in connection with the complete installation of the HVAC and mechanical systems as indicated on the Drawings and as specified herein.

The Project will include but not be limited to the Disciplines of: HVAC mechanical work, and electrical work.

Plans and specifications will be available from the Community College System of New Hampshire, **Tuesday May 19th, 2020 on the CCSNH website** www.ccsnh.edu/about-ccsnh/bidding-rfp/

Plans and specifications will also be available at the following printers:

- Signature Press and Blueprinting, Inc., 45 Londonderry Turnpike, Rte. 28 Bypass, Hooksett, NH 03106;
- Construction Summary of NH: Inc., 734 Chestnut Street, Manchester, NH 03104;
- Infinite Imaging: 933 Islington Street, Portsmouth, NH 03801
- Minuteman Press: 109 Gosling Road, Newington, NH 03801;
- Works in Progress, 20 Farrell Street, Suite 103, South Burlington, VT 05403
- The Blue Book, <http://www.thebluebook.com/>
- Community College System of New Hampshire website
www.ccsnh.edu/about-ccsnh/bidding-rfp/

BIDDERS SHOULD ACT PROMPTLY AND SUBMIT ALL QUESTIONS IN WRITING TO: MATTHEW MOORE, DIRECTOR OF CAPITAL PLANNING AND DEVELOPMENT, E-MAIL memoore@ccsnh.edu .

SITE VISITS WILL BE HELD

Tuesday, May 26th at 10 a.m. and another on Thursday, May 28th at 10 a.m. Meet at the MCC maintenance shop, north end of campus. You may attend one or both, it's up to you. These times are provided for you and will be the only times available for on site visits.

There are two substantial completion dates for the Project:

Boiler Replacement substantial completion date is September 15, 2020.

Mechanical Equipment substantial completion date is November 30, 2020.

Proposals must be completed in both words and figures on forms furnished by the College, or on previously-approved, substantially-identical forms generated by computer software, which shall be submitted electronically in an e-mail titled: **“Bid for: MCC19-04 MCC Boiler and Mechanical Equipment Replacement”** received by MATTHEW MOORE at memoore@ccsnh.edu as specified no later than **2:00 PM, Tuesday, June 9th, 2020.**

Companies, corporations or trade names, except sole proprietorships must be registered with the Secretary of State (Corporate Division, Telephone No. 603/271-3244) in order to do business with the State of New Hampshire.

Bidders must show three recent years’ experience with installations of a similar complexity and cost and prior experience with installations of the materials within 50 miles of the project site.

The successful bidder will be required to comply with State of New Hampshire RSA#21-1:81-a. The successful bidder will be required to furnish a 100% payment and 100% performance bond prior to execution of contract.

The award will be based on the proposal that best meets the needs of the college. Factors included will be the cost, completeness of the proposal, quality of the technology provided, and experience of the contractor and installation team. The college reserves the right to waive any informality in or to reject any or all proposals.

All contract documents can be found on the CCSNH website at www.ccsnh.edu/about-ccsnh/bidding-rfp/

Before your submission, always check for any addenda or other materials that may have been issued which would affect the invitation to bid by checking the CCSNH website at www.ccsnh.edu/about-ccsnh/bidding-rfp/

CCSNH reserves the right to waive any and all informalities in its best interest or to reject any or all proposals.



Matthew Moore, PE,
Director of Capital Planning & Development
Community College System of New Hampshire

END OF DOCUMENT

DOCUMENT 001153 - REQUEST FOR QUALIFICATIONS

1.1 PURPOSE, LAWS, AND REGULATIONS

- A. The purpose of the Prequalification Procedure described in this Document is to provide Owner with a mechanism to evaluate and determine whether Prospective Bidders are qualified to participate in the construction of Project. Evaluation will be limited to that office of the Prospective Bidder that is proposed to perform the Work.

1.2 DEFINITIONS

- A. Prospective Bidder: A Prospective Bidder is a person or entity who submits a Submittal of Qualifications to Owner.

1.3 QUALIFICATION PROCEDURES

- A. Prospective Bidders shall complete all required forms and attachments described in the Prequalification Documents, entering "Not Applicable" where information does not apply. Absence of any of the forms included in the Prequalification Documents will be reason for possible disqualification.
- B. Status of Prospective Bidders:
 - 1. Proprietors submitting bids shall indicate their status as proprietors.
 - 2. Prospective Bidders submitting qualifications for partnerships shall indicate their status as partners and shall submit a certified copy of the power of attorney authorizing the executor of the submittal to bind the partnership.
 - 3. Prospective Bidders submitting qualifications for corporations shall indicate their status as corporations and shall submit a certified copy of the board of directors' authorization for the Prospective Bidder to bind the corporation and shall affix the corporate seal on the submittal.
 - 4. Prospective Bidders shall provide the following:
 - a. Names and addresses of proprietors, of all members of a partnership, or of the corporation's officers.
 - b. Name of jurisdiction where the partnership is registered or where the corporation is incorporated. Corporations must be licensed to do business in Project state at the time of executing the Contract.

1.4 WITHDRAWAL

- A. A Qualification Statement may be withdrawn on personal request received from the Prospective Bidder.

1.5 QUALIFICATION STATEMENT

- A. The undersigned submits answers to the following questions to enable the Community College System of New Hampshire to judge experience and ability in the work proposed to be done.

- 1. The work, if awarded to you, will have the resident personal supervision of whom? State his/her name, title, and their special qualifications.

- 2. (a) Provide a brief history of your firm. (b) Demonstrate that your firm has provided satisfactory work on similar projects.

a) _____

b) _____

- 3. How many years has your organization been in business as a contractor under the name in which you propose to execute this contract?

- 4. Has your present organization ever failed to complete any work awarded to it? If so, state when, where and why:

- 5. Provide three (3) Examples of Experience with full responsibility for work of a similar size to this project and within 50 miles of the project site.

Qualifications to perform the work: List Three

Experience with full responsibility for work of a similar size and within 50 miles of the project site.

Bidders are to provide evidence of qualifications with the bid.

NAME OF REFERENCE PROJECT _____

Location of Project _____

Date work performed _____

Name of Owner
Contact Name & Phone Number _____

Description of Project _____

Approx. Contract value _____

NAME OF REFERENCE PROJECT _____

Location of Project _____

Date work performed _____

Name of Owner
Contact Name & Phone Number _____

Description of Project _____

Approx. Contract value _____

NAME OF REFERENCE PROJECT _____

Location of Project _____

Date work performed _____

Name of Owner
Contact Name & Phone Number _____

Description of Project _____

Approx. Contract value _____

DOCUMENT 00204

INSTRUCTIONS TO BIDDERS – Community College System of New Hampshire (CCSNH)
Issued 2-05-2004; Revised as noted

Revised 4/17/18

PART	ITEM
1	DEFINITIONS
2	PREPARATION AND SUBMISSION OF BIDS
3	RECEIPT AND OPENING OF BIDS
4	WITHDRAWAL OF BIDS
5	PROPOSAL GUARANTY (intentionally omitted)
6	CONDITIONS AT SITE OR BUILDING
7	EXPLANATION TO BIDDERS
8	REJECTION OF BIDS
9	CONTRACT BOND
10	CONTRACTOR'S AND SUBCONTRACTOR'S INSURANCE
11	BIDDING DOCUMENTS
12	SUBSTITUTIONS
13	AWARD OF CONTRACT
14	PERMITS AND FEES

PART 1 DEFINITIONS

- 1.1 Refer to Document 00708: General Conditions – CCSNH:

PART 2 PREPARATION AND SUBMISSION OF BIDS

- 2.1 The Bidder is required to bid on all items called for in the Proposal. If Alternates are included, the Bidder shall set forth in the space provided the amount to be added to or deducted from the Lump Sum Base Bid or the Lump Sum Grand Total. If an Alternate called for does not involve a change in price, the Bidder shall so indicate in the space provided.
- 2.2 Bids shall be submitted upon the Proposal Form furnished and shall be signed in ink. The Bidder shall specify a unit price, both in words and figures, for each item called for in the Lump Sum Grand Total Proposal. All of the words and figures shall be in ink or typed. If a unit price or a Lump Sum Grand Total already entered by the Bidder on the Proposal Form is to be altered, it should be crossed out with ink, the new unit price and the Lump Sum Grand Total bid entered above or below it and initialed by the Bidder; also in ink. In case of discrepancy between the prices written in words and those written in figures, the prices written in words shall govern. Bids containing any conditions, omissions, unexplained erasures or alterations, or items not called for in the Proposal or irregularities of any kind may be rejected by the Chancellor as being incomplete non-conforming, or non-responsive.
- 2.3 Each bid must contain the full business address of the Bidder and be signed by him/her with his/her usual signature.
- A. Bids by a partnership of any form must furnish the full names of all partners, and must be signed in the partnership name by one of the members of the partnership or by an authorized representative, followed by the designation of the person signing. All Contracts with partnerships must include a certificate of authorization demonstrating that the partner(s) or authorized individuals have been authorized by the partnership to enter into the Contract on behalf of the partnership.
- B. Bids by a corporation of any form must be signed with the legal name of the corporation, followed by the name of the State of incorporation and by the signature and designation of the president, secretary or other person authorized to bind it in the matter. The name of each person signing shall also be typed or printed below the signature. *[A bid by a person who affixes to his/her signature, the word "President," "Secretary," "Agent" or other designation, without disclosing whom he/she is representing if other than the contracting entity noted above, may be held to the bid of the individual signing.]*
- C. Bids by proprietorships (individuals), or by individuals with a registered trade name, or doing business under an assumed name (aka d/b/a), shall be executed by the individual in their name, with reference to the trade name or assumed name.

- 2.4 Bids to be scanned and transmitted by electronic mail to memoore@ccsnh.edu no later than the bid deadline.

PART 3 RECEIPT AND OPENING OF BIDS

- 3.1 The bid opening officer will decide when the specified time has arrived, and no bid received or presented thereafter will be considered. No responsibility or liability will be attached to any officer for the premature opening of a bid not properly addressed and identified.

PART 4 WITHDRAWAL OF BIDS

- 4.1 A bid may be withdrawn upon written request received from the bidder at the Director of Capital Planning and Development office at 26 College Drive, Concord, NH 03301-7407, with reasonable time prior to the time fixed for opening. Negligence on the part of the bidder in preparing the bid confers no right for the withdrawal of the bid after it has been opened.

PART 5 PROPOSAL GUARANTY (intentionally omitted)

PART 6 CONDITIONS AT SITE OR BUILDING

- 6.1 Bidders shall visit the site and be responsible for having ascertained pertinent local conditions; such as location, accessibility and general character of the site or building, the character and extent of existing work within or adjacent to the site, and any other work being performed thereon at the time of submitting the bid.

PART 7 EXPLANATION TO BIDDERS

- 7.1 No oral explanation in regard to the meaning of the Bidding Documents will be made and no oral instructions will be given before the award of the Contract. Discrepancies, omissions or doubts as to the meanings of Bidding Documents shall be communicated in writing to the Director of Capital Planning and Development for interpretation no later than five (5) working days before the hour and date set for the bid opening. Any interpretations will be in the form of an Addendum to the Bidding Documents that will be forwarded to all Bidders of record and sent to all other locations identified in the Invitation to Bid where documents are made available.

PART 8 REJECTION OF BIDS

- 8.1 The Chancellor reserves the right to reject any or all bids, to waive technicalities or to advertise for new bids, if in his/her judgment, the best interests of the State will be promoted thereby. The Chancellor reserves the right to reject the bid of a Bidder who is not in a position to perform the Contract.
- 8.2 The Chancellor reserves the right to waive any informality in bids received, if in the best interest of the CCSNH.
- 8.3 The Chancellor reserves the right to reject any Bidders not meeting all stated requirements.

PART 9 CONTRACT BOND

- 9.1 The successful Bidder, at the time of the execution of the Contract, must deposit with the Chancellor, Surety in the sum equal to one hundred percent (100%) of the amount of the Contract as required by RSA 447:16. The form of Bond shall be that provided for by the CCSNH and the Surety shall be acceptable to the Chancellor. The Contract Bond must be written by a Company licensed to do business in New Hampshire at the time the policy is issued. In addition, the Company issuing the bond shall be listed on the current list of "Surety Companies Acceptable on Federal Bonds" as published by the U.S. Department of the Treasury, Financial Management Services, Circular Number 570. see <http://www.fms.treas.gov/c570/index.html>

PART 10 CONTRACTOR'S AND SUBCONTRACTOR'S INSURANCE

- 10.1 The Contractor shall deliver to the Chancellor at the time of submitting a signed Contract, certificates of all insurance required hereunder. The certificates of insurance shall contain a description of the project, including the project name and number, and shall state that the companies issuing insurance will mail to the Chancellor thirty (30) days' notice of cancellation, alteration of material change of any listed policies or ten (10) days in cases of non-payment of premium. The Contractor shall keep in force the insurance required herein for the period of the Contract, through the Warranty period. and Owners and Contractors Protective (OCP) Liability coverage shall be kept in force through the date of Substantial Completion, or longer at the Director of Capital Planning and Development's direction. The Contractor shall have a continuing duty to provide new certificates of insurance as policies are amended or renewed. At the request of the Chancellor, the Contractor shall promptly make available a copy of any and all listed insurance policies. The required insurance must be written by a Company licensed to do business in the State of New Hampshire at the time the policy is issued. In addition, the company must have a rating of no less than A- based on the current A.M. Best with a size of VIII and satisfying and the terms and conditions described below or the minimum limits required of the Prime Contractor under the Contract Documents.
- 10.2 Prior to the start of the Contractor's Work, the Contractor and any subcontractors, consultants or third parties approved to perform Services pursuant to this contract, will carry, in full force and effect during the entire term of this Agreement, insurance with a carrier rated at minimum "A-" by A.M. Best with a size of VIII and satisfying and the terms and conditions described below or the minimum limits required of Prime Contractor under the Contract Documents.
- A. Commercial General Liability (CGL) with limits of Insurance of not less than \$1,000,000 each occurrence and \$2,000,000 Annual Aggregate.
- .1) If the CGL coverage contains a General Aggregate Limit, such General Aggregate shall apply separately to each project.
 - .2) CGL coverage shall be written on ISO Occurrence form CG 00 01 (10/93) or a substitute form providing equivalent coverage and shall cover liability arising from premises, operations, independent contractors, products- completed operations, and personal and advertising injury.
 - .3) Owner and all other parties required of the Contractor, shall be included as insured's on the CGL, using ISO Additional Insured Endorsement CG 20 10 (11/85) or CG 2010 (10/93) **AND** CG 20 37 (10/01) or CG2033(10/01) **AND** CG2037 (10/01) or an endorsement providing equivalent coverage to the additional insured's. This insurance for the additional insured's shall be as broad as the coverage provided for the named insured Contractor. It shall apply as Primary and non-contributing Insurance before any other insurance or self-insurance, including any deductible, maintained by, or provided to, the additional insured.
 - .4) Contractor shall maintain CGL coverage for itself and all additional insured's for the duration of the project and maintain Completed Operations coverage for itself and each additional insured for at least 7 years after completion of the Work.

- .5) If Contractor is performing snow removal the policy must include the addition of CG 22 92 12 07 for Snow Removal Operations Coverage or equivalent

10.3 Commercial Automobile Liability

- .1) Business Auto Liability with limits of at least \$1,000,000 for each accident.
- .2) Business Auto coverage must include coverage for liability arising out of all owned, leased, hired and non-owned automobiles.
- .3) Owner and all other parties required of the Contractor, shall be included as additional insured's on the auto policy.

10.4 Commercial Umbrella

- .1) Umbrella limits must be at least \$2,000,000.
- .2) Umbrella coverage must include as insured's all entities that are additional insured's on the CGL and coverage shall be as broad as provided on the underlying coverages.

10.5 Workers Compensation and Employers Liability

- .1) Employers Liability Insurance limits of at least \$500,000 each accident for bodily injury by accident and \$500,000 each employee for injury by disease.
- .2) Where applicable, U.S. Longshore and Harborworkers Compensation Act Endorsement shall be attached to the policy.
- .3) Where applicable, the Maritime Coverage Endorsement shall be attached to the Policy.
- .4) All employees, including the Owner, partners and officers, shall provide proof of workers' compensation coverage prior to working on the job site.

10.6 Waiver of Subrogation

- .1) To the fullest extent permitted by law, Contractor waives all rights against Owner and Architect and their agents, officers, directors and employees for recovery of damages to the extent these damages are covered by commercial general liability, commercial umbrella liability, business auto liability or workers compensation and employers liability insurance where acceptable by law.

10.7 Pollution Liability Insurance

- .1) Pollution Limits with at least \$1,000,000 each occurrence, claim or wrongful act with an aggregate of \$1,000,000 for bodily injury, property damage, pollution or environmental harm arising out of the work, asbestos, lead, or silica related claims, claims arising out of microbial matter or bacteria, testing, monitoring, measuring operations or laboratory analyses, or liability arising out of treatment facility. If a motor vehicle is used in connection with the work,

the business automobile policy will include coverage at least as broad as ISO CA 99 48 and be endorsed to include Motor Carrier Act Endorsement MCS 90.

.2) The policy must meet all other insurance requirements applicable to general liability, including, but not limited to additional insured, waiver of subrogation and cancellation notification.

.3) If there is a retroactive date, claims made will apply back to the first date of services provided to the Owner.

.4) The coverage shall be effective for 5 years following completion of the engagement.

.5) Proof of Pollution Liability Insurance shall be provided on a certificate acceptable to the Owner.

10.8 Attached to each certificate of insurance shall be a copy of the Additional Insured Endorsement that is part of the Contractor's Commercial General Liability Policy. These certificates and the insurance policies required shall contain a provision that coverage afforded under the policies will not be canceled or allowed to expire until at least 30 days prior written notice has been given to the Owner. Any subcontractors, consultants or third parties performing services for Contractor as contemplated herein, shall also maintain insurance as required above. Notwithstanding the foregoing, the Owner, in its sole and absolute discretion and taking into account the scope and character of the Services to be provided by Contractor, may reduce the required liability insurance minimums. Such reduction in the required liability insurance minimum of Contractor

shall be evidence by a written instrument specifically referencing this Exhibit I and signed by the Owner.

- 10.9 The Contractor shall require each Subcontractor employed on the Project to maintain the coverage listed above unless the Contractor's insurance covers activities of the Subcontractor on the Project.
- 10.10 No operations under this Contract shall commence until certificates of insurance attesting to the above listed requirements have been filed with the Chancellor and a Notice to Proceed is issued.
- A. If blasting and/or demolition is required by the Contract, the Contractor or subcontractor shall obtain the respective coverage for those activities, and shall furnish to the Chancellor a Certificate of Insurance evidencing the required coverages prior to commencement of any operations involving blasting or demolition or both.
- B. Owner's and Contractor's Protective Liability (OCP) coverage for the benefit of the Community College System of New Hampshire.
1. Limits of Liability:
- a. \$2,000,000 Each Occurrence
- b. \$3,000,000 Aggregate
- ***** [OR] *****
- c. \$2,000,000 Bodily Injury & Property
- C. Property and Builder's Risk Insurance (Fire and Extended Coverage):
1. The Community College System of New Hampshire shall insure the work included in the Contract, including extras and change orders, on an "All Risk" basis, on one hundred percent (100%) completed value basis of the Contract, as modified. Builder's Risk coverage shall include materials located at the Contractor's premises, on-site, in-transit, and at any temporary site. The policy by its own terms or by endorsement shall specifically permit partial or beneficiary occupancy prior to completion or acceptance of the entire work. The policies shall be in the names of the Community College System of New Hampshire and the Contractor. The policies shall provide for the inclusion of the names of all other Contractors, Subcontractors, and others employed on the premises as insureds. The policies shall stipulate that the insurance companies shall have no right of subrogation against any Contractors, Subcontractors or other parties employed on the premises.
2. CCSNH is not responsible to insure Contractor's owned or leased equipment/property.
- D. General Insurance Conditions
1. Failure to secure and maintain, or add by endorsement, Owner and all subsidiaries, agents, and employees as required shall not act as a defense to the enforcement of the terms of this Contract. Any such insurance policy shall apply separately to each insured against whom claim is made or suit is brought and shall contain no provision which excludes coverage of a claim made by one insured under the policy against another insured under the policy.
2. Each policy shall contain a clause prohibiting cancellation or modifications of the policy earlier than thirty (30) days or ten (10) days in cases of non-payment of premium after written notice thereof has been received by CCSNH.

- E. Indemnification:
1. To the fullest extent of the law the Contractor shall indemnify, defend, and hold harmless the Community College System of New Hampshire, its Officers, and its agents and employees from and against any and all claims, liabilities, suits or penalties arising out of (or which may be claimed to arise out of) acts or omissions of the Contractor or subcontractors in the performance of work covered by the Contract. This covenant shall survive the termination of the Contract. Notwithstanding the foregoing, nothing herein contained shall be deemed to constitute a waiver of the sovereign immunity of the Community College System of New Hampshire, which immunity is hereby reserved by the Community College System of New Hampshire. The covenant in paragraph I shall survive the termination of this Agreement.
- F. Additional Insurance for Design/Build Contracts:
1. In addition to the insurance requirements listed in the above paragraphs, the Designer/Builder Team shall provide the following coverage.
 - a. The Designer/Builder Team, or the Designer shall purchase and maintain professional liability coverage for this project. The coverage shall provide the CCSNH with protection against design errors and omissions and shall have an annual aggregate limit of no less than \$2,000,000. The coverage shall be maintained through the legal stature of repose period, currently stipulated to be three (3) years from the date of Substantial Completion. If the professional liability coverage is maintained by other than the firm holding the prime contract with the CCSNH for this project, the prime contractor shall provide evidence of indemnifications, approved by the CCSNH, that indicate that this insurance coverage is in place and available for the protection of the CCSNH. The indemnification may not create a re-assignment of contractual responsibilities between the CCSNH and the prime contractor.

PART 11 BIDDING DOCUMENTS

- 11.1 Bidders shall use only complete sets of Bidding Documents in preparation of bids; the CCSNH assumes no responsibility for mistakes due to the use of incomplete sets of Bidding Documents.

PART 12 SUBSTITUTIONS

- 12.1 Where Bidding Documents stipulate particular Products, substitution requests will ONLY be considered before receipt of Bids. Refer to specification section 01600 – Product Requirements.

PART 13 AWARD OF CONTRACT

- 13.1 The Contract will be Awarded as soon as possible to the Responsible Bidder on the basis of the Highest Score, see Score Sheet in Section 00300.
- A. The CCSNH may request a Negotiated Price from the Highest Score Responsible Bidder.

- 13.2 The signed Contract, together with the Contract Bond, and certificate of insurance shall be returned to the CCSNH within 10 days after the date of notice that the Proposal has been accepted.
- A. If the successful bidder fails to execute the Contract and submit acceptable bond and required attachments within 20 days after the date of notice of acceptance of the Proposal, the CCSNH may cancel the notice of award. Contract award may then be made to the next lowest responsible bidder or the Work may be re-advertised.
- 13.3 Prior to the issuance of Notice to Proceed, each Bidder shall be prepared, if so requested by the Chancellor, to present evidence of his/her experience, qualifications, and financial ability to carry out the terms of the Contract.
- 13.4 A Contract that has been Awarded with required attachments is not executed until submitted and approved by the CCSNH Board of Trustees, if required, and issuance of the Notice to Proceed by the CCSNH.

PART 14 PERMITS AND FEES

- 14.1 CCSNH shall secure and pay for all Permits and Fees required by the Work of this Contract.

END OF DOCUMENT 002004

SECTION 00300 – BID PROPOSAL FORM – CCSNH

PROPOSAL – STIPULATED BASE LUMP SUM GRAND TOTAL BID – GENERAL CONSTRUCTION

PROPOSAL TO: **Received no later than 2:00 PM, Tuesday, June 9th, 2020.**
Matthew Moore, PE
memoore@ccsnh.edu
Director of Capital Planning & Development
Community College System of New Hampshire
26 College Drive
Concord, New Hampshire 03301

SUBJECT: Project #MCC19-04
MCC Mechanical Equipment Replacement

1. CERTIFICATION: The undersigned Prime Contractor

Name of Firm: _____

Signature: _____

Name and Title: _____
(Contractor’s Name Printed Here)

certifies that they have examined and fully comprehend the requirements and intent of the Bidding and Contract Documents for this Project, including any and all Addenda issued, and also certifies that they have visited the location of the Project work and examined all conditions at the site which will affect the work.

2. BASE BID (STIPULATED LUMP SUM GRAND TOTAL)

The undersigned Contractor proposes to furnish all labor, materials, equipment, services and related items necessary for, or incidental to, the proper execution and completion of the Work in strict conformance with the Bidding and Contract Documents, on or before the time of completion specified, for the Stipulated Sum for Materials plus Labor of:

LUMP SUM GRAND TOTAL BID AMOUNT:

(Words)

DOLLARS (\$) _____)
(Figures)

3. ADDENDUM RECEIPT

The undersigned Contractor acknowledges the receipt of the following Addenda to the Bidding and Contract Documents, but he agrees that he is bound by all Addenda, whether or not listed herein:

Addendum No. _____ Dated: _____

Addendum No. _____ Dated: _____

Addendum No. _____ Dated: _____

STATEMENT OF NON-COLLUSION

By submission of this bid, each bidder and each person signing on behalf of any bidder certifies, and in the case of a joint bid each party thereto certifies as to its own organization, under penalty of perjury, that to the best of his knowledge and belief: (1) The prices in this bid have been arrived at independently without collusion, consultation, communications, or agreement, for the purpose of restricting competition as to any matter relating to such prices with any other bidder or with any competitor; (2) Unless required by law, the prices which have been quoted in this bid have not been knowingly disclosed by the bidder prior to opening, directly or indirectly, to any other bidder or to any other competitor, and (3) No attempt has been made or will be made by the bidder to induce any other person, partnership or corporation to submit or not to submit a bid for the purpose of restricting competition.

SIGNATURE: _____

NAME: _____

TITLE: _____

DATE: _____

PHONE: _____

EMAIL: _____

Corporate Seal:

DOCUMENT 00708

GENERAL CONDITIONS – COMMUNITY COLLEGE SYSTEM OF NEW HAMPSHIRE (CCSNH)

PART	ITEM
1	DEFINITIONS
2	CONTRACT DOCUMENTS
3	NOTICE
4	ACCESS TO THE WORK
5	ACCIDENT PROTECTION
6	HAZARDOUS MATERIALS
7	SUBCONTRACTS
8	RESPONSIBILITY OF CONTRACTOR TO ACT IN EMERGENCY
9	MUTUAL RESPONSIBILITY OF CONTRACTORS
10	PAYMENTS TO CONTRACTOR
11	CONTRACTOR'S TITLE TO MATERIALS
12	CHANGES IN WORK
13	ASSIGNMENTS
14	SUPERINTENDENCE BY CONTRACTOR
15	FAILURE TO COMPLETE WORK ON TIME
16	SUBSTANTIAL COMPLETION AND FINAL INSPECTION
17	DEFAULT AND TERMINATION OF CONTRACT
18	TERMINATION OF CONTRACT WITHOUT FAULT
19	ASSIGNMENT PROVISION

PART 1 DEFINITIONS

- A. **Addendum.** Written and/or graphic information issued before opening *Proposals* that modifies or interprets the *Bidding Documents* by additions, deletions, clarifications or corrections.
- B. **Advertisement.** A public announcement in the form of an *Invitation to Bid*, inviting *Bids* for *Work* to be performed and/or *Materials* to be furnished.
- C. **Alteration Order.** A written agreement between the *Contractor* and the *Community College System of New Hampshire* that amends the *Contract* and identifies *Work* that affects either the *Contract Sum*, *Completion Date*, *Credit*, or any combination thereof.
- D. **Alternate.** A proposed change in the *Work* described in the *Contract Documents* providing the *Community College System of New Hampshire* with an option to select between alternative materials, products or systems, or to add or delete portions of *Work*.
- E. **Architect.** As defined in RSA 310-A:28, a person who, by reason of having acquired through professional education and practical experience an advanced training in building construction and architectural design and an extensive knowledge of building standards created to safeguard the public from hazards such as fire, panic, structural failure, and unsanitary conditions, is technically and legally qualified to practice architecture and who is licensed by the State of New Hampshire Board of Licensure for Architects to engage in the practice of architecture. The Architect has no contractual agreement with the *Contractor* and therefore shall not directly interact with the *Contractor*.
- F. **Award.** The acceptance of a *Bid* prior to execution of *Contract*.
- G. **Bid.** A complete and properly signed *Proposal*, submitted in accordance with the *Bidding Requirements*, to perform the *Work* for the amount or amounts stipulated therein.
- H. **Bid Bond.** One form of a *Proposal Guaranty* executed by the *Bidder* and a *Surety* to guarantee that the *Bidder* will enter into a *Contract* within a specified time.
- I. **Bid Opening Officer.** An authorized representative of the Community College System of New Hampshire, who is responsible for opening and reading of *Bids*.
- J. **Bidder.** A *Corporation*, *Partnership*, or *Proprietorship* submitting a *Proposal*, subsequent to meeting the Community College System of New Hampshire's *Bidding Requirements*.
- K. **Bidding Documents.** Collectively, the *Invitation to Bid*, *Bidding Requirements*, *Specifications*, *Drawings*, and *Addendum*.
- L. **Bidding Requirements.** The documents that contain information regarding bidding procedures with which a *Bidder* must conform and a *Proposal* that a *Bidder* shall use to submit a *Bid*.
- M. **Builders Risk Insurance.** A specialized form of property insurance that provides coverage for loss or damage during the course of construction.

- N. **Calendar Day.** A day shown on the calendar.
- O. **Certificate of Occupancy.** A document issued by the Office of the State Fire Marshal or its authorized representative certifying that all of, or a designated portion of a building, is approved for its designated use.
- P. **Certificate of Full or Partial Substantial Completion.** A document prepared by the *Community College System of New Hampshire* when the *Project* reaches *Substantial Completion* and only issued after review and acceptance of the *Contractor's Request for Certificate of Full or Partial Substantial Completion*.
- Q. **Chancellor.** The Chancellor of the Community College System of New Hampshire.
- R. **Change Order.** A written agreement between the *Contractor* and the *Community College System of New Hampshire* that identifies *Work* to be completed as part of an Allowance Item. Any change that affects either the *Contract Sum*, *Contract Time* or *Credit* shall be processed as an *Change Order*.
- S. **Clerk of the Works.** An authorized representative identified by the *Community College System of New Hampshire*, responsible for observing construction on the *Community College System of New Hampshire's* behalf for conformance with the *Contract Documents*.
- T. **College.** The college who is responsible for the facility and/or will occupy the facility after and/or during the *Work*. The College(s) has/have no contractual agreement with the *Contractor* and therefore shall not direct the *Contractor* in any way.
- U. **Commercial General Liability Insurance.** A broad form of liability insurance covering claims for bodily injury and property damage which combines under one policy coverage for business liability exposures, except those specifically excluded.
- V. **Completion Date.** The last day of the time allotted or the specific date established as identified in the *Contract Documents* for *Substantial Completion* of the *Work*, including any authorized extensions.
- W. **Consultant.** The *Architect*, *Engineer*, and/or professional engaged to develop/provide *Drawings*, *Specifications* and/or other services for the *Project*. The Consultant has no contractual agreement with the *Contractor* and therefore all interaction between any Consultant and the *Contractor* shall be done thru the *Contract Representative*.
- X. **Contract.** The written agreement between the *Community College System of New Hampshire* and the *Contractor* setting forth the obligations of the parties as outlined in the *Contract Documents*.
- Y. **Contract Representative.** The *Community College System of New Hampshire's* appointed representative is the CCSNH Director of Capital Planning and Development having specific authority to act on the *Community College System of New Hampshire's* behalf and shall be responsible for general supervision, control, and direction over all matters pertaining to design, construction, maintenance standards, preservation, and administration of the *Contract*. The *Architect* does not have such authority.

- Z. **Contract Bond.** The approved form of security to the Community College System of New Hampshire (political subdivision) in compliance with RSA 447:16 executed by the *Contractor* and their *Surety* or Sureties, guaranteeing complete execution of the contract and all supplemental agreements pertaining thereto including the payment of all legal debts pertaining to the construction of the *Project*.
- AA. **Contract Documents.** Collectively, the *Invitation To Bid*, *Bidding Requirements*, *Contract Bond*, *Specifications*, *Drawings*, *Addendum*, and other documents included in the *Contract*, and modifications, clarifications, authorized *Alteration Orders* and *Change Orders* issued after the execution of the *Contract*, to complete the *Project*. All documents shall be written in English.
- BB. **Contract Sum.** The amount stated in the *Contract*. This sum shall be derived from the *Lump Sum Base Bid*, *Lump Sum Grand Total*, or *Negotiated Price*; modified to reflect the acceptance of any *Alternates*. The *Notice to Proceed* shall state the amount that the *Community College System of New Hampshire* is obligated to pay the *Contractor*.
- CC. **Contractor.** The *Corporation*, *Partnership*, or *Proprietorship*, or any combination thereof, contracting with the Community College System of New Hampshire for performance of prescribed work.
- DD. **Contractor's Request for Certificate of Full or Partial Substantial Completion.** A document prepared by the *Contractor* when the *Project* reaches *Substantial Completion*.
- EE. **Contractual Liability.** Liability assumed by the *Contractor* under a *Contract*.
- FF. **Corporation.** A legal entity organized under the laws of a particular jurisdiction who is legally authorized to do business in the State.
- GG. **Credit.** Any Change that results in a reduction in the *Contract Sum* or *Lump Sum Grand Total* Items. All credits shall be processed by an *Alteration Order* and may include modifications to *Lump Sum Grand Total* Items.
- HH. **Day.** Unless designated as a *Working Day*, or unless otherwise indicated, this term will mean a *Calendar Day*.
- II. **Drawings (Plans).** The graphic and pictorial documents or reproductions thereof, which show the location, character, dimensions, and details of the prescribed work.
- JJ. **Final Completion.** Term denoting that the *Work* has been completed in accordance with the terms and conditions of the *Contract Documents* and all *Punch List* items have been completed.
- KK. **Final Payment.** Payment made by the *Community College System of New Hampshire* to the *Contractor*, upon *Final Completion*.
- LL. **General Conditions.** The part of the *Contract Documents* establishing the rights, responsibilities and relationships of the parties.

- MM. **Hazardous Material.** Shall include any material regulated by federal or state law and shall include but not limited to asbestos, toxic or hazardous waste, PCBs, combustible gases and materials, petroleum or radioactive material, or any other substances under any conditions and in such quantities as would pose a substantial danger to persons or property exposed to such substances.
- NN. **Indemnification.** A contractual obligation by which one person or entity agrees to reimburse others for loss or damage arising from specified liabilities.
- OO. **Invitation to Bid.** A portion of the *Bidding Documents*; the *Advertisement* for *Proposals* for *Work* or *Materials* on which *Bids* are requested. The *Advertisement* will indicate the time and place of the opening of *Proposals*, the type and location of *Work* to be performed, the character and quantity of the *Material* to be furnished and provide information on how to obtain *Drawings*, *Specifications* and *Proposal*.
- PP. **Liability Insurance.** A contract under which an insurance company agrees to protect a person or entity against claims arising from a real or alleged failure to fulfill an obligation or duty to a third party who is a named or an incidental beneficiary.
- QQ. **Lump Sum Base Bid.** One type of *Proposal* where the *Bid* is established by a single item price to perform all *Work* excluding any *Alternates* that may or may not become part of the *Contract*.
- RR. **Lump Sum Grand Total.** One type of *Proposal* where the *Bid* is established as a total of various items to perform all *Work* excluding any *Alternates* that may or may not become part of the *Contract*.
- SS. **Low Bid.** The *Bid* stating the lowest price proposed for performance of the *Work*, conforming to the *Bidding Documents*.
- TT. **Lowest Responsible Bidder.** The *Bidder* who submits the lowest bona fide *Bid* and is considered by the Community College System of New Hampshire to be fully responsible and qualified to perform the *Work* for which the *Bid* is submitted.
- UU. **Material(s).** Any substance and/or product specified for use in the construction of the *Project* and its appurtenances.
- VV. **Negotiated Price.** A *Proposal* modified by the *Lowest Responsible Bidder* thru communication with the Community College System of New Hampshire in which changes are made to the *Proposal* and/or *Completion Date* as required to meet budget, funding or scheduling requirements.
- WW. **Notice to Proceed.** A written notice to the *Contractor* to proceed with a portion of or all of the *Contract Work*; including the beginning of *Contract* time when applicable. The Notice to Proceed shall act as the final step in awarding the *Contract* or portion thereof.
- XX. **Occurrence Policy.** An insurance policy that covers acts or omissions occurring during the policy term, regardless of when a claim against the insured is first asserted, even if the policy is no longer in existence.

- YY. **Owner's Protective Liability Coverage.** Third-party legal liability insurance coverage protecting the *Community College System of New Hampshire* from claims arising from the construction process.
- ZZ. **Partnership.** An association of two or more persons or entities to conduct a business that shares profits and losses at a certain proportion.
- AAA. **Professional Engineer.** Referred to as Engineer. As defined in RSA 310-A:2, a person who by reason of advanced knowledge of mathematics and the physical sciences, acquired by professional education and practical experience, is technically and legally qualified to practice engineering, and who is licensed by or otherwise authorized by State of New Hampshire Professional Engineers Board to engage in the practice of engineering. The Engineer has no contractual agreement with the *Contractor* and therefore shall not directly interact with the *Contractor*.
- BBB. **Project.** The total construction of the *Work* to be performed.
- CCC. **Proposal.** A *Bidder's* offer, on *Community College System of New Hampshire* prescribed forms, to perform stated work at the quoted price(s).
- DDD. **Proposal Guaranty.** The security furnished with a *Proposal*, which shall be a *Bid Bond*, certified check or cashier's check and which provide that the *Bidder* if awarded the *Contract* will execute such *Contract* in accordance with the requirements of the *Bidding Documents*.
- EEE. **Proprietorship (Individual).** A form of business organization that is owned entirely by one person.
- FFF. **Provide.** To furnish and install a product, materials, systems, and/or equipment, complete in place, fully tested and approved.
- GGG. **Punch List.** A written document attached to the *Certificate of Substantial Completion* listing items to be completed or corrected prior to the *Community College System of New Hampshire* approval of *Final Payment*.
- HHH. **Specifications.** The volume that is part of the *Contract Documents* which contain the *General Conditions*, *Supplementary General Conditions*, *Invitation to Bid*, and individual sections that consist of written requirements for material, equipment, construction systems, standards and workmanship, and other documents or reports as applicable.
- III. **State.** The State of New Hampshire.
- JJJ. **Subcontractor.** A *Corporation*, *Partnership*, *Proprietorship*, Joint Venture or any combination thereof, to whom the *Contractor* sublets any part of the *Contract*.
- KKK. **Substantial Completion.** As determined by an inspection by the *Contract Representative* that the work or portion thereof is substantially complete, in accordance with the *Contract Documents*, such that the *Community College System of New Hampshire* may occupy or utilize the *Work* for its intended use without disruption or interference by the *Contractor* in completing or correcting any remaining unfinished or unacceptable *Work*.

- LLL. **Substitution.** A *Material*, product or item of equipment in place of that specified.
- MMM. **Superintendent.** The *Contractor's* authorized representative responsible for field supervision, coordination, and completion of the *Work*.
- NNN. **Supplementary General Conditions.** A part of the *Contract Documents* which supplements and may also modify, change, add to or delete from provisions of the *General Conditions*.
- OOO. **Surety.** A *Corporation, Partnership, or Proprietorship* other than the *Contractor*, executing a bond furnished by the *Contractor*.
- PPP. **Umbrella Liability Insurance.** Insurance providing coverage in an amount above existing liability policies.
- QQQ. **Unit Price.** An amount stated in a *Lump Sum Grand Total Bid* as a price per unit for an item or portion of the contract or for specific materials and/or services described in the *Contract Documents*.
- RRR. **Work.** The construction and services required by the *Contract Documents* to furnish all labor, materials, equipment, and incidentals necessary to complete the duties, obligations, and requirements imposed by the *Contract*.
- SSS. **Workers' Compensation Insurance.** Insurance covering the liability of an employer to employees for compensation and other benefits required by workers' compensation laws with respect to injury, sickness, disease or death arising from their employment.
- TTT. **Working Day.** Any calendar day, except Saturdays, Sundays, and Contract designated legal holidays.

PART 2 CONTRACT DOCUMENTS

- 2.1 The Contract Documents consist of the Invitation to Bid, Contract Agreement, General Conditions, Supplementary General Conditions, Drawings and Specifications, including all Addenda issued prior to execution of the Contract, wage scales where applicable, Bonds where required, insurance certificates, other documents listed in the Agreement and Modifications issued after the execution of the Contract, Change Orders and Alteration Orders issued in accordance with Part 12 of the General Conditions.
- A. Hierarchy of the Contract Documents shall be interpreted according to the following classes:
1. Community College System of New Hampshire approved modifications to the Contract Documents after execution of the Contract.
 2. Addenda.
 3. Supplemental General Conditions.
 4. General Conditions.
 5. Division 1 – General Requirements.
 6. Remaining Specifications.
 7. Larger Scale Drawings & Details.
 8. Remaining Drawings.
- 2.2 A fully executed Contract shall not be in effect until the contract is approved and an issuance of the Notice to Proceed by the Community College System of New Hampshire.
- 2.3 This Contract is executed in a number of counterparts, each of which is an original and constitutes the entire agreement between the parties. This Contract shall be construed according to the laws of the State. No portion of this Contract shall be understood to waive the sovereign immunity of the *Community College System of New Hampshire*. This Contract shall not be amended, except as specified in Parts 13 and 20.
- 2.4 The Contract Documents are complementary and anything called for by one of the Contract Documents and not called for by the others shall be of like effect as if required by all.
- 2.5 Should the Contract Documents contain inconsistencies within a class identified in Item 2.1A, the Contractor shall provide the better quality or greater quantity of work and/or materials. The Contractor shall identify any perceived discrepancies to the Contract Representative prior to proceeding.
- 2.6 The Contractors and all Subcontractors shall refer to all of the Contract Documents, including those not specifically showing the work of their specialized trades, and shall perform all work reasonably inferable from them as being necessary to produce the intended results in compliance with applicable Federal, State, and Local codes.
- 2.7 All indications or notations which apply to one of a number of similar situations, materials or processes shall be deemed to apply to all such situations, materials or processes wherever they appear in the work, except where a contrary result is clearly indicated by the Contract Documents.
- 2.8 Where codes, standards, requirements, and publications of public and private bodies are referred to in the Contract Documents, such references shall be understood to be to the latest final and complete

- revision at the time of receiving Bids unless specifically identified, except where otherwise indicated.
- 2.9 Where no explicit quality or standards for materials or workmanship is established for work, such work is to be consistent with the best quality workmanship standards of the applicable trade.
- 2.10 All manufactured articles, materials, and equipment shall be applied, assembled, installed, connected, erected, tested, cleaned, and conditioned in accordance with the manufacturer's written or printed directions and instructions, unless specifically indicated otherwise in the Contract Documents.
- 2.11 The Drawings are made to scale as identified therein, but all working dimensions shall be taken from the figured dimensions and by actual measurements at the job; in no case by scaling. The Contractor shall study and compare all of the Drawings and verify all figures before laying out or constructing work. The Contractor shall be responsible for errors in his/her work that might have been avoided thereby. Whether or not an error is believed to exist, deviation from the Drawings and the dimensions given thereon shall be made only after approval in writing from the Contract Representative.
- 2.12 All Drawings and Specifications and copies thereof are the property of the Community College System of New Hampshire and shall not be used by the Contractor or Subcontractor on other Projects.

PART 3 NOTICE

- 3.1 Any written notice by either party to the Contract shall be sufficiently given if delivered to or at the last known business address of the person, partnership or corporation constituting the other party to the Contract, or to his/her, their, or its duly authorized agent, representative, or officer, or when sent by registered mail to such last known business address. The last known business address shall be that location which is last provided in writing.
- 3.2 The parties shall provide their physical location/address, mailing address, telephone number, fax number, and, where available, pager number(s), email address(es), and other methods of contact for all persons associated with the Contract.

PART 4 ACCESS TO THE WORK

- 4.1 The Contractor shall provide for access to the work, at all times, for observation and/or inspection by the Community College System of New Hampshire, Architect, Consultant, Engineer and government officials having jurisdiction. The Contractor shall provide proper facilities for such access and inspection.

PART 5 ACCIDENT PROTECTION

- 5.1 It is a condition of this Contract, and shall be made a condition of each subcontract entered into pursuant to the Contract, that the Contractor, any Subcontractors, or Independent Contractors shall not require any laborer or mechanic employed in the performance of the Contract to work in surroundings or under working conditions which are unsanitary, hazardous or dangerous to the laborer's health or safety as determined by construction safety and health standards of the Occupational Safety and Health Administration, United States Department of Labor, which standards include, by reference, the established Federal Safety and Health Regulations for Construction. These standards and regulations comprise Part 1910 and Part 1926 respectively of Title 29 of the Code of Federal Regulations, as may be revised from time to time. In the event any revisions in the Code of Federal Regulations are published, such revisions will be deemed to supersede the appropriate Part 1910 and Part 1926, and be effective as of the date set forth in the revised regulation.

PART 6 HAZARDOUS MATERIALS

- 6.1 The Contractor shall also be aware of laws and regulations relating to hazardous materials that may be encountered during construction operations, either within project limits or at material sites off the project. The health and safety of employees, the general public, and the potential of damage to the overall environment is possible if hazardous materials are not recognized, reported, and the appropriate action taken to dispose of, remove from the site, or otherwise contain the possible contaminants.
- 6.2 If any abnormal condition is encountered or exposed that indicates the presence of a hazardous material or toxic waste, construction operations shall be immediately suspended in the area and the Contract Representative notified. No further work shall be conducted in the area of the contaminated material until the site has been investigated and the Community College System of New Hampshire has given approval to continue the work in the area. The Contractor shall fully cooperate with the Community College System of New Hampshire and perform any remedial work as directed. Work shall continue in other areas of the Project unless otherwise directed.
- 6.3 Exposure to hazardous materials may result from contact with, but not necessarily limited to, such items as drums, barrels, and other containers, waste such as cars, batteries, and building construction debris. Containers leaking unknown chemicals or liquids, abandoned cars leaking petroleum products, batteries leaking acid, construction debris which may include asbestos, or any other source of suspected hazardous material found within excavation areas or stockpiled on land within construction limits shall be referred to the Department of Environmental Services and Contract Representative so that a proper identification of the materials may be made and disposal procedures initiated as required.
- 6.4 Disposition of the hazardous material or toxic waste shall be made under the requirements and regulations of the Department of Environmental Services. Work required to dispose of these materials and any remedial work shall be performed under a Supplemental Agreement or Contract item, if included in the Contract.

PART 7 SUBCONTRACTS

- 7.1 Nothing contained in the Specifications or Drawings shall be construed as creating any contractual relationship between any Subcontractor and the Community College System of New Hampshire. The Sections of the Specifications are not intended to control the Contractor in dividing the work among Subcontractors or to limit the work performed by any trade.
- 7.2 The Contractor shall be as fully responsible for the acts and omissions of Subcontractors and of persons employed by them, as he/she is for the acts and omissions of persons directly employed by him/her.
- 7.3 The Contractor shall, without additional expense to the Community College System of New Hampshire, utilize the services of specialty Subcontractors, as required to complete the work.
- 7.4 The Contract Representative will not undertake efforts to settle or resolve any differences between the Contractor and Subcontractors or between Subcontractors.
- 7.5 The Contractor shall cause appropriate provisions to be inserted in all subcontracts relative to the work to bind Subcontractors to the Contractor by the terms of the General Conditions and other Contract Documents insofar as applicable to the work of Subcontractors and to give the Contractor the same power to terminate any subcontract that the Contract Representative may exercise over the Contractor under any provisions of the Contract Documents.

PART 8 RESPONSIBILITY OF CONTRACTOR TO ACT IN EMERGENCY

- 8.1 In case of any emergency that threatens loss or injury of property, and/or safety of life, the Contractor shall act as the situation may warrant. He/she shall notify the Contract Representative thereof immediately thereafter. Any compensation claimed by the Contractor together with substantiating documents in regard to expense, shall be submitted to the Contract Representative and the amount of compensation shall be determined by agreement.
- 8.2 In the event the Community College System of New Hampshire learns of an emergency that threatens loss or injury of property, and/or safety of life, the Community College System of New Hampshire shall notify the Contractor using the contact information provided pursuant to PART 3 herein. The Community College System of New Hampshire may, but shall have no duty to take reasonable steps to mitigate the damage or loss to the Contractor. In either event, the Community College System of New Hampshire shall have no duty to undertake any specific acts and shall have no liability for actions or inactions taken absent gross negligence.

PART 9 MUTUAL RESPONSIBILITY OF CONTRACTORS

- 9.1 If the Contractor or any of his/her Subcontractors or employees causes loss or damage to any separate Contractor or Subcontractor on the work, the Contractor or Subcontractor agrees to settle with such separate Contractor or Subcontractor by agreement, if he/she will so settle. If such separate Contractor or Subcontractor sues the Community College System of New Hampshire because of any loss so sustained, the Contract Representative shall notify the Contractor and/or their Subcontractors, who shall indemnify and hold harmless the Community College System of New Hampshire against any expenses or judgment arising therefrom.

PART 10 PAYMENTS TO CONTRACTOR

- 10.1 The Community College System of New Hampshire will process payments to the Contractor each month on the basis of duly certified and approved estimates of the work performed during the preceding period. In preparing estimates, the material delivered on the site and any preparatory work done may be taken into consideration. Payments will only be approved in an amount no greater than the percentage of project completion, as determined by the Contract Representative.
- 10.2 At least ten (10) days before the end of the billing period, the Contractor shall submit to the Contract Representative, an itemized Requisition for Payment, supported by such data substantiating the Contractor's right to payment as the Contract Representative may require. If payment is to be made for materials or equipment not incorporated in the work, but delivered and suitably stored at the site, or at some other location agreed upon in writing, such payment shall be conditional upon inspection and/or observation by the Community College System of New Hampshire and submission by the Contractor of bills of sale or such other procedure satisfactory to the Contract Representative to establish the Community College System of New Hampshire's title to such materials or equipment or otherwise protect the Community College System of New Hampshire's interest including applicable insurance and transportation to the site.
- 10.3 Immediately upon receipt of the Monthly Requisition for Payment, Contractor shall post same at the Contractor's Field Office or project site in a location where Subcontractors have clear access.
- 10.4 Retainage:
- A. Contract Payment Withheld: A 5% retainage shall be withheld from each Progress Payment until issuance of a Certificate of Substantial Completion. The balance remaining after the specified percentage has been retained, less all previous payments, will be certified for payment on each partial estimate.
- ***** [OR] *****
- B. Irrevocable Letter of Credit: In lieu of retainage for Projects amounting to Five Hundred Thousand (\$500,000.00) or more, the Contractor, with the approval of the Community College System of New Hampshire, may provide the Community College System of New Hampshire with a Letter of Credit in an amount equal to five percent (5%) of the total adjusted Contract amount at the time of such request. Any such Letter of Credit must be irrevocable (that is, it may be modified or revoked only with the consent of the Community College System of New Hampshire). It shall have a termination date at least one hundred twenty (120) days after the completion date specified in the underlying Contract, or as may be altered in accordance with the Contract Documents, whichever is later. The Letter of Credit shall authorize the Community College System of New Hampshire to require the issuing financial institution to deposit with the Community College System of New Hampshire an amount equal to the retainage that would have been deducted from payment to the Contractor, as specified in 10.4.A.1. The Community College System of New Hampshire may utilize the amount so deposited in the same manner as retainage.
- 10.5 Retainage will be released at Final Payment.
- A. After the Certificate of Substantial Completion has been issued, upon written application by the Contractor and with the approval of the Surety, the Contract Representative may release a portion of the retained amount.

10.6 Payment for Material On Hand:

- A. Partial payments are made for materials to be incorporated in the Work, provided the materials meet the requirements of the Contract and are delivered on, or in the vicinity of, the Project site and stored in acceptable places. Partial payments will not exceed 90 percent of the Contract unit price for the item or the amount supported by copies of paid invoices, freight bills, or other supporting documents required by the Community College System of New Hampshire. The quantity paid will not exceed the corresponding quantity estimate in the Contract. No partial payment will be made on living or perishable materials until incorporated in the Work.
- B. When material payments exceed \$100,000 or 10 percent (10%) of the total contract amount, whichever is less, notarized copies of paid invoices or copies of canceled checks for all such materials must be submitted to the Contract Representative within 45 days of the end date of the estimate on which the material allowance was paid. Failure to provide such documentation will result in the deduction of such material allowance from future estimates until documentation is provided.
- C. All material and work covered by partial payments made shall thereupon become the sole property of the Community College System of New Hampshire, but this provision shall not be construed as relieving the Contractor of the sole responsibility of all materials and work upon which payments have been made or the restoration of any damaged work or as a waiver of the right of the Community College System of New Hampshire to require the fulfillment of all the terms of the Contract.

10.7 Payment for Material Not on Hand:

- A. Upon receipt of a written request by the Contractor, partial payment may be made for acceptable, fully-fabricated, nonperishable materials not delivered that are unique to the Project provided the materials meet the requirements of the Contract and are stored in excess of 30 days at locations approved by the Community College System of New Hampshire, and provided all required certificates of compliance, mill test reports, shop inspector's acceptance and any other required materials certification have been furnished. Materials shall be identifiable and accessible for inspection. Storage areas shall provide adequate protection so that such materials will meet the Contract requirements upon delivery to the site.
- B. Partial payment will be based on the actual cost to the Contractor as indicated on invoices furnished to the Contract Representative. When material payments exceed \$100,000 or 10 percent of the total contract amount, whichever is less, notarized copies of paid invoices or copies of canceled checks for all such materials must be submitted to the Contract Representative within 45 days of the end date of the estimate on which the material allowance was paid. Failure to provide such documentation will result in the deduction of such material allowance from future estimates until documentation is provided. Payment shall not exceed 90 percent of the bid price. NO payment will be made on materials for any item in the contract whose total dollar value is less than \$5,000. Approval of partial payment will not constitute final acceptance of the materials for use in completing items of work.

10.8 Release of Claims:

- A. Neither the final payment nor any part of the retained percentage shall become due until the Contractor shall deliver a complete release of all claims arising under and by virtue of this Contract, including claims for all Subcontractors and suppliers of either materials or labor, plus a release of the Contract Bond and a statement that all Subcontractors and suppliers have been paid. The Chancellor, may pay any and all such claims, in whole or in part, and deduct the amount or amounts so paid from any partial or final payment.

10.9 Final Payment:

- A. Application for Final Payment received from the Contractor will be processed for payment not less than 90 days after project acceptance and final completion unless accompanied by a release of the Contract Bond. This payment shall be the amount of the Contract, amended by approved alteration orders, less previous payments minus liquidated damages, additional penalties or holdbacks. All prior partial estimates and payments shall be subject to correction in the final estimate and payment.

10.10 Acceptance of Final Payment Constitutes Release:

- A. The acceptance of the Final Payment by the Contractor shall be and shall operate as a release to the Contractor of all claims and of all liability to the Community College System of New Hampshire for all things done or furnished in connection with this work. No payment, however, final or otherwise, shall operate to release the Contractor and its Sureties from any obligations under this Contract or the Contract Bond. Acceptance of Final Payment shall not impact any warranties provided by the Contractor with respect to this project.

PART 11 CONTRACTOR'S TITLE TO MATERIALS

- 11.1 No materials or supplies for the work shall be purchased by the Contractor or any Subcontractor subject to any chattel mortgage or under a conditional sale or other agreement by which an interest is retained by the seller. The Contractor warrants that good title has been obtained for all materials and supplies for which partial payment has been accepted. If any claim is made with respect to materials provided by the Contractor, Subcontractors, or Independent Contractors, the Contractor shall defend any such claim and shall pay any judgment or settlement thereon.

PART 12 CHANGES IN WORK

- 12.1 No charge for any extra work or material will be allowed without a fully executed Alteration Order. (Refer to Specification Section 01200-Price and Payment Procedures)
- 12.2 The Chancellor may at any time, by a written order, and without notice to the Sureties, make changes in the Drawings and Specifications and Completion Date of the Contract and within the general scope thereof.
- 12.3 If any part of the work as installed be at variance with the Contract requirements, the Contract Representative may allow all or any part of such work to remain in place, if found to be in the best interest of the Community College System of New Hampshire, subject to proper adjustment in the

Contract Price. Acceptance of installed work in one instance or in any instance does not constitute a waiver of Specifications, General Conditions or contract requirements.

- 12.4 The Contractor shall hold the Community College System of New Hampshire and its officers, agents, servants, and employees harmless from liability of any nature including cost and expenses, for or on account of any patented or unpatented invention, process, article or applicable items manufactured or used in the performance of the Contract, including its use, unless otherwise specifically stipulated in the Contract Documents.

PART 13 ASSIGNMENTS

- 13.1 The Contractor shall not assign the whole or any part of this Contract or any monies due or to become due, hereunder, without the written consent of the Chancellor and of all Sureties executing any Bonds on behalf of the Contractor if in connection with said Contract.

PART 14 SUPERINTENDENCE BY CONTRACTOR

- 14.1 The Contractor shall have on the project site, at all times when work is being performed, a competent English speaking Superintendent capable of reading and thoroughly understanding the contract documents and thoroughly experienced in the type of work being performed, satisfactory to the Community College System of New Hampshire. The Contractor shall not change superintendents without permission from the Contract Representative and shall submit a request in writing with justification for such a change.
- A. The Superintendent shall be responsible for verifying that all materials, installation, coordination, and workmanship are in conformance with the contract documents.
 - B. Unless the Contract Representative has granted prior written approval, the Superintendent shall not, himself, engage in "hands-on" construction work.
 - C. In the event the Superintendent fails or refuses to perform functions mentioned above as determined by the Contract Representative, the Contractor agrees to a stipulated penalty of \$1,200.00 per day, in addition to any liquidated damages provided hereunder.

PART 15 FAILURE TO COMPLETE WORK ON TIME

- 15.1 If the Contractor fails to complete all of the work or sections of the Project, if sections are indicated, within the time specified in the Contract or within any additional time allowed, for each working day the Liquidated Damages identified in 16.3 will be deducted from any money due the Contractor. This deduction will be made, not as a penalty, but as fixed, agreed liquidated damages for inconvenience to the Community College System of New Hampshire and for reimbursing the Community College System of New Hampshire the cost of the Administration of the Contract, including personnel, time, engineering and inspection. Should the amount of money otherwise due the Contractor be less than the amount of such liquidated damages, the Contractor and its Surety shall be liable to the Community College System of New Hampshire for such deficiency.
- 15.2 If the Community College System of New Hampshire permits the Contractor to continue and finish the work after the time fixed for its completion, it shall in no way operate as a waiver on the part of the Community College System of New Hampshire of any of its rights under the Contract. When the final acceptance has been duly made by the Contract Representative, any liquidated damage charges shall end.
- 15.3 The fixed, agreed, liquidated damages shall be assessed in accordance with the following schedule:

Original Contract Amount, Plus Any Extras, Alteration Orders, and Alternates		Amount of Liquidated Damages Per Working Day
From More Than:	To and Including:	
\$0	\$25,000.00	\$200.00
\$25,000.00	\$50,000.00	\$250.00
\$50,000.00	\$100,000.00	\$400.00
\$100,000.00	\$500,000.00	\$450.00
\$500,000.00	\$1,000,000.00	\$800.00
\$1,000,000.00	\$2,000,000.00	\$1,200.00
\$2,000,000.00	\$5,000,000.00	\$1,600.00
\$5,000,000.00	\$10,000,000.00	\$2,000.00
\$10,000,000.00	and above	\$2,400.00

Revised 02-25-2007

PART 16 SUBSTANTIAL COMPLETION AND FINAL INSPECTION

Revised 12/08/04

- 16.1 The Contractor shall provide a signed Substantial Completion Application to the Contract Representative when the work is believed to be substantially complete, in accordance with specification section 01700, accompanied by a list of items, referred to as the Punch List, to be completed or corrected. The failure to include any items of such list does not alter the responsibility of the Contractor to complete all work in accordance with the Contract Documents. On the basis of an inspection by the Contract Representative who determines that the work is substantially complete, a Certificate of Substantial Completion will be issued.
- A. The Certificate of Substantial Completion shall:
1. Include any modifications to the Punch List or value as determined by the Contract Representative.
 2. Establish the Date of Substantial Completion.
 - a. Warranties required by the Contract Documents shall commence on the Date of Substantial Completion unless otherwise provided in the Certificate of Substantial Completion.
 3. Identify the responsibilities of the Community College System of New Hampshire and the Contractor for security, maintenance, heat, utilities, and damage to the work and insurance.
 4. Fix the time limit within which the Contractor shall complete the items listed herein.
- 16.2 Partial Occupancy or Use: The Community College System of New Hampshire may take occupancy or use of completed or partially completed portions of the work upon written agreement between the Chancellor and the Contractor. Said partial occupancy or use shall have the approval of the insurer and Code enforcement authorities having jurisdiction. Said partial occupancy or use, (whether substantial completion has been obtained or not) provided the Contract Representative and Contractor have agreed upon written terms detailing each of the entities responsibilities in their entirety, may be exercised under these General Conditions.
- A. A Written agreement shall stipulate the time period for completion of all Work and the commencement date for all applicable contract warranties. Said written agreement shall be preceded by a Contractor generated listing of all incomplete Work, meeting with the approval of the Contract Representative, before partial occupancy or use is taken by the Community College System of New Hampshire with prior approval of the Division.
- 16.3 If the Contractor fails to complete the items on the "punch list," by the date specified on the Substantial Completion Certificate, then in addition to the corrective measures listed in the Certificate of Substantial Completion, the Community College System of New Hampshire may use the monies still due the Contractor to have such items completed and the Contractor shall lose any claim to the monies so used. The Surety may be notified of any delay or failure to complete the work.
- 16.4 Upon written notice that the work is ready for final inspection and acceptance, the Contract Representative shall promptly make such inspection, to determine the work is acceptable under the Contract Documents and the Contract fully performed. The Contractor shall submit a request for payment, specifically identifying Final Payment. The Contractor shall provide all certificates and reports, as required, throughout the contract and shall coordinate their preparation and submission

prior to request for final payment. Failure to submit such certificates and reports shall be considered default of contract.

PART 17 DEFAULT AND TERMINATION OF CONTRACT**17.1 If the Contractor:**

- A. Fails to begin work under Contract within the time identified in specification section 01100.
- B. Fails to perform the work with sufficient workers and equipment, or with sufficient materials to assume prompt completion of said work, or
- C. Performs the work unsuitably or neglects or refuses to remove materials or to perform anew such work as may be rejected as unacceptable and unsuitable, or
- D. Discontinues the prosecution of the work, or
- E. Fails to resume work, which has been discontinued, within a reasonable time after notice to do so, or
- F. Becomes insolvent or has declared bankruptcy, or commits any act of bankruptcy or insolvency, or
- G. Makes an assignment for the benefit of creditors, or
- H. For any other causes whatsoever, fails to carry on the work in an acceptable manner.

17.2 The Chancellor will give notice, in writing, to the Contractor and his Surety for such delay, neglect, and default for any item identified above.

- A. Upon receipt of Notification of Default and the Contractor or Surety does not proceed in accordance with said Notification, then the Chancellor will Terminate the Contract. Upon which, the Chancellor shall have full power and authority, without violating the Contract, to assume the prosecution of the work. The Chancellor may enter into one or more agreements for the completion of said Contract according to the terms and conditions thereof, or use such other methods as will be required for the completion of said Contract in an acceptable manner.
 - 1. All extra costs and charges incurred by the Community College System of New Hampshire as a result of such delay, neglect or default, together with the cost of completing the work under the Contract will be deducted from any monies due or which may become due said Contractor. If such expenses exceed the sum that would have been payable under the Contract, then the Contractor and the Surety shall be liable and shall pay to the Community College System of New Hampshire, the amount of such excess.

PART 18 TERMINATION OF CONTRACT WITHOUT FAULT

- 18.1 Except in cases controlled by the preceding section, the Chancellor, for any cause, including, but not limited to an order of any Federal authority or petition of the Contractor due to circumstances beyond its control may, by written notice to the Contractor and the Surety, with the concurrence of

the Governor and Council, terminate the Contract or any portion thereof subject to the Condition(s) A, B, C, and D provided below.

- 18.2 Notwithstanding anything to the contrary contained in these conditions, it is understood and agreed by the parties hereto that all obligations of the Community College System of New Hampshire hereunder, including the continuance of payments, are contingent upon the availability and continued appropriation of State and/or Federal Funds, and in no event shall the Community College System of New Hampshire be liable for any payments hereunder in excess of such available or appropriated funds. In the event of a reduction, termination or failure to appropriate any or all such available funds or appropriations or a reduction of expenditures of Community College System of New Hampshire funds by the Advisory Budget Control Committee, the Chancellor may, by written notice to the Contractor and Surety, immediately terminate this Contract in whole or in part in accordance with the following conditions:
- A. When a Contract, or portion thereof, is terminated before completion of all items of work in the Contract, payment will be made for the actual items of work completed. Payment of items of work not completed at time of termination shall be the greater of the following amounts:
 - 1. A percentage of the Contract unit price, which percentage shall be the percentage of completion of the particular item at time of termination.
 - 2. Such amount as shall be mutually agreed upon by the parties. No claim for loss of anticipated profits on items or units of work not completed will be allowed.
 - B. Reimbursement for organization of the work and mobilization, when not otherwise included in the Contract, shall be made where the volume of work completed is too small to compensate the Contractor for these expenses under the Contract; the intent being that an equitable settlement be made with the Contractor.
 - C. Acceptable materials, obtained or ordered by the Contractor for the work, and that are not incorporated in the work shall, at the option of the Contractor, be purchased from the Contractor based upon the delivered cost of the materials at such points of delivery as may be designated by the Contract Representative. The Contractor shall do everything possible to cancel unfilled orders.
 - D. Termination of a Contract, or a portion thereof, shall not relieve the Contractor of its responsibilities for the work completed nor shall it relieve the Surety of its obligations for and concerning any claims arising out of the work performed.

PART 19 ASSIGNMENT PROVISION

- 19.1 The Contractor hereby agrees that it will assign to the Community College System of New Hampshire, all causes of action that it may acquire under the anti-trust laws of New Hampshire and the United States as a result of conspiracies, combinations of contracts in restraint of trade which affect the price of goods or services obtained by the Community College System of New Hampshire under this Contract, if so requested by the Community College System of New Hampshire.

END OF SECTION

SECTION 01100

SUMMARY

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Contract description.
- B. Work by College.
- C. College supplied products.
- D. Contractor's use of site.
- E. Work sequence.
- F. College occupancy.
- G. Specification Conventions.

1.2 CONTRACT DESCRIPTION

- A. This project consists of Boiler & Mechanical Equipment Replacement. Provide labor, materials, accessories, and other related items as required to complete operations in connection with the complete installation of the HVAC and mechanical systems as indicated on the Drawings and as specified herein.
- B. The Project will include but not be limited to the Disciplines of: mechanical work, and electrical work .
- C. Perform Work of Contract under stipulated lump sum grand total contract with the College in accordance with Conditions of Contract.
- D. The Contractor shall, except as otherwise specifically stated in the Contract Documents, provide and pay for all materials, labor, tools, equipment, water, heat, fuel, light, power, transportation, superintendence, temporary construction of every nature, and all other services and facilities of every nature whatsoever necessary to execute, complete, and deliver the work within the specified time.

1.3 WORK BY COLLEGE

- 1. NONE

1.4 COLLEGE SUPPLIED PRODUCTS

1. NONE

1.5 CONTRACTOR'S USE OF SITE [AND PREMISES]

- A. Limit use of site and premises to allow:
 1. College occupancy.
 2. Work by Others and Work by College.
- B. Access to Site: Limited to Normal working hours.
- C. Construction Operations: Limited to areas as designated in the plans and specifications.
- D. Time Restrictions for Performing Work: Normal working hours of [7:30] am to [4:30] pm, Monday through Friday with the following restrictions:
 1. No access during the following observed holidays:
 - a. New Year's Day.
 - b. Martin Luther King Jr. Civil Rights Day.
 - c. Washington's Birthday.
 - d. Memorial Day.
 - e. Independence Day.
 - f. Labor Day.
 - g. Veterans' Day.
 - h. Thanksgiving Day.
 - i. Day after Thanksgiving.
 - j. Christmas Day.
 2. Access for work outside of normal working hours shall be requested in writing to the Contract Representative, at least one week in advance. The Contract Representative may accept or reject the request.
- E. Utility Outages and Shutdown: Shall be coordinated with the building users to minimize disruption of services, and may require work to take place outside of normal working hours with request and approval.

1.6 WORK SEQUENCE

- A. Work shall commence within 7, days after issuance of Notice to Proceed. Failure to comply shall constitute Default of Contract.
- B. Construct Work to accommodate College's occupancy requirements during construction period, coordinate construction schedule and operations with CCSNH Contract Administrator:

1.7 COLLEGE OCCUPANCY

- A. The College intends to occupy the campus during the Project. The Contractor's guarantee of work identified in Section 1700 shall not commence until the Contractor is granted a Certificate of Substantial Completion.
- B. Cooperate with College to minimize conflict, and to facilitate College's operations.
- C. Schedule the Work to accommodate College occupancy.
- D. Partial Occupancy. The College will be permitted to partially occupy the premises as phases of the project are completed. Warranties for items contained within the areas subject to partial occupancy shall commence upon the College's use of those premises identified in the Partial Occupancy. Warranties on systems extending beyond the area subject to the Partial Occupancy shall not commence until all areas utilizing those system(s) are complete and fully functional.

1.9 SPECIFICATION CONVENTIONS

- E. These specifications are written in imperative mood and streamlined form. This imperative language is directed to the Contractor, unless specifically noted otherwise. The words "shall be" are included by inference where a colon (:) is used within sentences or phrases.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01200

PRICE AND PAYMENT PROCEDURES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Allowances (intentionally omitted).
- B. Testing and inspection allowances. (intentionally omitted)
- C. Schedule of values.
- D. Requisition for payment.
- E. Change procedures.
- F. Defect assessment.
- G. Unit prices.
- H. Alternates (intentionally omitted).

1.2 ALLOWANCES (intentionally omitted).

1.3 TESTING AND INSPECTION ALLOWANCES (intentionally omitted)

1.4 SCHEDULE OF VALUES

- A. Submit printed schedule on AIA Form G703 - Continuation Sheet for G702. Contractor's standard form or electronic media printout will be considered.
- B. Submit Schedule of Values in duplicate within 15 days after date of issuance of Notice to Proceed. Failure to submit within specified time period will constitute Default of Contract.
- C. Format: Utilize Table of Contents of these Specifications. Identify each line item with number and title of major specification Section. Identify bonds and insurance, allowances, and alternates
- D. Include a separate line item for the amount of each Allowance and Alternates specified in this section. For unit cost Allowances, identify quantities taken from Contract Documents multiplied by unit cost to achieve total for each item.
- E. Revise schedule to list approved Change Orders, with each Requisitions For Payment.

1.5 REQUISITION FOR PAYMENT

- A. Submit one copy of each application.
- B. Content and Format: Items on the Requisition for Payment shall be consistent with the items on the Proposal Form. Utilize the Schedule of Values as documentation for payment items.
- C. Submit updated construction schedule with each Requisition for Payment.
- D. Payment Period: Submit at intervals stipulated in Document 00708 General Conditions. CCSNH
- E. Substantiating Data: When the Contract Representative requires substantiating information, submit data justifying dollar amounts in question.
- F. Include the following with Requisition for Payment, payment will not be processed if any items are missing or incomplete:
 - 1. Record documents as specified in Section 01700, for review by the Contract Representative, which will be returned to Contractor.
 - 2. Affidavits attesting to off-site stored products.
 - 3. Construction progress schedules, revised and current as specified in Section 01330.

1.6 CHANGE PROCEDURES

- A. Submittals: Submit name of individual authorized to receive change documents, and be responsible for informing others in Contractor's employ or Subcontractors of changes to the Work.
- B. The Contract Representative will advise of minor changes in the Work not involving adjustment to Contract Sum/Price or Contract Time, or that may be necessary to carry out the work included in the Contract, by issuing supplemental instructions.
- C. The Contract Representative may issue a Proposal Request including a detailed description of proposed change(s) with supplementary or revised Drawings and specifications, a change in Contract Time for executing the change. The Contractor will prepare and submit estimate within ten days.
- D. Contractor may propose changes by submitting a request for change(s) to the Contract Representative, describing proposed change and its full effect on the Work. Each request shall be a separate item and sequentially numbered. Include a statement describing reason for the change, and effect on Contract Sum/Price and Contract Time with full documentation and a statement describing effect on Work by separate or other Contractors.
- E. Stipulated Sum/Price Change Order: Based on Proposal Request and Contractor's fixed price quotation or Contractor's request for Change Order as approved by the Contract

Representative. Submit the breakdown of the following items on a Stipulated Sum/Price Change Order Form for review and approval by the Contract Representative:

1. The Contractor shall include the following indirect costs for work performed by the General Contractor as part the Contractors' price:
 - a. Worker's Compensation and Employee Liability.
 - b. Unemployment and Social Security Taxes.
 2. In addition to the above indirect costs the General Contractor shall be allowed the following markups:
 - a. Ten percent (10%). Said ten percent (10%) shall be all inclusive for overhead, supervision, and profit for Work performed by the General Contractor
 - b. Five percent (5%) on that part of work performed by Subcontractors.
 - c. The same percentages above shall apply to Subcontractors.
 3. On any change that involves a net credit to the State, no allowance for overhead, supervision and profit shall be figured.
 4. Extension of Contract Time: State any requests for extension of Contract Time with justification for such a request.
- F. Unit Price Change Order: For contract unit prices and quantities, the Change Order will be executed on fixed unit price basis. For unit costs or quantities of units of work which are not pre-determined, execute Work under Construction Change Directive. Changes in Contract Sum/Price or Contract Time will be computed as specified for Time and Material Change Order.
- G. Construction Change Directive : The Contract Representative may issue directive, signed by the Bureau Administrator or Assistant Administrator, instructing the Contractor to proceed with change in the Work, for subsequent inclusion in a Time and Material Change Order. Document will describe changes in the Work, and designate method of determining any change in Contract Sum/Price or Contract Time. Promptly execute change. Failure to comply will result in Default of Contract.
- H. Time and Material Change Order: Submit itemized account and supporting data within 10 days of completion of change. The Contract Representative will determine change allowable in Contract Sum/Price and Contract Time as provided in Contract Documents.
1. Maintain detailed records of work done on Time and Material basis. Provide full information required for evaluation of proposed changes, and to substantiate costs for changes in the Work.
 2. Document each quotation for change in cost or time with sufficient data to allow evaluation of quotation. If acceptable, a Change Order for a Not to Exceed Amount will be prepared.
 3. The Contractor as payment in full, including superintendence and overhead, shall accept the compensation herein provided and profit, for extra work performed. For all such work, the Contractor shall furnish certified copies of the payrolls on forms provided for that purpose, invoices of all materials, and such other information as may be required by the Contract Representative. Submit the breakdown of items on a Bureau Time and Material Change Order Form for review and approval by the Contract Representative:
 - a. Labor (Actual wage + 40%): The Construction Superintendent is responsible for logging the time for each individual. For all laborers and

- foremen engaged on the specific operation and entered directly on the Contractor's payroll, the Contractor will receive the actual rate of wage for each and every hour said laborers and Foremen are actually engaged in such work to which will be added an amount equal to forty percent (40%) of the sum thereof, which percentage shall include the cost percentages of the following items as applied to the labor cost involved:
- 1) Contract Bond Premium.
 - 2) Public Liability Insurance.
 - 3) Worker's Compensation Insurance.
 - 4) Federal Social Security.
 - 5) Unemployment Compensation Taxes
- b. Materials (Actual Cost + 10%): For all materials entering permanently into the work plus freight charges thereon, and for all labor not entered directly on his payroll, the Contractor will receive the actual cost, as shown by original receipted bills forwarded to the Contract Representative, to which cost will be added an amount equal to ten percent (10%) of the sum thereof. Bills presented by the Contractor for material taken back from his stock will be subject to the ten percent (10%) allowance if approved by the Contract Representative.
- c. Equipment (Reasonable Rental Charge + 0%): For any trucks, machinery or special equipment, other than small tools, the Contractor will receive a reasonable rental charge to which sum no percentage will be added. This rental charge shall be agreed upon in writing before the work is begun and shall include an operator and all fuel, lubricants, and the upkeep of the equipment.
4. In addition to the above costs the General Contractor shall be allowed the following markups:
- a. Ten percent (10%). Said ten percent (10%) shall be all inclusive for overhead, supervision, and profit for Work performed by the General Contractor
 - b. Five percent (5%) on that part of work performed by Subcontractors.
 - c. The same percentages above shall apply to Subcontractors.
5. Extension of Contract Time: State any requests for extension of Contract Time with justification for such a request.
- I. Any Changes that result in a credit to any portion of the contract and/or a change in the Contract Time must be processed as an Change Order except as provided for in Item 1.2E.
- J. Execution of Change Orders: CCSNH Contract Representative will issue Change Orders per the following procedures.
1. The Contract Representative reviews cost for Change in Work. If needed the Contract Representative will request additional items, back-up information, and request any possible changes or clarifications.
 2. Contract Representative will prepare a Change Order.
 3. Contract Representative will issue the Change Order to the Contractor for review and signature.
 4. Contractor submits signed Change Order to the Contract Representative.

5. The Contract Representative completes the Change Order with the signature of the College Representative
 6. A fully signed and executed Change Order is issued to Contract Representative, Clerk of the Works, and Contractor.
- K. Execution of Change Orders: The Contractor is responsible for preparing and updating a spreadsheet log itemizing all Proposed Changes. A separate spreadsheet shall be completed for each Allowance Item. The spreadsheet shall include columns for Proposed Change Number, Description, Amount of Change, (or initial order of magnitude), Status, and Approved Amounts. In addition a current balance remaining shall be included. Change Orders will be processed per the following procedures:
1. The Contract Representative reviews cost for Change in Work with the College and Consultant(s). If needed the Contract Representative will request additional items, back-up information, and request any possible changes or clarifications.
 2. Contract Representative and College Representative signs Change Order.
 3. Contractor can proceed with Change Order Work with direction from the Contract Representative.
 4. Fully signed and executed Change Order is issued to the Contract Representative, Clerk of the Works, and Contractor.
- L. Correlation Of Contractor Submittals:
1. Promptly revise Schedule of Values and Application for Payment forms to record each authorized Change Order as separate line item and adjust Contract Sum/Price.
 2. Promptly revise progress schedules to reflect change in Contract Time, revise sub-schedules to adjust times for other items of work affected by the change, and resubmit.
 3. Promptly enter changes in Project Record Documents.
- 1.7 DEFECT ASSESSMENT
- A. Replace the Work, or portions of the Work, not conforming to specified requirements.
 - B. If, in the opinion of the Contract Representative, it is not practical to remove and replace the Work, the Contract Representative will direct appropriate remedy or adjust payment.
 - C. The defective Work may remain, but unit sum/price will be adjusted to new sum/price at discretion of the Contract Representative.
 - D. Defective Work will be repaired to instructions of and acceptance by the Contract Representative, and unit sum/price will be adjusted to new sum/price at discretion of the Contract Representative.
 - E. Authority of the Contract Representative to assess defects and identify payment adjustments, is final.
 - F. Non-Payment For Rejected Products: Payment will not be made for rejected products for any of the following:
 1. Products wasted or disposed of in a manner that is not acceptable.
 2. Products determined as unacceptable before or after placement.

3. Products not completely unloaded from transporting vehicle.
4. Products placed beyond lines and levels of required Work.
5. Products remaining on hand after completion of the Work.
6. Loading, hauling, and disposing of rejected products.

1.8 UNIT PRICES

A. NONE

1.9 ALTERNATES (intentionally omitted)

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01300

ADMINISTRATIVE REQUIREMENTS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Coordination and project conditions.
- B. Permits and fees.
- C. Field engineering.
- D. Preconstruction meeting.
- E. Site mobilization meeting.
- F. Progress meetings.
- G. Pre-installation meetings.
- H. Cutting and patching.
- I. Notification of Subcontractors and Workmen's Compensation Insurance (SB 78)
- J. Special procedures.

1.2 COORDINATION AND PROJECT CONDITIONS

- A. Coordinate scheduling, submittals, and Work of various sections of the Specifications to ensure efficient and orderly sequence of installation of interdependent construction elements, with provisions for accommodating items installed later.
- B. The Contractor shall comply with the "Underground Utility Damage Prevention System" by notification to DIG-SAFE SYSTEM of intent to excavate near or around any underground utility installations in public ways. The Contractor shall call 1-800/225-4977 at least seventy-two (72) hours in advance of starting any excavation. Saturday, Sundays, and legal holidays are not included in the computation of the required seventy-two (72) hour notice.
- C. Prior to any Work, the Contractor shall hire an independent company to locate utilities potentially affected by the Work and as shown and/or identified in the Contract Documents. All utilities shall be identified by the Contractor on the Record Drawings.
- D. Verify utility requirements and characteristics of operating equipment are compatible with building utilities. Coordinate work of various sections having interdependent responsibilities for installing, connecting to, and placing in service, operating equipment.

- E. Coordinate space requirements, supports, and installation of mechanical and electrical Work indicated diagrammatically on Drawings. Follow routing shown for pipes, ducts, and conduit, as closely as practicable; place runs parallel with lines of building. Utilize spaces efficiently to maximize accessibility for other installations, for maintenance, and for repairs.
- F. In finished areas except as otherwise indicated, conceal pipes, ducts, and wiring within construction. Coordinate locations of fixtures and outlets with finish elements.
- G. Coordinate completion and clean-up of Work of separate sections in preparation for Substantial Completion [and for portions of Work designated for State's [partial] occupancy].
- H. After State occupancy of premises, coordinate access to site for correction of defective Work and Work not in accordance with Contract Documents, to minimize disruption of State's activities.

1.3 PERMITS AND FEES

- A. The CCSNH shall obtain and pay for all permits, and impact fees as may be required by law for construction of CCSNH's facility. The Contractor shall pay for all fees and charges, and use of the property other than the site of the work for storage of materials or other purposes.
- B. The Contractor shall pay all applicable Federal, State, and Local sales and other taxes, except taxes and assessments on the real property comprising the site of the Project.

1.4 FIELD ENGINEERING (not used)

1.5 PRECONSTRUCTION MEETING

- A. The Contract Representative will schedule meeting at the Project site prior to Contractor occupancy.
- B. Attendance required (unless otherwise waived): Contract Representative, Clerk of the Works, Contractor, Contractor's Superintendent, and major Subcontractors.
- C. Potential Agenda Topics:
 - 1. Distribution of Contract Documents.
 - 2. Submission of list of Subcontractors, insurance carriers, subcontracting relationship, list of products, schedule of values, and progress schedule.
 - 3. Designation of personnel representing parties in Contract.
 - 4. Use of premises by CCSNH and Contractor.
 - 5. College's requirements and partial occupancy.
 - 6. Construction facilities and controls provided by CCSNH.
 - 7. Temporary utilities provided by CCSNH
 - 8. Security and housekeeping procedures.
 - 9. Schedules.
 - 10. Application for payment procedures.
 - 11. Procedures for maintaining record documents.

12. Requirements for start-up of equipment.
 13. Inspection and acceptance of equipment put into service during construction period.
- D. Contract Representative shall record minutes and distribute copies within two days after meeting to participants, with one copy to each person in attendance and one to those affected by decisions made.

1.6 PROGRESS MEETINGS

- A. Schedule and administer meetings throughout progress of the Work at weekly intervals.
- B. Attendance required (unless otherwise waived): Contract Representative, Clerk of the Works, Contractor, Contractor's Superintendent, and major Subcontractors.
- C. Potential Agenda Topics:
1. Review minutes of previous meetings.
 2. Review of Work progress.
 3. Field observations, problems, and decisions.
 4. Identification of problems impeding planned progress.
 5. Review of submittals schedule and status of submittals.
 6. Review of off-site fabrication and delivery schedules.
 7. Maintenance of progress schedule.
 8. Corrective measures to regain projected schedules.
 9. Planned progress during succeeding work period.
 10. Coordination of projected progress.
 11. Maintenance of quality and work standards.
 12. Effect of proposed changes on progress schedule and coordination.
 13. Other business relating to Work.
- D. Contract Representative shall record minutes and distribute copies within two days after meeting to participants, with one copy to each person in attendance and one to those affected by decisions made.

1.7 PRE-INSTALLATION MEETING(S)

- A. When required in individual specification sections, convene pre-installation meetings at Project site prior to commencing work of specific section.
- B. Require attendance of parties directly affecting, or affected by, Work of specific section.
- C. Notify the Contract Representative seven days in advance of meeting date.
- D. Contractor shall prepare agenda and preside at meeting:
1. Review conditions of installation, preparation and installation procedures.
 2. Review coordination with related work.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.1 CUTTING AND PATCHING

- A. Employ skilled and experienced installer to perform cutting and patching.
- B. Submit written request in advance of cutting or altering elements affecting:
 - 1. Structural integrity of element.
 - 2. Integrity of weather-exposed or moisture-resistant elements.
 - 3. Efficiency, maintenance, or safety of element.
 - 4. Visual qualities of sight exposed elements.
 - 5. Work of CCSNH or separate contractor.
- C. Execute cutting, fitting, and patching [including excavation and fill,] to complete Work, and to:
 - 1. Fit the several parts together, to integrate with other Work.
 - 2. Uncover Work to install or correct ill-timed Work.
 - 3. Remove and replace defective and non-conforming Work.
 - 4. Remove samples of installed Work for testing.
 - 5. Provide openings in elements of Work for penetrations of mechanical and electrical Work.
- D. Execute work by methods to avoid damage to other Work, and to provide proper surfaces to receive patching and finishing.
- E. Cut masonry and concrete materials using masonry saw or core drill.
- F. Restore Work with new products in accordance with requirements of Contract Documents.
- G. Fit Work tight to pipes, sleeves, ducts, conduit, and other penetrations through surfaces.
- H. Maintain integrity of wall, ceiling, roof, or floor construction; completely seal voids.
- I. At penetrations of fire rated walls, partitions, ceiling, or floor construction, completely seal voids with material in accordance with design and code requirements, to full thickness of penetrated element.
- J. Refinish surfaces to match adjacent finishes. For continuous surfaces, refinish to nearest intersection; for assembly, refinish entire unit.
- K. Identify hazardous substances or conditions exposed during the Work to the Contract Representative for decision or remedy.

3.2 SPECIAL PROCEDURES

- A. Materials: As specified in product sections; match existing with new products [and salvaged products] for patching and extending work.
- B. Employ skilled and experienced installer to perform alteration work.
- C. Cut, move, or remove items as necessary for access to alterations and renovation Work. Replace and restore at completion.
- D. Remove unsuitable material not marked for salvage, including rotted wood, corroded metals, and deteriorated masonry and concrete. Replace materials as specified for finished Work.
- E. Remove debris and abandoned items from area and from concealed spaces.
- F. Prepare surface and remove surface finishes to permit installation of new work and finishes.
- G. Close openings in exterior surfaces to protect existing work from weather and extremes of temperature and humidity.
- H. Remove, cut, and patch Work in manner to minimize damage and to permit restoring products and finishes to original condition.
- I. Refinish existing visible surfaces to remain in renovated rooms and spaces, to original condition for each material, with neat transition to adjacent finishes.
- J. Where new Work abuts or aligns with existing, provide smooth and even transition. Patch Work to match existing adjacent Work in texture and appearance.
- K. When finished surfaces are cut so that smooth transition with new Work is not possible, terminate existing surface along straight line at natural line of division and submit recommendation to Contract Representative for review.
- L. Where change of plane of **1/inch** or more occurs, submit recommendation for providing smooth transition to Contract Representative for review.
- M. Trim existing doors to clear new floor finish. Refinish trim to original condition.
- N. Patch or replace portions of existing surfaces which are damaged, lifted, discolored, or showing other imperfections.
- O. Finish surfaces as specified in individual product sections.

END OF SECTION

SECTION 01330
SUBMITTAL PROCEDURES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Submittal procedures.
- B. Construction progress schedules.
- C. Subcontractor list.
- D. Proposed products list.
- E. Product data.
- F. Shop drawings.
- G. Samples.
- H. Design data.
- I. Test reports.
- J. Certificates.
- K. Manufacturer's instructions.
- L. Manufacturer's field reports.
- M. Erection drawings.
- N. Construction photographs.

1.2 SUBMITTAL PROCEDURES

- A. Transmit each submittal with CCSNH accepted form.
- B. Sequentially number transmittal forms. Mark revised submittals with original number and sequential alphabetic suffix.
- C. Identify Project, Contractor, subcontractor and supplier; pertinent drawing and detail number, and specification section number, appropriate to submittal.

- D. Apply Contractor's stamp, signed or initialed certifying that review, approval, verification of products required, field dimensions, adjacent construction Work, and coordination of information is in accordance with requirements of the Work and Contract Documents. Incomplete items or items submitted without the Contractor's signed stamp of approval thereon will be returned rejected.
- E. Schedule submittals to expedite Project. Coordinate submission of related items. Deliver to:
- Contract Representative
Matthew Moore
memoore@ccsnh.edu
Director of Capital Projects & Planning
Community College System of New Hampshire
26 College Drive
Concord, NH 03301
- F. For each submittal for review, allow 14 days excluding delivery time to and from Contract Representative.
1. All shop drawings to be returned to Contractor from the Contract Representative. Direct return of shop drawings from Architect or Engineer to Contractor is not permitted.
- G. Identify variations from Contract Documents and product or system limitations that may be detrimental to successful performance of completed Work.
- H. Allow space on submittals for Contractor and Architect or Engineer review stamps.
- I. When revised for resubmission, identify changes made since previous submission.
- J. Distribute copies of reviewed submittals as appropriate. Instruct parties to promptly report inability to comply with requirements.
- K. Submittals not requested will not be recognized or processed.
- L. Work shall not begin until [All] submittal items have been approved and returned to General Contractor by the Contract Representative.

1.3 CONSTRUCTION PROGRESS SCHEDULES

- A. Submit initial schedules at PreConstruction Meeting.
- B. Submit revised Progress Schedules with each Application for Payment.
- C. Distribute copies of reviewed schedules to Project site file, subcontractors, suppliers, and other concerned parties.
- D. Instruct recipients to promptly report, in writing, problems anticipated by projections indicated in schedules.

- E. Submit horizontal bar chart with separate line for each major portion of Work or operation\ and section of Work, identifying first work day of each week.
- F. Show complete sequence of construction by activity, identifying Work of separate stages and other logically grouped activities. Indicate early and late start, early and late finish, float dates, and duration.
- G. Indicate estimated percentage of completion for each item of Work at each submission.
- H. Submit separate schedule of submittal dates for shop drawings, product data, and samples, including CCSNH furnished products and dates reviewed submittals will be required from Contract Representative. Indicate decision dates for selection of finishes. Selection of finishes cannot occur until ALL finish items are submitted and products are approved.
- I. Indicate delivery dates for furnished products.
- J. Revisions To Schedules:
 - 1. Indicate progress of each activity to date of submittal, and projected completion date of each activity.
 - 2. Identify activities modified since previous submittal, major changes in scope, and other identifiable changes.
 - 3. Prepare narrative report to define problem areas, anticipated delays, and impact on Schedule. Report corrective action taken, or proposed, and its effect including effect of changes on schedules of separate contractors.

1.4 SUBCONTRACTOR LIST

- A. Submit list, at the PreConstruction Meeting, of subcontractors setting forth in detail the work for which they will be responsible. In addition, the General Contractor shall identify what work will be performed with the Bidder's own forces.
- B. Provide Subcontractor and Insurance information as required under SB 78.
 - 1. Subcontractor list is to include subcontracting relationship and the carrier of Workmen Compensation Insurance for all subcontractors, all tiers.
 - 2. Proof of Insurance is to be provided within 36 hours of request.
 - 3. Changes and additional to Subcontractor and Insurance is to be provided to the CCSNH within 36 hours of occurrence.
 - 4. The CCSNH will post this information in a publicly accessible website for the duration of the contract.

1.5 PRODUCT DATA

- A. Product Data: Submit for review for limited purpose of checking for conformance with information given and design concept expressed in Contract Documents.
- B. Submit electronic copies to the Contract Representative. The copy for the CCSNH is separate from the copy the Contractor to provide as part of close out procedures.

- C. Mark each copy to identify applicable products, models, options, and other data. Supplement manufacturers' standard data to provide information specific to this Project.
- D. Indicate product utility and electrical characteristics, utility connection requirements, and location of utility outlets for service for functional equipment and appliances.
- E. After review, produce copies and distribute in accordance with SUBMITTAL PROCEDURES article and for record documents described in Section 01700.

1.6 SHOP DRAWINGS

- A. Shop Drawings: Submit for review for limited purpose of checking for conformance with information given and design concept expressed in Contract Documents.
- B. Indicate special utility and electrical characteristics, utility connection requirements, and location of utility outlets for service for functional equipment and appliances.
- C. Submit an electronic copy to the Contract Representative. The copy for the CCSNH is separate from the copy the Contractor to provide as part of close out procedures.
- D. After review, produce copies and distribute in accordance with SUBMITTAL PROCEDURES article and for record documents described in Section 01700.

1.7 SAMPLES

- A. Samples: Submit for review for limited purpose of checking for conformance with information given and design concept expressed in Contract Documents.
- B. Samples For Selection as Specified in Product Sections:
 - 1. Submit to Contract Representative for aesthetic, color, or finish selection.
 - 2. Submit samples of finishes from full range of manufacturers' standard colors, in custom colors selected, textures, and patterns for Contract Representative and System approval.
- C. Submit samples to illustrate functional and aesthetic characteristics of Products, with integral parts and attachment devices. Coordinate sample submittals for interfacing work.
- D. Include identification on each sample, with full Project information.
- E. Submit number of samples specified in individual specification sections; Contract Representative will retain one sample and Architect or Engineer will retain one sample.
- F. Reviewed samples which may be used in the Work are indicated in individual specification sections.
- G. Samples will not be used for testing purposes unless specifically stated in specification section.
- H. After review, produce duplicates and distribute in accordance with SUBMITTAL PROCEDURES article and for record documents purposes described in Section 01700.

1.8 DESIGN DATA

- A. Submit for Contract Representative's knowledge.
- B. Submit for information for limited purpose of assessing conformance with information given and design concept expressed in Contract Documents.

1.9 TEST REPORTS

- A. Submit for Contract Representative's knowledge.
- B. Submit test reports for information for limited purpose of assessing conformance with information given and design concept expressed in Contract Documents.

1.10 CERTIFICATES

- A. When specified in individual specification sections, submit certification by manufacturer, installation/application subcontractor, or Contractor, to Contract Representative in quantities specified for Product Data.
- B. Indicate material or product conforms to or exceeds specified requirements. Submit supporting reference data, affidavits, and certifications as appropriate.
- C. Certificates may be recent or previous test results on material or Product, but must be acceptable to the Contract Representative.

1.11 MANUFACTURER'S INSTRUCTIONS

- A. When specified in individual specification sections, submit printed instructions for delivery, storage, assembly, installation, [start-up,] adjusting, and finishing, to the Contract Representative in quantities specified for Product Data.
- B. Indicate special procedures, perimeter conditions requiring special attention, and special environmental criteria required for application or installation.

1.12 MANUFACTURER'S FIELD REPORTS

- A. Submit reports for Contract Representative's and System's benefit.
- B. Submit report in duplicate within 7 days of observation to the Contract Representative for information.
- C. Submit for information for limited purpose of assessing conformance with information given and design concept expressed in Contract Documents.

1.13 ERECTION DRAWINGS

- A. Submit to the Architect and Contract Representative for information for limited purpose of assessing conformance with information given and design concept expressed in Contract Documents.

- B. Data indicating inappropriate or unacceptable Work may be subject to action by the Architect, Engineer, or Contract Representative.

1.14 CONSTRUCTION PHOTOGRAPHS

- A. Provide photographs of construction throughout progress of Work produced by an experienced] photographer, acceptable to the Contract Representative.
- B. Twice monthly submit photographs.
- C. Photographs: Submit digital images on 3-1/2” diskettes or on compact discs.
- D. Take multiple site photographs from differing directions and interior photographs indicating relative progress of the Work, three (3) days maximum prior to submitting.
- E. Identify each image. Identify name of Project, contract number phase orientation of view, date and time of view.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01600

PRODUCT REQUIREMENTS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Products.
- B. Product delivery requirements.
- C. Product storage and handling requirements.
- D. Product options.
- E. Product substitution procedures.
- F. Equipment electrical characteristics and components.

1.2 PRODUCTS

- A. Furnish products of qualified manufacturers suitable for intended use. Furnish products of each type by single manufacturer unless specified otherwise.
- B. All materials and equipment shall be new, except as specifically permitted by Contract Documents.
- C. Furnish interchangeable components from same manufacturer for components being replaced.
- D. The use of asbestos containing materials shall be prohibited.

1.3 PRODUCT DELIVERY REQUIREMENTS

- A. Transport and handle products in accordance with manufacturer's instructions.
- B. Promptly inspect shipments to ensure products comply with requirements, quantities are correct, and products are undamaged.
- C. Provide equipment and personnel to handle products by methods to prevent soiling, disfigurement, or damage.

1.4 PRODUCT STORAGE AND HANDLING REQUIREMENTS

- A. Store and protect products in accordance with manufacturers' instructions.
- B. Store with seals and labels intact and legible.

- C. Store sensitive products in weather tight, climate controlled, enclosures in an environment favorable to product.
- D. For exterior storage of fabricated products, place on sloped supports above ground.
- E. Provide bonded off-site storage and protection when site does not permit on-site storage or protection only with prior approval from the Contract Representative.
- F. Cover products subject to deterioration with impervious sheet covering. Provide ventilation to prevent condensation and degradation of products.
- G. Store loose granular materials on solid flat surfaces in well-drained area. Prevent mixing with foreign matter.
- H. Provide equipment and personnel to store products by methods to prevent soiling, disfigurement, or damage.
- I. Arrange storage of products to permit access for inspection. Periodically inspect to verify products are undamaged and are maintained in acceptable condition.

1.5 PRODUCT OPTIONS

- A. Products Specified by Reference Standards or by Description Only: Any product meeting those standards or description.
- B. Products Specified by Naming One or More Manufacturers with or without provision for substitutions: Products of one of manufacturers named and meeting specifications, no options or substitutions allowed. Submit request for substitution for any manufacturer not named in accordance with the following article.

1.6 PRODUCT SUBSTITUTION PROCEDURES

- A. Where Bidding Documents stipulate particular Products, substitution requests will ONLY be considered before receipt of Bids. Submit requests per the requirements specified in this section.
 - 1. All requests shall be submitted to the Contract Representative not later than five (5) business days before the hour and day set for bid opening. Incomplete requests or requests received after this deadline will not be considered.
 - 2. All requests that are approved and are acceptable to the Department will be issued as part of an Addendum to each Bidder who has received a set of bidding documents, so that all Bidders may avail themselves of the change in submitting their Proposals.
- B. Substitutions [may] be considered after bid opening when a product becomes unavailable through no fault of the Contractor. The Contractor shall apply to the Contract Representative, in writing, within ten (10) days of his realizing his inability to furnish the article specified, describing completely the substitution he desires to make. The Contractor shall include a dated written statement from the manufacturer outlining an explanation for the unavailability of the product. Substitutions for reasons of lead times, i.e., the time between when the Contractor orders necessary materials from the vendor

and anticipated delivery, will only be reviewed if the lead time is more than the length of the contract time. The Department may extend the contract time to accommodate the product specified. No additional costs from the Contractor will be considered due to the fact that the Contractor shall verify lead times and coordinate with contract time during the bidding phase.

- C. Document each request with complete data substantiating compliance of proposed Substitution with Contract Documents.
- D. A request constitutes a representation that Bidder:
 - 1. Has investigated proposed product and determined that it meets or exceeds quality level of specified product.
 - 2. Will provide same warranty for Substitution as for specified product.
 - 3. Will coordinate installation and make changes to other Work which may be required for the Work to be complete with no additional cost to the State.
 - 4. Waives claims for additional costs or time extension which may subsequently become apparent.
 - 5. Will reimburse Department and Architect and/or Engineer for review or redesign services associated with re-approval by authorities having jurisdiction.
- E. Substitutions will not be considered when they are indicated or implied on Shop Drawing or Product Data submittals, without separate written request, or when acceptance will require revision to Contract Documents.
- F. Substitution Submittal Procedure:
 - 1. Submit three copies of request for Substitution for consideration. Limit each request to one proposed Substitution.
 - 2. Submit Shop Drawings, Product Data, and certified test results attesting to proposed product equivalence. Burden of proof is on proposer.
 - 3. The Department will notify Bidders in writing of decision to accept by issuing an addendum.

PART 2 PRODUCTS

- A. Not used

PART 3 EXECUTION

Not Used.

END OF SECTION

SECTION 01700

EXECUTION REQUIREMENTS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Closeout procedures.
- B. Final cleaning.
- C. Protecting installed construction.
- D. Project record documents.
- E. Manual for materials and finishes.
- F. Product warranties and product bonds.
- G. Guarantee of work.

1.2 CLOSEOUT PROCEDURES

- A. Submit a signed Substantial Completion Application attesting that the Contract Documents have been reviewed, Work has been inspected, and that all Work is complete in accordance with Contract Documents and ready for Contract Representative review. The Substantial Completion Application for use by the Contractor is attached to the end of this specification section. The Contract Representative may modify this Agreement to accommodate any changes in Work.
 - 1. Provide submittals to the Contract Representative as required by the Contract Documents and as required by authorities having jurisdiction.
- B. Only after completion of all Punch List items and submission of all items the Contractor shall submit a Final Application for Payment identifying total adjusted Contract Sum, previous payments, and sum remaining due.
- C. College will occupy portions of building as specified in Section 01100.

1.3 FINAL CLEANING

- A. Execute final cleaning prior to final project assessment.
- B. Clean debris from roofs, gutters, downspouts, and drainage systems.
- C. Clean site; sweep paved areas, rake clean landscaped surfaces.
- D. Remove waste and surplus materials, rubbish, and construction facilities from site.

1.4 PROTECTING INSTALLED CONSTRUCTION

- A. Protect installed Work and provide special protection where specified in individual specification sections.
- B. Provide temporary and removable protection for installed products. Control activity in immediate work area to prevent damage.
- C. Provide protective coverings at walls, projections, jambs, sills, and soffits of openings.
- D. Protect finished floors, stairs, and other surfaces from traffic, dirt, wear, damage, or movement of heavy objects, by protecting with durable sheet materials.
- E. Prohibit traffic or storage upon waterproofed or roofed surfaces. When traffic or activity is necessary, obtain recommendations for protection from waterproofing or roofing material manufacturer.
- F. Prohibit traffic from landscaped areas.

1.5 PROJECT RECORD DOCUMENTS

- A. Maintain on site one set of the following record documents; record actual revisions to the Work:
 - 1. Drawings.
 - 2. Specifications.
 - 3. Addenda.
 - 4. Change Orders and other modifications to the Contract.
 - 5. Reviewed Shop Drawings, Product Data, and Samples.
 - 6. Manufacturer's instruction for assembly, installation, and adjusting.
- B. Ensure entries are complete and accurate, enabling future reference by State.
- C. Store record documents separate from documents used for construction.
- D. Record information concurrent with construction progress, not less than weekly.
- E. Specifications: Legibly mark and record at each product section description of actual products installed, including the following:
 - 1. Manufacturer's name and product model and number.
 - 2. Product substitutions or alternates utilized.
 - 3. Changes made by Addenda and modifications.
- F. Record Drawings and Shop Drawings: Legibly mark each item to record actual construction including:
 - 1. Measured depths of foundations in relation to finish [first] [main] floor datum.
 - 2. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements.
 - 3. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the Work.
 - 4. Field changes of dimension and detail.

5. Details not on original Contract drawings.
 - G. Submit documents to the Contract Representative at time of Substantial Completion.
- 1.6 MANUAL FOR MATERIALS AND FINISHES
- A. Submit two copies of preliminary draft or proposed formats and outlines of contents before start of Work. The Contract Representative will review draft and return one copy with comments.
 - B. For equipment, or component parts of equipment put into service during construction and operated by State, submit documents within ten days after acceptance.
 - C. Submit one copy of completed volumes (15) fifteen days prior to Substantial Completion. Draft copy be reviewed and returned after Substantial Completion, with Architect/Engineer comments. Revise content of document sets as required prior to final submission.
 - D. Submit one set of revised final volumes in final form prior to final inspection, and one electronic version.
 - E. Building Products, Applied Materials, and Finishes: Include product data, with catalog number, size, composition, and color and texture designations. Include information for re-ordering custom manufactured products.
 - F. Instructions for Care and Maintenance: Include manufacturer's recommendations for cleaning agents and methods, precautions against detrimental agents and methods, and recommended schedule for cleaning and maintenance.
 - G. Moisture Protection and Weather Exposed Products: Include product data listing applicable reference standards, chemical composition, and details of installation. Include recommendations for inspections, maintenance, and repair.
 - H. Additional Requirements: As specified in individual product specification sections.
 - I. Include listing in Table of Contents for design data, with tabbed fly sheet and space for insertion of data.
- 1.7 PRODUCT WARRANTIES AND PRODUCT BONDS
- A. Obtain warranties and bonds executed in duplicate by responsible subcontractors, suppliers, and manufacturers, within ten days after Substantial Completion. All warranties start dates shall be the Substantial Completion Date, if project is phased all warranties to start at the date of Substantial Completion of each phase.
 - B. Execute and assemble transferable warranty documents and bonds from subcontractors, suppliers, and manufacturers.
 - C. Verify documents are in proper form, contain full information, and are notarized.

- D. Co-execute submittals when required.
- E. Include Table of Contents and assemble in three D side ring binder with durable plastic cover.
- F. Submit prior to final Application for Payment.
- G. Time Of Submittals:
 - 1. For equipment or component parts of equipment put into service during construction with State's permission, submit documents within (10) ten days after acceptance.
 - 2. Make other submittals within (10) ten days after Date of Substantial Completion, prior to final Application for Payment.
 - 3. For items of Work for which acceptance is delayed beyond Date of Substantial Completion, submit within (10) ten days after acceptance, listing date of acceptance as beginning of warranty or bond period.

1.8 GUARANTEE OF WORK

- A. Except as otherwise specified, all work shall be guaranteed by the Contractor against defects resulting from the use of inferior materials, equipment or workmanship for one (1) year from the Date of Substantial Completion of the work.
- B. If, within any guarantee period, repairs or changes are required in connection with guaranteed work, which in the opinion of the Contract Representative, is rendered necessary as a result of the use of materials, equipment or workmanship which are inferior, defective, or not in accordance with the terms of the Contract shall, promptly upon receipt of notice from the Commissioner, and at his own expense:
 - 1. Place in satisfactory condition in every particular, all such guaranteed work, correct all defects therein.
 - 2. Make good all damage to the building or site, or equipment or contents thereof, which in the opinion of the Contract Representative, is the result of the use of materials, equipment or workmanship which are inferior, defective, or not in accordance with the terms of the Contract.
 - 3. Make good any work or material, or the equipment and contents of said building or site disturbed in fulfilling any such guarantee.
- C. In any case, wherein fulfilling the requirements of the Contract or of may guarantee, embraced in or required thereby, the Contractor disturbs any work guaranteed under another contract, he shall restore such disturbed work to a condition satisfactory to the Contract Representative and guarantee such resorted work to the same extent as it was guaranteed under such other contracts.
- D. If the Contractor, after notice, fails to proceed promptly to comply with the terms of the guarantee, the Commissioner may have the defects corrected and the Contractor and his/her Surety shall be liable for all expense incurred.
- E. All special guarantees applicable to definite parts of the work that may be stipulated in the Specifications or other papers forming a part of the Contract shall be subject to the term of this paragraph during the first year of the life of such special guarantee.

- F. Failure to adhere to guarantee terms may result in suspension or barring from the prequalification list, or, alternatively, the requirement of a Letter of Credit or other guaranty equal to a percentage of the Contract amount.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

Not Used.

END OF SECTION



Project #MCC19-04

EXHIBIT "A"

FOR

MCC19-04 MCC Mechanical Equipment Replacement

AT

MANCHESTER COMMUNITY COLLEGE

1066 Front Street, Manchester, NH

A COMPONENT OF THE

Community College System of New Hampshire

26 College Drive, Concord, NH

PROJECT MANUAL

Attached to this exhibit are Project Drawings and Specifications:

Boiler Replacement Drawings Dated 3/11/2020

Boiler Replacement Specifications Dated 3/11/2020`

Mechanical Equipment Replacement Drawings Dated 4/22/2020

Mechanical Equipment Replacement Specifications Dated 4/22/2020

MANCHESTER COMMUNITY COLLEGE

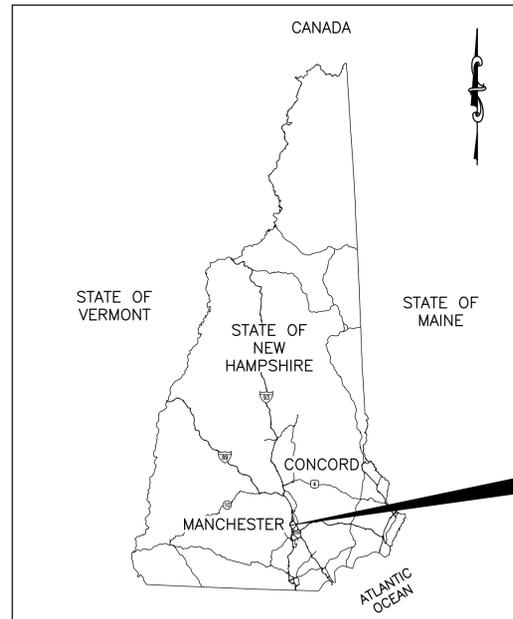
MANCHESTER, NEW HAMPSHIRE

Issued for: CONSTRUCTION

BOILER REPLACEMENT AT MANCHESTER COMMUNITY COLLEGE

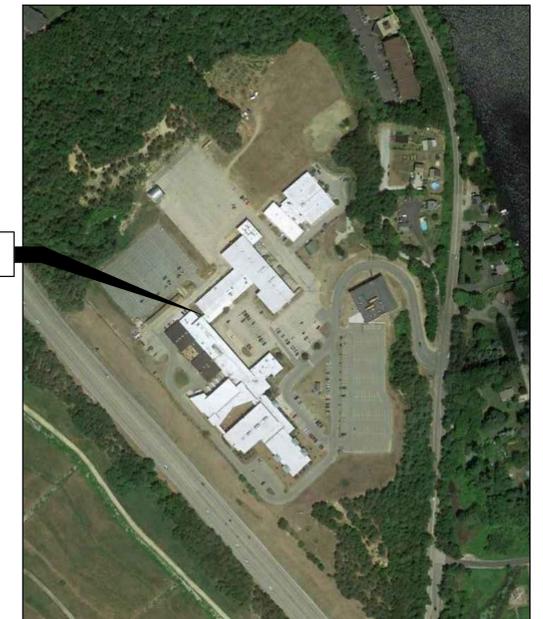
MCC-19-04

MARCH 11, 2020



PROJECT SITE MAP
SCALE: N.T.S.

DRAWING INDEX		
DRAWING	TITLE	SHEET NUMBER
G-001	COVER SHEET	1 OF 10
M-001	MECHANICAL NOTES, ABBREVIATIONS, AND LEGEND	2 OF 10
MD-401	MECHANICAL DEMOLITION PART PLANS	3 OF 10
M-101	BOILER ROOMS 112 & 115 MECHANICAL PLAN	4 OF 10
M-401	MECHANICAL PART PLANS	5 OF 10
M-501	MECHANICAL DETAILS	6 OF 10
M-601	MECHANICAL SCHEDULES	7 OF 10
M-701	SEQUENCE OF OPERATIONS	8 OF 10
ED-401	ELECTRICAL DEMOLITION PLANS AND NOTES	9 OF 10
E-401	ELECTRICAL PLANS AND SCHEDULES	10 OF 10



VICINITY MAP
SCALE: N.T.S.

 47A York St Portland, ME 04101 207.553.7753	MANCHESTER COMMUNITY COLLEGE MANCHESTER, NH		
	BOILER REPLACEMENT MCC 19-04		
0 ISSUED FOR CONSTRUCTION REV DESCRIPTION	PML BCT DWN APP DATE	03/11/20	COVER SHEET
PLEASE NOTE: THIS DOCUMENT MAY NOT ACCURATELY REPRESENT THE FINAL DOCUMENT. ONLY AN ENGINEER, ARCHITECT OR SURVEYOR SIGNED, SEALED AND DATED PAPER COPY, PROVIDED BY THIS OFFICE, MAY BE UTILIZED FOR BIDDING OR CONSTRUCTION PURPOSES.	SIZE: ANSI D DATE: 03/11/2020 DES BY: BCT DWN BY: PML CKD BY: BCT	PROJECT NO. 372.004.001	DRAWING NO. G-001
		SHEET 1 OF 10	

ABBREVIATIONS

A	AMP	HZ	HERTZ
AC	AIR CONDITIONER	IMC	INTERNATIONAL MECHANICAL CODE
ACS	ACCESS	IN, IN.	INCHES
AFF	ABOVE FINISHED FLOOR	KW	KILOWATT
AD	ACCESS DOOR	L	LOUVER
APD	AIR PRESSURE DROP	LAT	LEAVING AIR TEMPERATURE
AP	ACCESS PANEL	LB	POUND
AS	AIR SEPARATOR	LCP	LOCAL CONTROL PANEL
ASME	AMERICAN SOCIETY OF MECHANICAL ENGINEERS	LPC	LOW PRESSURE CONDENSATE
		LPS	LOW PRESSURE STEAM
ASTM	AMERICAN SOCIETY FOR TESTING AND MATERIALS	LWCO	LOW WATER CUT OFF
		LWT	LEAVING WATER TEMPERATURE
B	BOILER	MAX	MAXIMUM
BAS	BUILDING AUTOMATION SYSTEM	MBH	1000 BTU PER HOUR
BHP	BRAKE HORSEPOWER	MCA	MAXIMUM CIRCUIT AMPACITY
BTU	BRITISH THERMAL UNIT	MCP	MAIN CONTROL PANEL
BTUH	BRITISH THERMAL UNIT/HOUR	MEZZ	MEZZANINE
CA	COMBUSTION AIR	MIN	MINIMUM
CD	CONDENSATE DRAIN/CEILING DIFFUSER	MOPD	MAXIMUM OVER-CURRENT PROTECTION DEVICE
		NC	NOISE CRITERIA, NORMALLY CLOSED
CF	CEILING FAN	NG	NATURAL GAS
CFM	CUBIC FEET PER MINUTE	NO	NORMALLY CLOSED
CLG	COOLING	NPT	NATIONAL PIPE THREAD
CO	CLEANOUT	NTS	NOT TO SCALE
COND	CONDENSATE	OA	OUTSIDE AIR
CP	CONDENSATE PUMP	OD	OUTSIDE DIAMETER
CTU	CONDENSATE TRANSFER UNIT	OS&Y	OUTSIDE SCREW AND YOKE
CU	CONDENSING UNIT	P	PUMP
CUH	CABINET UNIT HEATER	PC	PUMPED CONDENSATE
DB	DRY BULB	PD	PRESSURE DROP
DC	DUST COLLECTOR	PDS	PRESSURE DIFFERENTIAL SWITCH
DDC	DIRECT DIGITAL CONTROL	PH	PHASE
DCWS	DOMESTIC COLD WATER SUPPLY	PRV	PRESSURE REDUCING VALVE
DCWR	DOMESTIC COLD WATER RETURN	PS	PRESSURE SWITCH
DEG.	DEGREE	PSI	POUNDS PER SQUARE INCH
DHWS	DOMESTIC HOT WATER SUPPLY	PSIG	POUNDS PER SQUARE IN. GAGE
DHWR	DOMESTIC HOT WATER RETURN	PT	PRESSURE TRANSMITTER
DIA, Ø	DIAMETER	RA	RETURN AIR
DN	DOWN	RG	REFRIGERANT GAS
DP, DPS	DIFFERENTIAL-PRESSURE SENSOR	RH	RELATIVE HUMIDITY
DWH	DOMESTIC WATER HEATER	RL	REFRIGERANT LIQUID
(E), EXIST	EXISTING	RAD	RADIATOR
EA	EACH, EXHAUST AIR	RCP	RADIANT CEILING PANEL
EAT	ENTERING AIR TEMPERATURE	RPM	REVOLUTIONS PER MINUTE
EC	ELECTRONICALLY COMMUTATED	SA	SUPPLY AIR
EDH	ELECTRIC DUCT HEATER	SC	STEAM COIL
EF	EXHAUST FAN	SG	SUPPLY GRILLE
EG	EXHAUST GRILLE	SP	STATIC PRESSURE
ERV	ENERGY RECOVERY VENTILATOR	SQ	SQUARE
ESP	EXTERNAL STATIC PRESSURE	SS	STAINLESS STEEL
ET	EXPANSION TANK	T	TEMPERATURE SENSOR, THERMOSTAT
ETR	EXISTING TO REMAIN	TC	TRANSFER GRILLE
EUH	ELECTRIC UNIT HEATER	TSP	TOTAL STATIC PRESSURE
EWT	ENTERING WATER TEMPERATURE	TYP	TYPICAL
F	FAN, FAHRENHEIT	UH	UNIT HEATER
FC	FLEXIBLE CONNECTION	V	VOLTS
FH	FILTER HOUSING	W/	WITH
FLA	FULL LOAD AMPS	WB	WET BULB
FPM	FEET PER MINUTE	WC	WATER COLUMN
FT	FEET	WG	WATER GAUGE
GA	GAUGE	WH	WATER HEATER
GM	GEAR MOTOR	WPD	WATER PRESSURE DROP
GPM	GALLONS PER MINUTE		
GWS	GLYCOL SUPPLY		
GWR	GLYCOL RETURN		
HP	HEAT PUMP, HORSEPOWER		
HR	HOUR		
HTG	HEATING		
HV	HEATING & VENTILATING		
HWS	HOT WATER SUPPLY		
HX	HEAT EXCHANGER		

MECHANICAL LINE TYPE LEGEND

—————	EXISTING ITEMS TO REMAIN
-----	ITEMS TO BE REMOVED
—————	ITEMS TO BE PROVIDED
-----	HIDDEN ITEMS
— · — · —	CONTROL WIRING

DUCTWORK SYMBOLS

	RETURN/EXHAUST DUCT UP
	RETURN/EXHAUST DUCT DOWN
	SUPPLY DUCT UP
	SUPPLY DUCT DOWN
	RISE(R) OR DROP(D)
	RADIUS ELBOW
	SQUARE ELBOW W/ TURNING VANES
	OFFSET
	DUCT TRANSITION FROM RECTANGULAR TO ROUND
	BULLHEAD TEE
	SPLIT TAKE-OFF W/ BRANCH DAMPERS SUPPLY
	TAKE-OFF
	EXHAUST/RETURN
	RETURN GRILLE
	CEILING SUPPLY DIFFUSER W/ DIRECTION SHOWN BY ARROWS
	BULLHEAD SPLIT
	CEILING DIFFUSER OR GRILLE W/ FLEXIBLE DUCT

MECHANICAL SYMBOLS

	SECTION NUMBER
	DRAWING WHERE SECTION IS DRAWN
	SYMBOL PER ABBREVIATION LIST
	EQUIPMENT SEQUENCE NUMBER
	DIFFUSER, REGISTER OR GRILLE
	SEQUENCE NUMBER CFM
	UNIT HEATER
	DIRECTION OF AIR FLOW OUT
	DIRECTION OF AIR FLOW IN
	VOLUME DAMPER
	MOTORIZED DAMPER OPPOSED BLADE
	MOTORIZED DAMPER
	HAND DAMPER ACTUATOR
	FIRE DAMPER
	DIFFERENTIAL PRESSURE SENSOR
	TEMPERATURE SENSOR
	FLOW SWITCH
	CONNECT TO EXISTING
	FAN
	MANUAL DAMPER, HAND WHEEL
	THERMOSTAT
	VARIABLE-AREA FLOW METER
	SMACNA DUCT PRESSURE CLASS DESIGNATION MARKER
	WALL SWITCH
	CEILING FAN

PIPING SYMBOLS

	BALANCING VALVE
	COMBINATION FLOW MEASURING/BALANCING VALVE (CIRCUIT SETTER)
	BUTTERFLY VALVE
	GATE VALVE
	BALL VALVE
	BALL DRAIN VALVE W/ 3/4" HOSE THREAD, BRASS CAP & CHAIN
	GLOBE VALVE
	TWO-WAY AUTOMATIC CONTROL VALVE
	PRESSURE REDUCING VALVE
	OS&Y GATE VALVE
	SAFETY RELIEF VALVE
	THREE-WAY AUTOMATIC CONTROL VALVE
	CHECK VALVE
	SPRING-LOADED CHECK VALVE
	STRAINER
	STRAINER W/BALL DRAIN VALVE, HOSE BIB AND CAP
	UNION OR FLANGE AS DICTATED BY PIPE SIZE
	PIPE TEE FROM TOP
	PIPE TEE FROM BOTTOM
	PIPE RISE
	PIPE DROP
	END CAP
	DIAL THERMOMETER IN IMMERSION WELL
	THERMOMETER IN WELL
	P/T PORT (PRESSURE/TEMPERATURE)
	MANUAL AIR VENT
	AUTOMATIC AIR VENT WITH INLET ISOLATION BALL VALVE
	REDUCER (ECCENTRIC-FLAT ON BOTTOM OR FLAT ON TOP)
	REDUCER (CONCENTRIC)
	DIRECTION OF FLOW
	PUMP
	PRESSURE GAUGE WITH BALL VALVE
	BACKFLOW PREVENTER
	FLANGE CONNECTION
	FLEXIBLE CONNECTION
	VENT TO ATMOSPHERE
	VIBRATION ISOLATOR

APPLICABLE CODES AND STANDARDS

- NEW HAMPSHIRE STATE FIRE CODE SAF-C 6000
- NATIONAL FUEL GAS CODE, NFPA 54 (2015) AS AMENDED BY SAF-C 6000
- NATIONAL ELECTRICAL CODE (NEC) (2017) WITH NH AMENDMENTS
- INTERNATIONAL PLUMBING CODE (2015) WITH NH AMENDMENTS
- INTERNATIONAL MECHANICAL CODE (2015) WITH NH AMENDMENTS
- INTERNATIONAL ENERGY CONSERVATION CODE (2015) WITH NH AMENDMENTS
- SHEET METAL AND AIR CONDITIONING NATIONAL ASSOCIATION, INC. (SMACNA)

GENERAL NOTES

- GENERAL NOTES, SYMBOLS LIST AND DETAILS ARE APPLICABLE TO DRAWINGS MARKED M-#.
- DRAWINGS ARE DIAGRAMMATIC; DETERMINE LOCATIONS OF SYSTEMS AND COMPONENTS IN FIELD.
- COORDINATE WORK WITH TRADES INVOLVED. PROVIDE OFFSETS IN PIPING AND DUCTS (INCLUDING DIVIDED DUCTS) AND TRANSITIONS AROUND OBSTRUCTIONS AT NO ADDITIONAL COST TO THE OWNER.
- VERIFY EQUIPMENT CONNECTIONS WITH MANUFACTURER'S CERTIFIED DRAWINGS. VERIFY AND PROVIDE DUCT TRANSITIONS TO FURNISHED EQUIPMENT. FIELD VERIFY AND COORDINATE DIMENSIONS BEFORE FABRICATION.
- INSTALL EQUIPMENT, PIPING AND DUCTWORK AS REQUIRED TO PROVIDE A VIBRATION FREE INSTALLATION AND TO FACILITATE EQUIPMENT ACCESS AS REQUIRED BY EQUIPMENT MANUFACTURER.
- INTERNAL AIR FLOW DIMENSIONS ARE SHOWN FOR DUCTS.
- PROVIDE CLAMPS, OFFSETS, EXPANSION JOINTS, ANCHORS AND GUIDES AS NECESSARY TO PREVENT STRESS ON PIPING.
- PROVIDE VENTS AT HIGH POINTS IN PIPING SYSTEMS AND DRAIN VALVES AT LOW POINTS. THIS INCLUDES LOW POINTS IN COMPRESSED AIR SYSTEM PIPING TO ACCOMMODATE DRAINING MOISTURE IN LINES.
- PROVIDE AT LEAST THREE-ELBOW SWINGS FOR PIPE TAKE-OFFS.
- MANUALLY OPERABLE EQUIPMENT SHALL BE ACCESSIBLE FOR OPERATION WITHOUT REQUIRING SPECIAL EQUIPMENT.
- PROVIDE ADEQUATE CLEARANCE FOR ACCESS TO HARDWARE AND DUCT FLANGES.
- PROTECT ROOF AND DUCTWORK TO MAINTAIN OWNERS EXISTING ROOF WARRANTIES. LAY DOWN PROTECTIVE SURFACES DURING DEMOLITION AND INSTALLATION.

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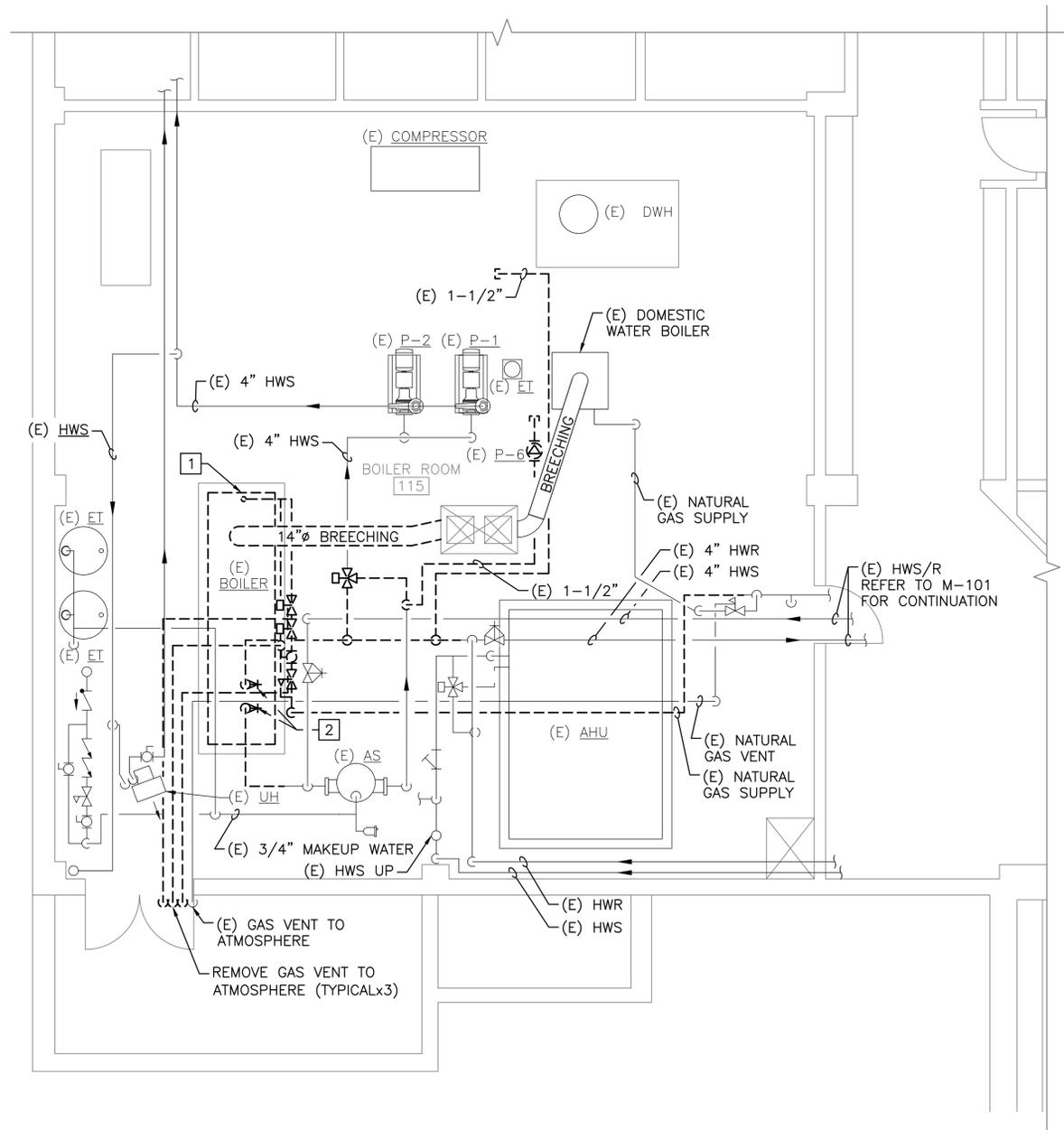
				MANCHESTER COMMUNITY COLLEGE MANCHESTER, NH			
				BOILER REPLACEMENT MCC 19-04			
				MECHANICAL NOTES, ABBREVIATIONS, AND LEGEND			
0	ISSUED FOR CONSTRUCTION	PML	BCT	03/11/20			
REV	DESCRIPTION	DWN	APP	DATE			
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				DATE: 03/11/2020	372.004.001	M-001	
				DES BY: DHB	SHEET	2 OF 10	
				DWN BY: PML			
				CKD BY: PWB			

NOTES:

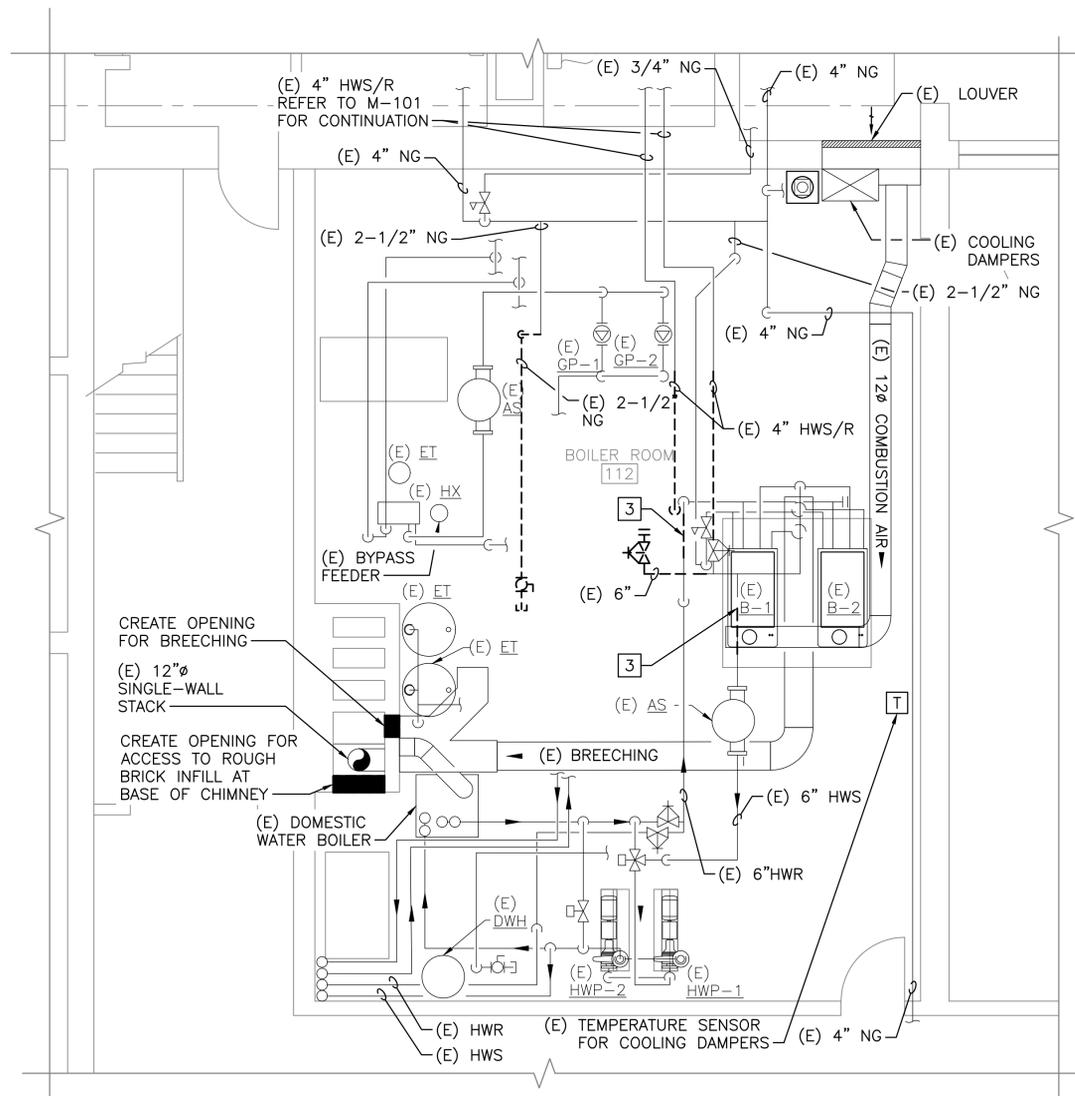
- SEE DRAWING M-001 FOR MECHANICAL NOTES, ABBREVIATIONS, AND LEGEND.
- THE INTENT OF THE DESIGN IS TO LEAVE THE EXISTING SYSTEMS OPERATING IN PLACE UNTIL THE CHANGEOVER PERIOD IN WHICH BOILER'S B-3 AND B-4 ARE PUT INTO SERVICE. THE MAJORITY OF THE DEMOLITION WORK SHALL BE PERFORMED AFTER THE CHANGEOVER PERIOD.

DEMOLITION KEYED NOTES:

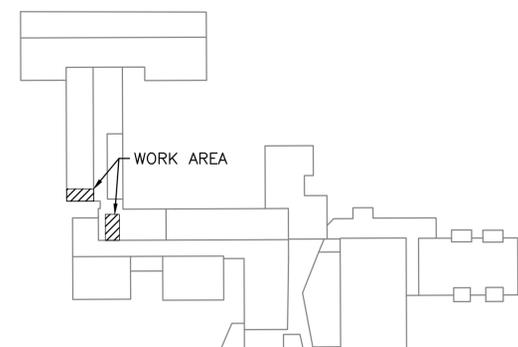
- REMOVE CLEAVER BROOKS PACKAGE BOILER. REMOVE ASSOCIATED PIPING AND BREECHING TO THE EXTENT INDICATED.
- TWO 4" OS&Y VALVES IN VERTICAL. REMOVE AND DELIVER TO OWNER.
- THE REMOVAL OF THESE SECTION OF PIPE SHALL TAKE PLACE DURING THE CHANGEOVER PERIOD.



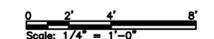
1 BOILER RM 115 MECHANICAL DEMOLITION PLAN
 WD-401 SCALE: 1/4" = 1'-0"



2 BOILER RM 112 MECHANICAL DEMOLITION PLAN
 WD-401 SCALE: 1/4" = 1'-0"



KEY PLAN
 SCALE: NTS



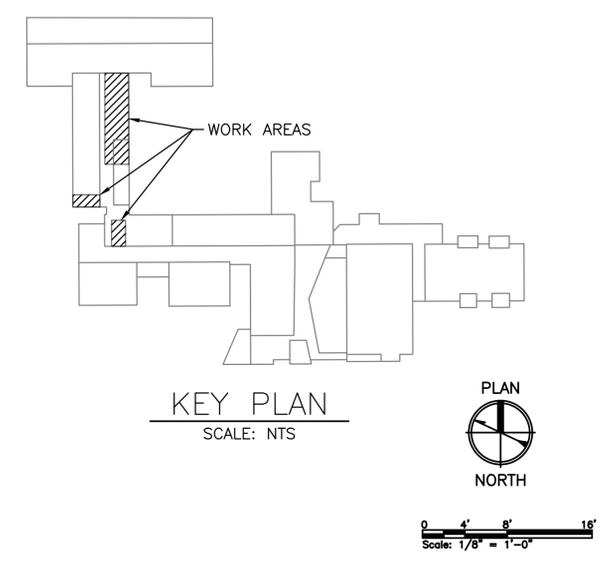
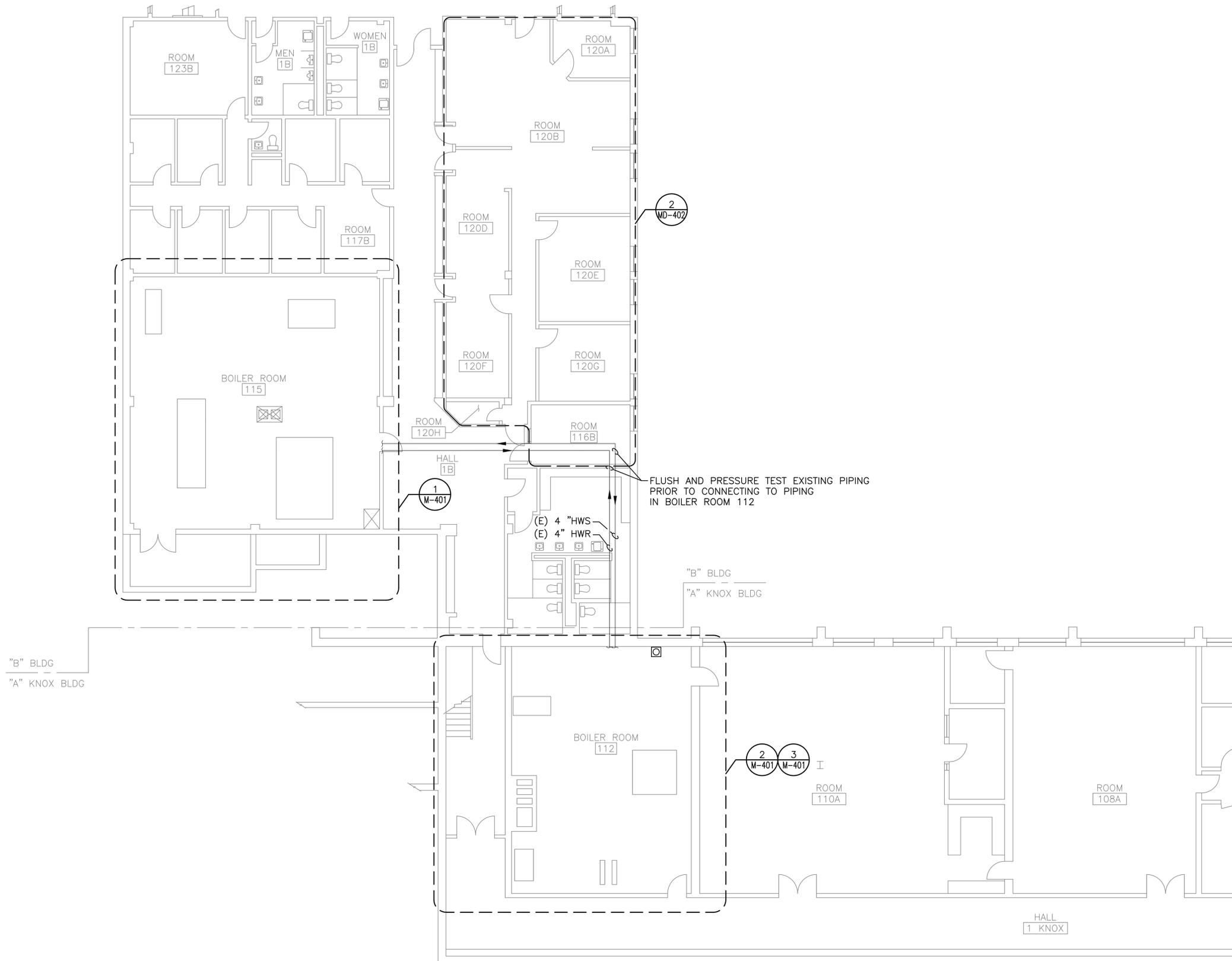
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				MECHANICAL DEMOLITION PART PLANS			
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				DATE:	03/11/2020		372.004.001
				DES BY:	DHB		SHEET
				DWN BY:	PML		3 OF 10
				CKD BY:	PWB		MD-401

- NOTES:
 1. SEE DRAWING M-001 FOR MECHANICAL NOTES, ABBREVIATIONS, AND LEGEND.



BOILER ROOMS 112 & 115 MECHANICAL PLAN
 SCALE: 1/8" = 1'-0"



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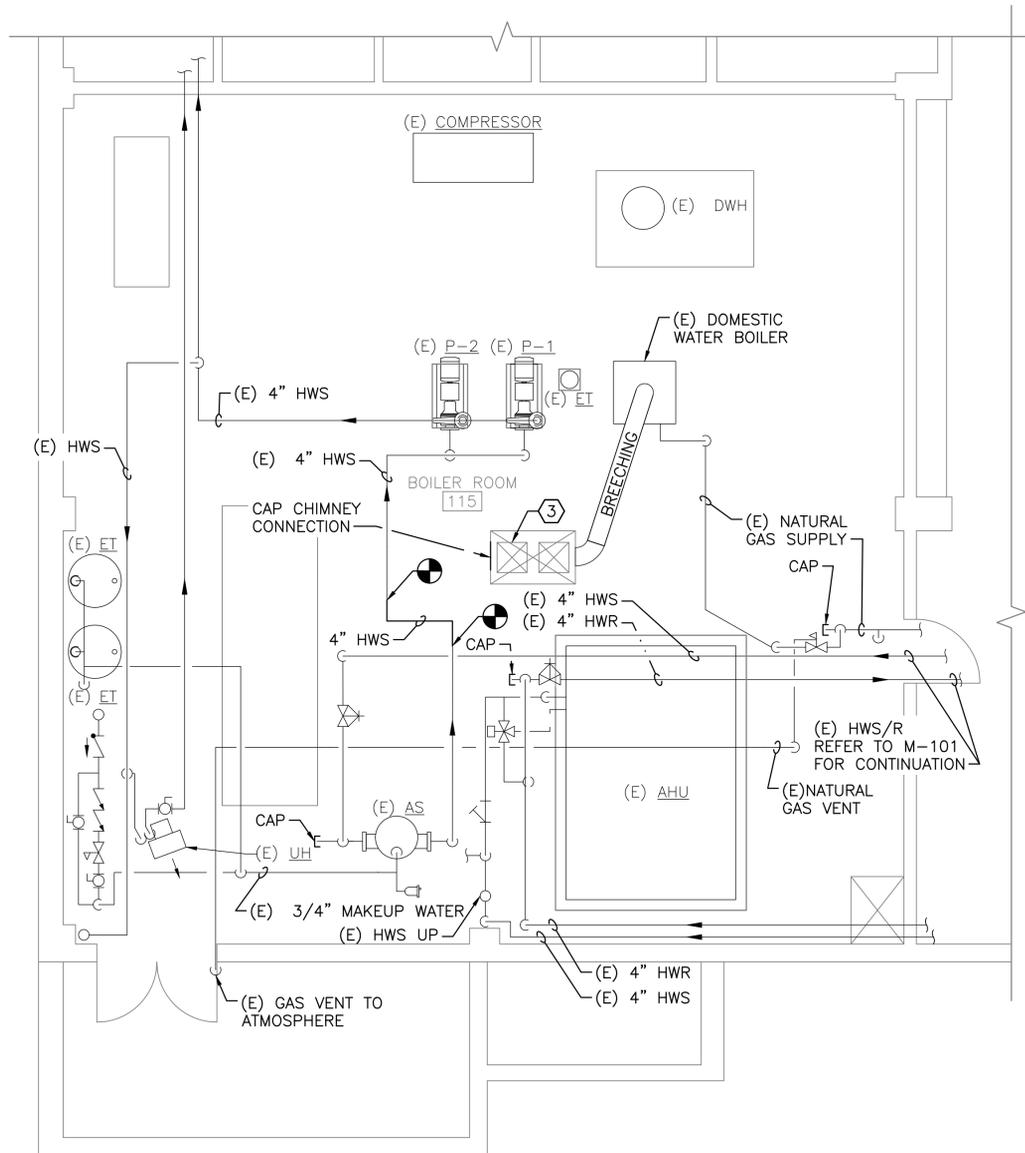
MANCHESTER COMMUNITY COLLEGE MANCHESTER, NH	
BOILER REPLACEMENT MCC 19-04	
BOILER ROOMS 112 & 115 MECHANICAL PLAN	
PROJECT NO. 372.004.001	DRAWING NO. M-101
SHEET 4 OF 10	

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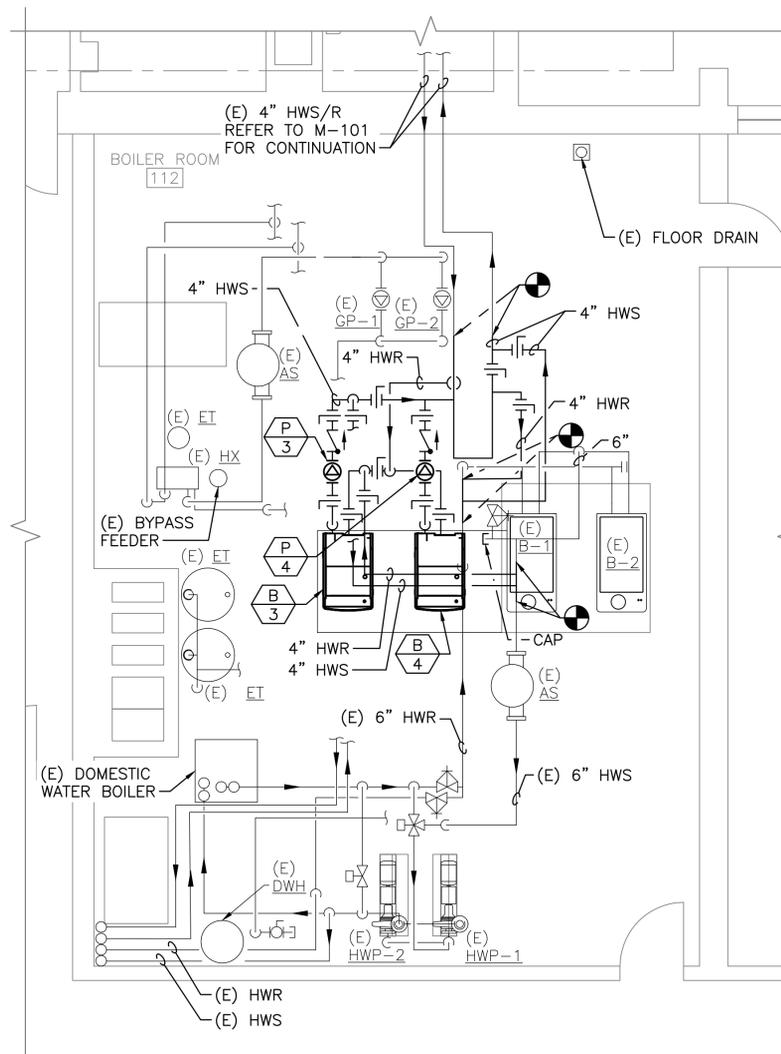
SIZE: ANSI D
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 DWN BY: PML
 CKD BY: PWB

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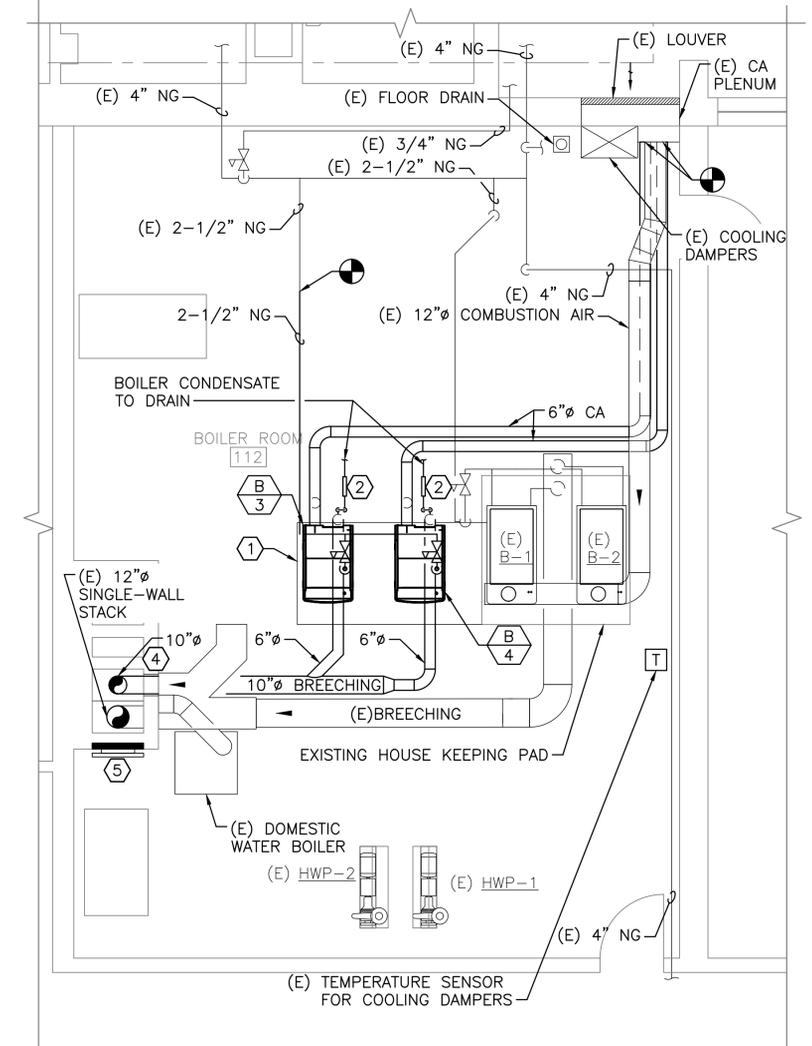
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1 BOILER RM 115 MECHANICAL PLAN
M-401 SCALE: 1/4" = 1'-0" M-101



2 BOILER RM 112 HYDRONIC PIPING PLAN
M-401 SCALE: 1/4" = 1'-0" M-101



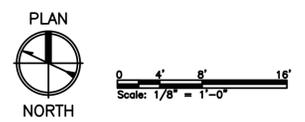
3 BOILER RM 112 GAS AND BREECHING PLAN
M-401 SCALE: 1/4" = 1'-0" M-101

KEYED NOTES:

- 1 PROVIDE 4" HIGH HOUSEKEEPING PAD. BOILER PLACEMENT SHALL BE AS RECOMMENDED BY THE MANUFACTURER.
- 2 BOILER MANUFACTURER'S ACID NEUTRALIZATION KIT.
- 3 CAP TOP OF CHIMNEY.
- 4 SINGLE-WALL STAINLESS STEEL UP IN MASONRY CHIMNEY TO ABOVE TOP OF CHIMNEY. TOP OF MASONRY CHIMNEY IS APPROXIMATELY 45 FT ABOVE FINISHED FLOOR.
- 5 INFILL CHIMNEY WITH BRICK MASONRY TO MATCH EXISTING. PROVIDE 18"x24" FIRE-RATED ACCESS PANEL APPROXIMATELY 24 INCHES ABOVE FINISHED FLOOR.

NOTES:

1. SEE DRAWING M-001 FOR MECHANICAL NOTES, ABBREVIATIONS, AND LEGEND.
2. THE INTENT OF THE DESIGN IS TO LEAVE THE EXISTING SYSTEMS OPERATING IN PLACE UNTIL THE CHANGEOVER PERIOD IN WHICH BOILER'S B-3 AND B-4 ARE PUT INTO SERVICE. THE MAJORITY OF THE WORK ON THIS DRAWING SHALL BE PERFORMED BEFORE THE CHANGEOVER PERIOD.
3. VALVES AT BOILERS AND PUMPS SHOWN ARE FOR REFERENCE ONLY. SEE DETAILS ON DRAWING M-501 FOR COMPLETE REQUIREMENTS.

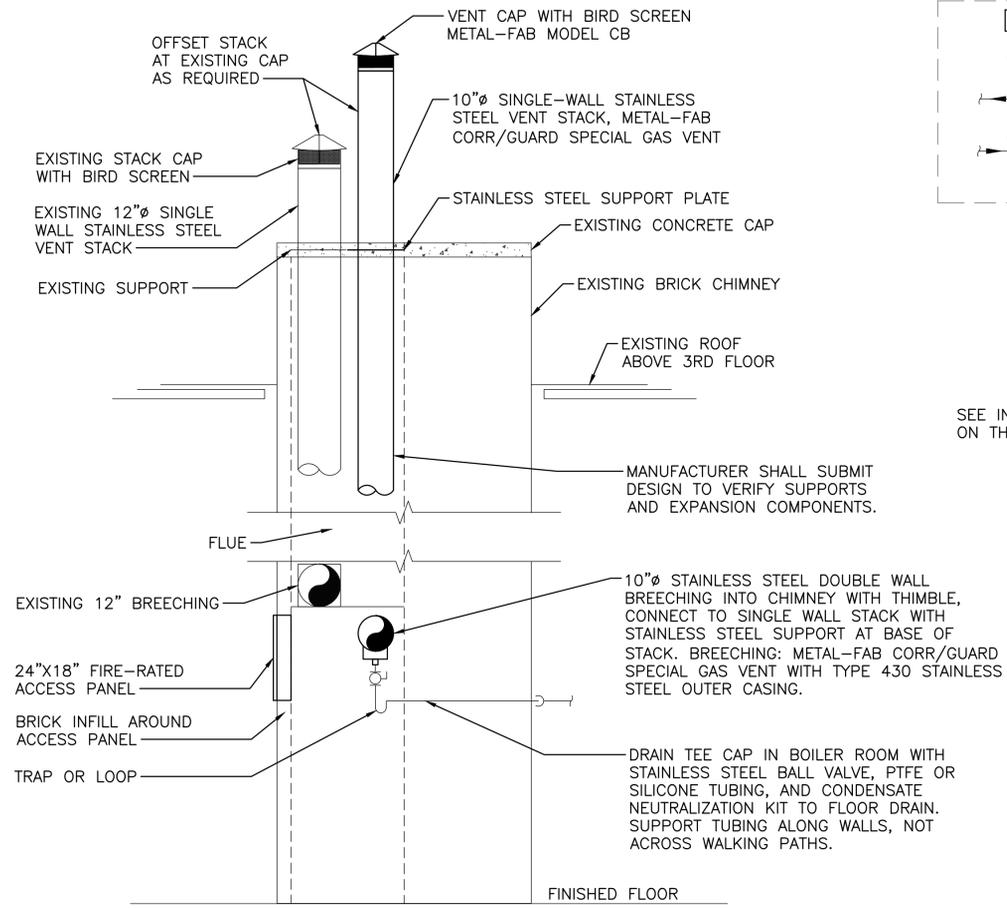


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			M-401

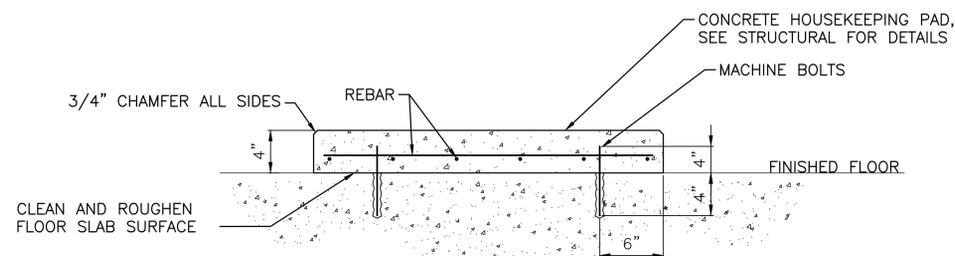


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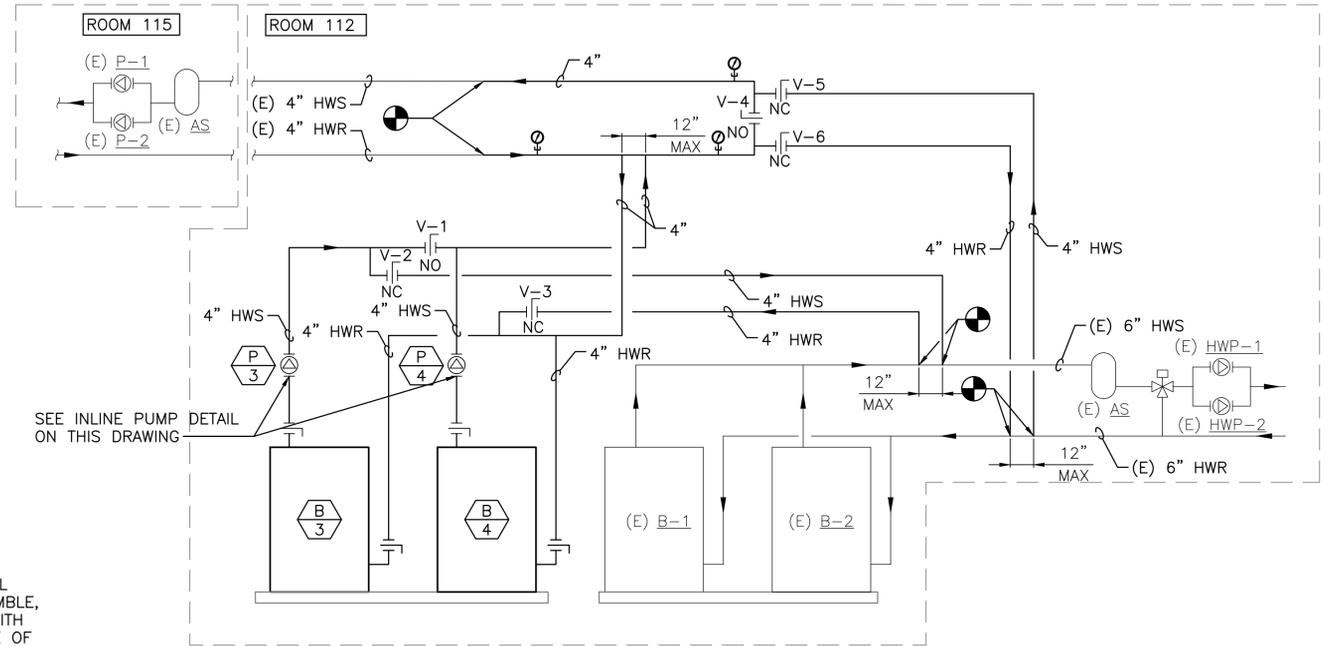
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CHIMNEY DETAIL
SCALE: NTS



CONCRETE PAD DETAIL
SCALE: NTS

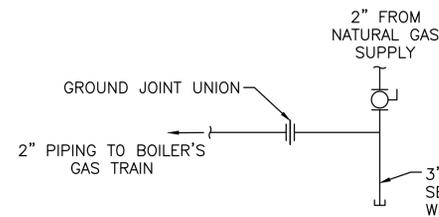


BOILER BACKUP CHANGEOVER NOTES:

BOILER B-3 AS BACKUP FOR BOILERS B-1 AND B-2
DISABLE B-3, B-4, P-3 AND P-4 AT BOILER CONTROLLER. CLOSE MANUAL VALVE V-1 (NO). OPEN MANUAL VALVES V-2 (NC) AND V-3 (NC). INITIATE "B-3 BACKUP" AT BAS. ENABLE B-3, B-4, P-3 AND P-4.

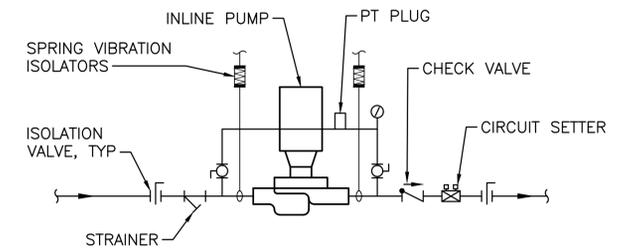
BOILERS B-1 AND B-2 AS BACKUP FOR BOILER B-3 AND B-4
DISABLE PUMPS P-1 AND P-2 AT DISCONNECTS. CLOSE MANUAL VALVE V-4 (NO). OPEN MANUAL VALVES V-5 (NC) AND V-6 (NC). ENABLE P-1 AND P-2. INITIATE "B-1 & 2 BACKUP AT BAS" HOT WATER RETURN FROM B-1 & 2 SYSTEM WILL BE USED AS HOT WATER SUPPLY FOR B-3 & 4 SYSTEM.

BOILER PIPING SCHEMATIC
SCALE: NTS



NOTES:
1. FULL PORTED BALL VALVE
2. REMOVABLE SEDIMENT CAP

GAS CONNECTION TO BOILER DETAIL
NOT TO SCALE



NOTES:
1. VALVES SHALL BE SAME SIZE AS PIPE.
2. PROVIDE SPRING VIBRATION ISOLATORS FOR PUMP, NEXT HANGER DOWN STREAM OF PUMP.

INLINE PUMP P-3 & P-4 DETAIL
SCALE: NTS

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BOILER REPLACEMENT MCC 19-04	
MECHANICAL DETAILS	
PROJECT NO. 372.004.001	DRAWING NO. M-501
SHEET 6 OF 10	

GAS FIRED HYDRONIC BOILER SCHEDULE

UNIT NO	LOCATION	SERVES	BOILER TYPE	FUEL TYPE	INPUT (MBH)	THERMAL EFFICIENCY (%)	TURNDOWN RATIO	GAS PRESSURE (IN. WC)	CONDENSATE FLOW AT FULL FIRE (GPH)	WATERSIDE					AIR CONNECTIONS		ELECTRICAL			ENCLOSURE DIMENSIONS W x D x H (IN.)	MANUFACTURER AND MODEL ①	NOTES	
										CONTENT (GAL)	RATED FLOW (GPM)	RATED WPD WITH WATER (PSI)	RATED RISE (DEG. F)	BALANCE FLOW (GPM)	HEATING SUPPLY/RETURN CONNECTIONS (IN.)	VENT CAT. IV (IN.)	COMBUSTION AIR (IN.)	V/PH/HZ	FLA (AMPS)				MOPD (AMPS)
B-3	BOILER RM 112	HEATING	CONDENSING	NATURAL GAS	1,500	94.6	20 TO 1	6 TO 14	9.0	44	170	3.0	20	130	4	6	6	120/1/60	16.0	20	28x43.6x78	AERCO BENCHMARK STANDARD BMK 1500	ALL
B-4	BOILER RM 112	HEATING	CONDENSING	NATURAL GAS	1,500	94.6	20 TO 1	6 TO 14	9.0	44	170	3.0	20	130	4	6	6	120/1/60	16.0	20	28x43.6x78	AERCO BENCHMARK STANDARD BMK 1500	ALL

GENERAL NOTES:

1. STAINLESS STEEL 1-PASS DOWN-FIRED FIRETUBE TYPE BOILER; SEE SPECIFICATIONS FOR REQUIREMENTS.
2. MAXIMUM WORKING PRESSURE 125 PSIG. PROVIDE PRESSURE RELIEF VALVE WITH PRESSURE SETTING TO MATCH THOSE ON EXISTING REMOVED BOILER.
3. VENTING IN CATEGORY IV SUITABLE FOR AL29-4C MATERIAL.
4. DIRECT VENT COMBUSTION.
5. GAS TRAIN WITH DUAL SAFETY SHUTOFF GAS VALVE, ASME CSD-1 TEST COCKS, DOWNSTREAM MANUAL BALL SHUTOFF VALVE, LOW AND HIGH GAS PRESSURE SAFETY SWITCHES.
6. SERVICE CLEARANCES (IN.): TOP 18, SIDES 24, REAR 24, FRONT 24.
7. PROVIDE NEUTRALIZATION KIT FOR BOILER CONDENSATE DRAIN.
8. ACS CONTROL MANAGEMENT CONTROLLER OR APPROVED EQUAL FROM ALTERNATIVE BOILER MANUFACTURER.
9. MODBUS CONTROL COMMUNICATIONS PROTOCOL.
10. PROVIDE THE SERVICES OF THE MANUFACTURER'S AUTHORIZED REPRESENTATIVE TO PERFORM BOILER START-UP SERVICES AND COMMISSIONING. SUBMIT BOUND REPORT TO OWNER.

PUMP SCHEDULE

UNIT NO	LOCATION	SERVES	TYPE	FLUID	FLOW (GPM)	HEAD (FT WG)	NPSH (FT WG)	SPEED (RPM)	IMPELLER DIAMETER (IN.)	EFFICIENCY (%)	CONNECTIONS IN X OUT FLANGE (IN.)	POWER (BHP)	MOTOR (HP)	ELECTRICAL VOLTAGE (V/PH/HZ)	MANUFACTURER AND MODEL ①	NOTES
P-3	BOILER ROOM 112	B-3	VERTICAL	WATER	130	15	0.7	1160	6.3	68	3x3	0.7	1	120/1/60	TACO KV3007	-
P-4	BOILER ROOM 112	B-4	VERTICAL	WATER	130	15	0.7	1160	6.3	68	3x3	0.7	1	120/1/60	TACO KV3007	-

NOTES:

1. -

KEYED NOTE:

- ① MANUFACTURER'S NAME AND MODEL NUMBER ARE THE BASIS OF DESIGN PRODUCTS AND ARE INTENDED TO INDICATE THE STANDARD OF MATERIAL OR ARTICLES REQUIRED. DESIGN IS PREDICATED AROUND LISTED MANUFACTURERS AS NOTED ON SCHEDULES; SEE SPECIFICATIONS FOR ALLOWABLE MANUFACTURERS AND PRODUCTS.

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DES BY:	DHB	SHEET	7 OF 10
DWN BY:	PML		
CKD BY:	PWB		

SEQUENCE OF OPERATION

GENERAL: PROVIDE CONTROL OF BOILERS B-3 AND B-4, BOILER PUMPS, COMBUSTION AIR DAMPERS, AND RELATED ACCESSORIES. INTEGRATE INTO EXISTING CONTROLS.

BOILER PUMPS

ON A CALL FOR BOILER OPERATION, THE ASSOCIATED BOILER PUMP STARTS AND RUNS CONTINUOUSLY, SUBJECT TO BOILER AND PUMP ALARMS. A CURRENT TRANSFORMER MONITORS PUMP STATUS, AND GENERATES AN ALARM IF STATUS DOES NOT MATCH COMMAND (WITH SUITABLE TIME DELAY). UPON A STATUS ALARM, THE PUMP AND ITS BOILER SWITCH TO LAG STATUS.

BOILERS B-3 AND B-4

CONTROL OF HWS SERVED BY EXISTING P-1 AND P-2 STAGES THE BOILERS TO MAINTAIN HWS SETPOINT, WITH OUTDOOR TEMPERATURE-BASED RESET OF THE LOOP TEMPERATURE, AND OF EACH BOILER'S TEMPERATURE. CONTROLS MONITOR BOILER RUNTIME, AND AUTOMATICALLY ALTERNATE LEAD AND LAG STATUS OF THE BOILERS AFTER EVERY 96 HOURS (ADJUSTABLE) OF OPERATION. GRAPHICS SCREENS PROVIDE MANUAL ENABLE/DISABLE CONTROL FOR EACH BOILER AND ITS PUMP; WHEN A BOILER/PUMP PAIR ARE MANUALLY DISABLED, THEY ARE REMOVED FROM THE LEAD/LAG SEQUENCE AND THEIR FLOW AND TEMPERATURE ALARMS ARE DISABLED. IF A BOILER'S CONTROLLER SIGNALS A FAULT PREVENTING IT FROM OPERATING, THE BOILER AND ITS PUMP ARE DISABLED IN THE BAS. AN LWCO EITHER INTERNAL OR EXTERNAL TO EACH BOILER SHUTS DOWN THE BOILER AND SIGNALS A FAULT ALARM.

BOILER MONITORING

A BMS PROTOCOL CONVERTER, SELECTED TO BE COMPATIBLE WITH THE EXISTING BUILDING DDC SYSTEM, PROVIDES AN INTERFACE BETWEEN THE BOILER'S INTEGRAL CONTROLLER AND THE DDC SYSTEM. THE DDC SYSTEM MONITORS AND TRENDS BOILER OPERATING CONDITIONS, INCLUDING BUT NOT LIMITED TO CALL FOR OPERATION, OPERATING TEMPERATURE, LOCKOUT BY SAFETY DEVICES, AND GENERAL FAULT CONDITION. IF BOILER TEMPERATURE DOES NOT MATCH COMMAND (AFTER A SUITABLE TIME DELAY) AN ALARM IS GENERATED.

B-3 BACKUP AND B-1 & 2 BACKUP

SELECTOR SWITCHES IN A LOCKED BOX IN BOILER ROOM 112 WITH STATUS INDICATOR LIGHTS WITH NAMEPLATES ON THE FRONT PANEL, WITH OVERRIDES ON GRAPHICS SCREENS IN THE BAS, ENABLE "NORMAL," "B-3 BACKUP," AND "B-1 & 2 BACKUP" MODES OF OPERATION. IN "B-3 BACKUP" MODE, B-3 AND P-3 ARE ADDED TO THE B-1 AND B-2 SEQUENCE OF OPERATION AND CYCLE IN LEAD/LAG FASHION TO MAINTAIN THE HWP-1 & 2 SUPPLY LOOP TEMPERATURE, WITH TEMPERATURE SETPOINTS EQUAL TO THE B-1 & 2 SETPOINTS. IN "B-1 & B-2 BACKUP" MODE, B-3 AND B-4 OPERATE IN THEIR NORMAL MODE IF ENABLED, BUT THE P-1 AND P-2 HWS LOOP TEMPERATURE IS ALSO BOOSTED BY WHATEVER TEMPERATURE THE HWR FROM HWP-1 & 2 IS PROVIDING AT THE TIME. DURING ANY BACKUP MODE, REMINDER MESSAGES ARE INDICATED ON THE BAS MAIN SCREEN OR AS DIRECTED.

COMBUSTION AIR

THE OPERATION OF BOILERS B-3 & B-4 IS INTEGRATED INTO EXISTING CONTROL OF THE UPPER COMBUSTION AIR DAMPER. ON A CALL FOR ANY BOILER TO PROVIDE HEATING, THE DAMPER OPENS. THE DAMPER STATUS IS MONITORED BY AN ACTUATOR AUXILIARY SWITCH; IF DAMPER STATUS DOES NOT MATCH THE COMMAND, AN ALARM IS GENERATED, AND IS INDICATED ON THE B-3 & B-4 GRAPHICS SCREENS.

GRAPHICS

DDC SYSTEM GRAPHICS SCREENS SHALL DISPLAY PUMP AND BOILER STATUS AND ALARMS.

BOILER AND PUMP CONTROL

SCALE: NTS

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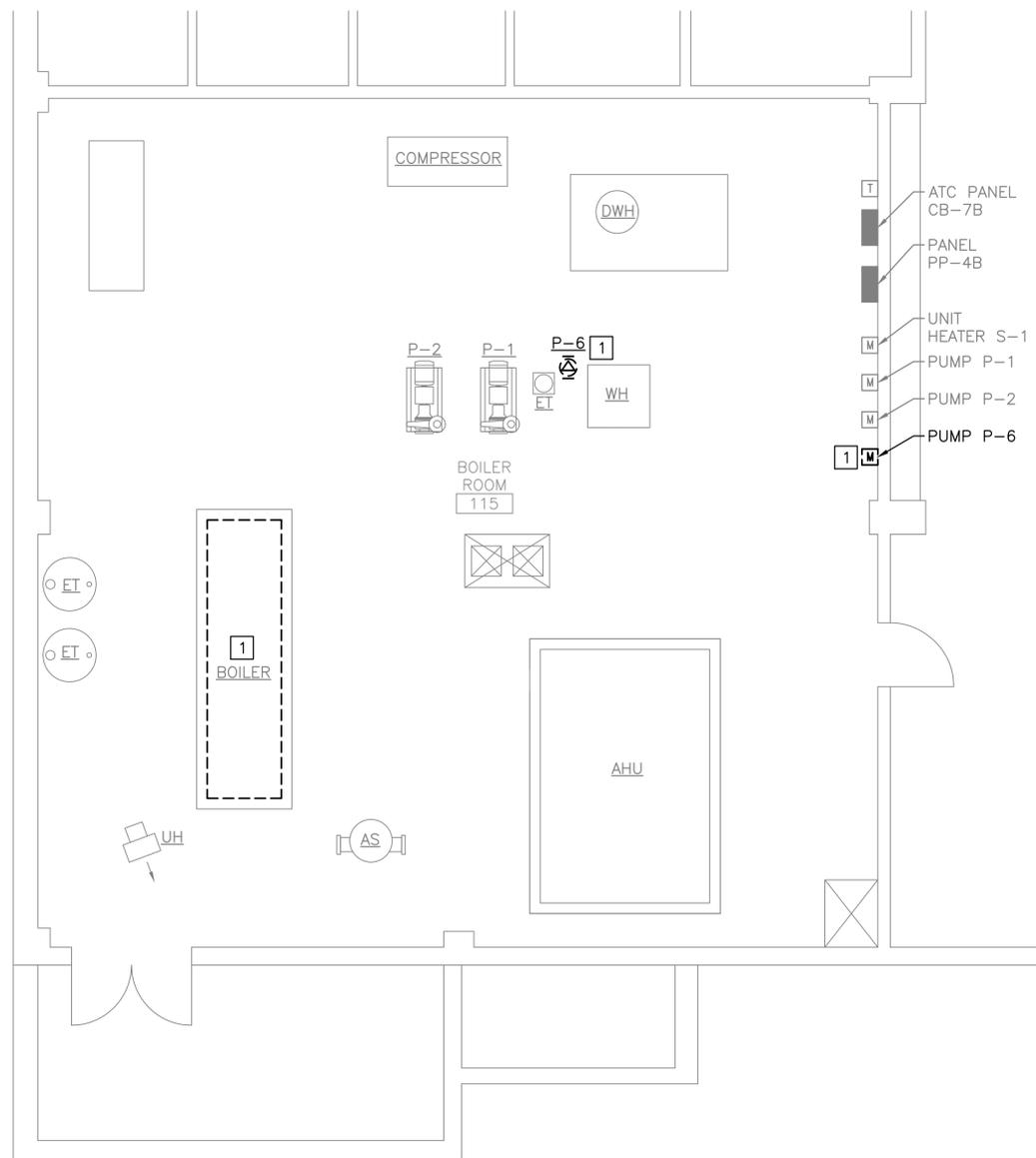
47A York St
Portland, ME
04101
207.553.7753

0	ISSUED FOR CONSTRUCTION	PML	BCT	03/11/20
REV	DESCRIPTION	DWN	APP	DATE

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SIZE: ANSI D
DATE: 03/11/2020
DES BY: DHB
DWN BY: PML
CKD BY: PWB

MANCHESTER COMMUNITY COLLEGE MANCHESTER, NH	
BOILER REPLACEMENT MCC 19-04	
SEQUENCE OF OPERATIONS	
PROJECT NO. 372.004.001	DRAWING NO. M-701
SHEET 8 OF 10	



GENERAL NOTES

- ALL GENERAL NOTES, SYMBOL LISTS AND DETAILS ARE TO BE CONSIDERED AS APPLICABLE TO ALL ELECTRICAL DRAWINGS FOR THIS PROJECT. SYMBOLS AND ABBREVIATIONS SHOWN IN LEGEND ARE FOR REFERENCE ONLY AND DO NOT INDICATE THEIR INCORPORATION IN THE DESIGN.
- DRAWINGS ARE SCHEMATIC AND DIAGRAMMATIC. USE JUDGMENT AND CARE TO INSTALL ALL ELECTRICAL WORK TO FUNCTION PROPERLY AND FIT WITHIN BUILDING CONSTRUCTION AND FINISHES. ELECTRICAL CONDUCTORS, CONDUIT, COMPONENTS, NOT SHOWN OR SPECIFIED, WHICH ARE REQUIRED FOR ANY DEVICE OR SYSTEM TO PRODUCE A COMPLETE AND OPERATIVE SYSTEM ARE REQUIRED TO BE FURNISHED AND INSTALLED.
- PERFORM ALL WORK IN ACCORDANCE WITH NFPA-70, NATIONAL ELECTRICAL CODE (NEC) 2017.
- VERIFY THAT FIELD MEASUREMENTS, SURFACES, SUBSTRATES AND CONDITIONS ARE AS REQUIRED, AND READY TO RECEIVE WORK. DO NOT PROCEED WITH WORK UNTIL UNSATISFACTORY CONDITIONS HAVE BEEN CORRECTED. BY BEGINNING WORK, CONTRACTOR ACCEPTS CONDITIONS AND ASSUMES RESPONSIBILITY FOR CORRECTING UNSUITABLE CONDITIONS ENCOUNTERED AT NO ADDITIONAL COST.
- REMOVE ALL ELECTRICAL EQUIPMENT COMPLETELY WHERE INDICATED. REMOVE ALL CONDUIT, CIRCUIT CONDUCTORS, SWITCHES, LIGHTING FIXTURES AND MISCELLANEOUS APPLIANCES BACK TO ENERGIZING SOURCE OR JUNCTION BOX WHERE MULTIPLE EQUIPMENT IS POWERED.
- ALL CONDUCTOR MATERIAL, INCLUDING WIRING, PANELBOARD BUSES, TRANSFORMER WINDINGS, AND GROUNDING MUST BE COPPER. ALUMINUM CONDUCTORS ARE NOT ALLOWED.
- UNLESS OTHERWISE NOTED, FOR ALL 20A-1P BRANCH CIRCUIT WIRING USE 2#12 AWG CONDUCTORS AND #12 GND. HOME RUNS FED FROM 20A-1P CIRCUITS IN EXCESS OF 100 FEET USE #10 AWG.
- PROVIDE GALVANIZED STEEL WALL PLATES FOR ALL WIRING DEVICES.
- USE THHN/THWN INSULATION FOR ALL INTERIOR DISTRIBUTION AND BRANCH WIRING.
- UNLESS OTHERWISE NOTED, PROVIDE TYPE EMT CONDUIT LIQUID TIGHT FLEXIBLE METAL CONDUIT FOR FINAL CONNECTIONS TO MOTORS.
- ALL EQUIPMENT DISCONNECTS AND MANUAL MOTOR STARTERS ARE PROVIDED BY ELECTRICAL CONTRACTOR UNLESS NOTED AS FURNISHED WITH EQUIPMENT (FWE). MOUNT ALL DISCONNECTS AND MOTOR STARTERS IN AN ACCESSIBLE LOCATION WITHIN SIGHT OF THE LOAD SERVED.
- SEAL ALL PENETRATIONS THROUGH FLOORS, RATED WALLS AND PARTITIONS WITH UL APPROVED FIRE SEALANT MATERIAL TO MAINTAIN THE RATING OF SEPARATION.
- EQUIPMENT CONNECTIONS ARE SHOWN FOR BASIS-OF-DESIGN PRODUCTS. COORDINATE ALL EQUIPMENT CONNECTIONS - INCLUDING DISCONNECTING MEANS, OVERCURRENT PROTECTION, AND WIRE SIZING - WITH SELECTED MANUFACTURER'S RECOMMENDED INSTRUCTIONS.
- PROVIDE ALL MOUNTING HARDWARE NECESSARY FOR A COMPLETE INSTALLATION. MOUNT EQUIPMENT AND ROUTE CONDUIT SO AS NOT TO INTERFERE WITH OPERATIONS SUCH AS OVERHEAD DOORS, DOOR SWINGS, ETC.
- MANUFACTURERS' NAME AND MODEL NUMBERS ARE USED THROUGHOUT THE PROJECT FOR DESCRIPTIVE PURPOSES ONLY AND ARE INTENDED TO INDICATE THE STANDARD OF MATERIAL OR ARTICLES REQUIRED. DESIGN IS PREDICATED AROUND LISTED MANUFACTURERS AS NOTED ON SCHEDULES AND NOTES AND IS NOT INTENDED TO LIMIT THE CONTRACTOR TO ONE MANUFACTURER.
- SUPPLY ALL DISTRIBUTION EQUIPMENT FROM THE SAME MANUFACTURER. APPROVED MANUFACTURERS INCLUDE SQUARE D, EATON/CUTLER-HAMMER, SIEMENS, OR APPROVED EQUAL.
- LABEL ALL NEW EQUIPMENT ENCLOSURES, SWITCHES, RECEPTACLES, AND DEVICES WITH THE SOURCE CIRCUIT AND EQUIPMENT CONTROLLED WHERE APPLICABLE. APPLY APPROPRIATE ARC-FLASH LABELS TO ALL NEW PANELBOARDS AND SWITCHBOARDS.

LINE TYPES:

- EXISTING
- NEW
- - - - - DEMOLITION

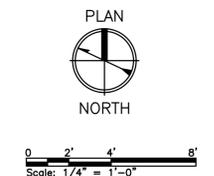
DEMOLITION KEYED NOTE:

- 1** REMOVE EQUIPMENT CIRCUIT COMPLETELY. REMOVE LOCAL DISCONNECT, ALL CONDUIT, CIRCUIT CONDUCTORS BACK TO ENERGIZING SOURCE.

LEGEND:

- NON-FUSED SAFETY SWITCH
- NEMA ENCLOSURE (NEMA 1 UNLESS OTHERWISE NOTED)
- AMPERE RATING
- PANELBOARD, NORMAL POWER
- MANUAL MOTOR STARTER, TOGGLE OPERATED, SINGLE PHASE. 1,2 OR 3 POLE AS REQUIRED OVERLOAD PROTECTION
- TRANSFORMER
- HOME RUN

1 BOILER RM 115 ELECTRICAL DEMOLITION PLAN
 ED-401 SCALE: 1/4" = 1'-0"



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COBY COMPANY, LLC
CCE
 engineering & design

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 Portland, ME
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 207.553.7753

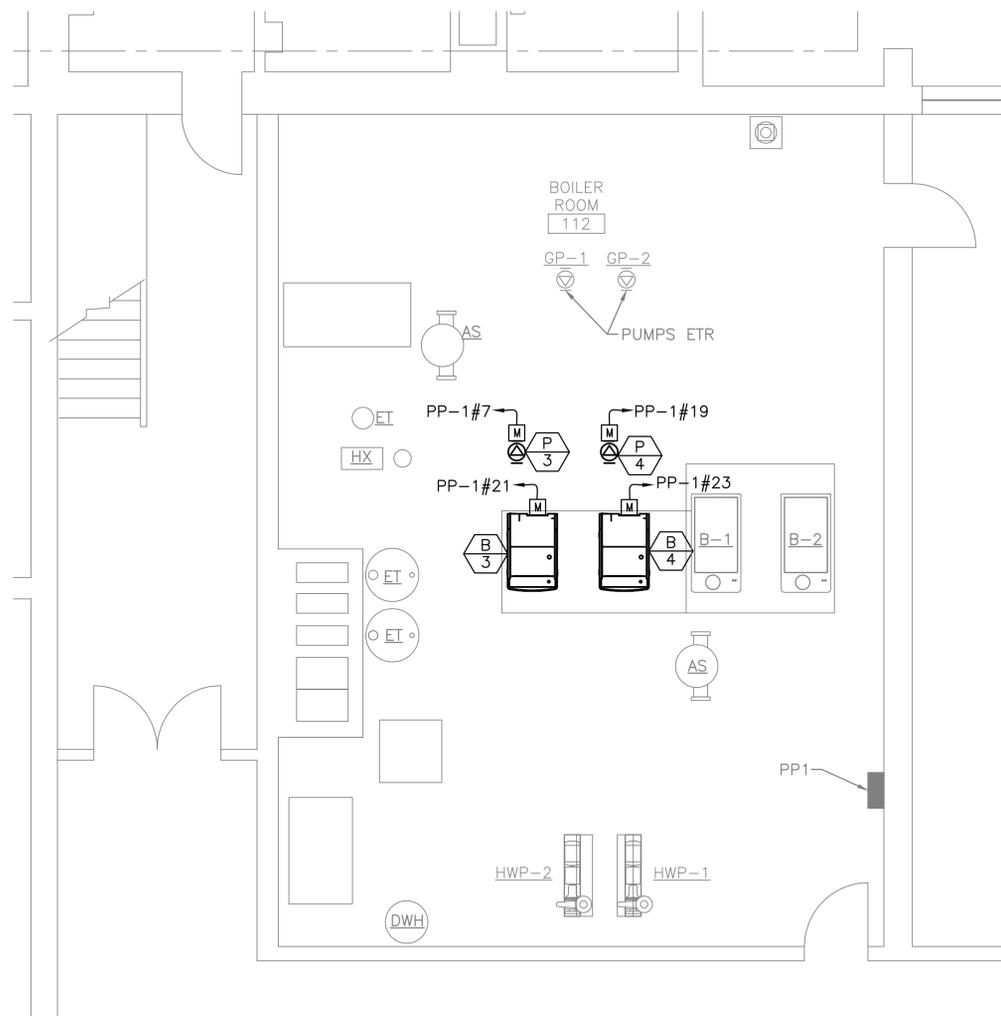
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0	ISSUED FOR CONSTRUCTION	JLH	BCT	03/11/20

SIZE: ANSI D
 DATE: 03/11/2020
 DES BY: JLH
 DWN BY: JLH
 CKD BY: JMB

MANCHESTER COMMUNITY COLLEGE MANCHESTER, NH	
BOILER REPLACEMENT MCC 19-04	
ELECTRICAL DEMOLITION PLANS AND NOTES	
PROJECT NO. 372.004.001	DRAWING NO. ED-401
SHEET 9 OF 10	

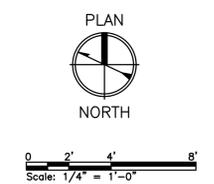
NOTES:

- SEE ED-401 FOR GENERAL NOTES AND LEGEND.
- HIGHLIGHTED/SHADED CIRCUITS INDICATE EXISTING CIRCUITS WITH UNVERIFIED LOADS.
- UNLESS OTHERWISE STATED PANEL SCHEDULES INDICATE NEW CIRCUIT BREAKERS TO BE PROVIDED.



PANELBOARD NO:		PANEL PP-1		SC RATING:		MOUNTING:		SURFACE MOUNTING		225 AMP MAIN LUGS				
PANELBOARD TYPE:		EATON PRL1		VOLTAGE:		208Y/120V 3 PHASE 4 WIRE		225 AMP BUS (COPPER)						
PANEL LOCATION:		BOILER ROOM 112		SUPPLIED FROM:										
CKT NO.	TRIP AMPS	NO. POLES	WIRE / CONDUIT	GND WIRE	LOAD SERVED	LOAD VA	φ	LOAD VA	LOAD SERVED	WIRE / CONDUIT	GND WIRE	NO. POLES	TRIP AMPS	CKT NO.
1	30				SPLIT AC ROOM 108		A		QUINCY CLIMATE CONTROL AIR COMPRESSOR				15	2
3					AIR DRYER		B							4
5	15				PUMP P-3	1920	C		ATC				20	6
7	30	1	2#10 / 3/4"C	#12	UNIT HEATERS		A		SPARE				20	8
9	20				SOUTH WALL OUTLET		B		HOT WATER BOILER				20	10
11	20				UNIT HEATERS		C		COMPRESSOR AIR DRYER				20	12
13	20						A		WEST WALL OUTLETS				20	14
15	20						B		SMALL UPPER RC PUMP				20	16
17	20						C						20	18
19	30	1	2#10 / 3/4"C	#12	PUMP P-4	1920	A							20
21	20	1	2#12 / 3/4"C	#12	BOILER B-3	1920	B		DICO OLD COMPRESSOR				20	22
23	20	1	2#12 / 3/4"C	#12	BOILER B-4	1920	C							24
25	20				OUTSIDE GFCI		A							26
27	30				SPLIT AC ROOM 110		B		NEW BOILER LEFT				20	28
29							C							30
31							A							32
33	70				BUILDING AIR COMP.		B						40	34
35							C							36
37							A							38
39					NEW BOILER RIGHT		B		CIRC PUMP 1,2				60	40
41							C							42
TOTAL PHASE A LOAD =					3.8 kVA		NOTES:					1. TOTAL CALCULATED LOADS INDICATED DO NOT REFLECT ENTIRE LOAD OF PANEL.		
TOTAL PHASE B LOAD =					1.9 kVA		2. EXISTING CIRCUIT BREAKER TO BE REUSED							
TOTAL PHASE C LOAD =					1.9 kVA									
TOTAL CONNECTED LOAD =					7.7 kVA									

2 BOILER RM 112 ELECTRICAL PLAN
E-401 SCALE: 1/4" = 1'-0"



		MANCHESTER COMMUNITY COLLEGE	
		MANCHESTER, NH	
		BOILER REPLACEMENT	
		MCC 19-04	
		ELECTRICAL PLANS AND SCHEDULES	
0	ISSUED FOR CONSTRUCTION	JLH	BCT 03/11/20
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		DATE: 03/11/2020	DRAWING NO. E-401
		DWG BY: JLH	SHEET 10 OF 10
		DWN BY: JMB	
		CKD BY: JMB	

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COMMUNITY COLLEGE SYSTEM OF NEW HAMPSHIRE

Boiler Replacement at Manchester Community College

Community College System of New Hampshire
26 College Drive
Concord, NH 03301-7407

Project Number MCC19-04

Technical Specifications Issued for Construction March 11, 2020

Prepared for:



26 College Drive
Concord, NH 03301-7407

Division	Section Title
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TECHNICAL SPECIFICATIONS GROUP

General Requirements Subgroup

DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

230500	COMMON WORK RESULTS FOR HVAC
230513	COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
230519	METERS AND GAUGES FOR HVAC PIPING
230529	HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
230548	VIBRATION CONTROLS FOR HVAC PIPING AND EQUIPMENT
230553	IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
230593	TESTING, ADJUSTING, AND BALANCING FOR HVAC
230713	DUCT INSULATION
230719	HVAC PIPING INSULATION
230900	INSTRUMENTATION AND CONTROL FOR MECHANICAL SYSTEMS
231123	FACILITY NATURAL-GAS PIPING
232113	HYDRONIC PIPING
232118	HYDRONIC SPECIALTIES
232123	HYDRONIC PUMPS
232500	HVAC WATER TREATMENT
233113	METAL DUCTS
235100	BREECHINGS, CHIMNEYS, AND STACKS
235216	CONDENSING BOILERS

END OF TABLE OF CONTENTS

SECTION 230500 – COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Provide labor, materials, accessories, and other related items as required to complete operations in connection with the complete installation of the HVAC and mechanical systems as indicated on the Drawings and as specified herein.

1.2 RELATED REQUIREMENTS

- A. Conditions of the Contract apply to the work, including the work of this Division. Examine Contract Documents for requirements affecting the work.
- B. Provide cooperation with, and assistance to, the Testing and Balancing (TAB) Agent specified in Division 23 Section "Testing, Adjusting, and Balancing for Mechanical Systems."

1.3 MECHANICAL PRE-CONSTRUCTION MEETING

- A. Conduct a mechanical conference at Project site to comply with the following:
 - 1. At least 14 days prior to beginning of mechanical work, conduct a meeting to review detailed requirements for mechanical systems installation and testing requirements. Review mechanical Drawings and Specifications, discuss project specific details and requirements, and review and discuss expectations for quality control. Establish preliminary work progress schedule and procedures for materials inspection, testing, and certifications. Require representatives of each entity directly concerned with mechanical systems installation to attend conference, including, but not limited to, the following:
 - a. General Contractor's superintendent.
 - b. Mechanical Subcontractors' project managers.
 - c. Mechanical Subcontractors' job foremen.
 - d. Sheetmetal job foreman.
 - e. Controls job foreman.
 - f. Job clerk.
 - g. Contract Representative of the Owner.
 - h. Owner's construction administrator.

1.4 DRAWINGS

- A. The general location of the apparatus and the details of the work are indicated on the Drawings. Exact locations not indicated shall be determined at the site as the work progresses and shall be subject to the Engineer's approval.
- B. It is not intended that the Drawings shall show every pipe, pipe rise, pipe drop, duct rise, duct drop, pipe fitting, duct fitting, or appliance, but it shall be a requirement to furnish, without

additional expense, material and labor necessary to complete the systems in accordance with the design intent and with the highest possible quality available.

1.5 ALTERATIONS

- A. Execute alterations, additions, removals, relocations, new work, and other related items as indicated or required to provide a complete installation in accordance with the intent of the Contract Documents, including changes required by building alterations.
- B. Existing work disturbed or damaged by the alterations or the new work shall be repaired or replaced to the Engineer's satisfaction and at no additional cost to the Owner.
- C. Existing ductwork, piping, and other systems indicated to be removed, shall be removed from the site. Cap off existing services remaining. The Owner's Contract Representative retains the right to ownership of heating and ventilating equipment scheduled to be removed; store such equipment where requested by the Contract Representative. Material not retained by the Contract Representative shall be removed from the site.

1.6 CONTINUITY OF SERVICE

- A. Arrange to execute the work at such times and in such locations as may be required to provide uninterrupted service for the building or any of its locations. Any unavoidable conditions requiring reduced building capacity shall be arranged for by programming with the Contract Representative at the building subject to the Engineer's approval. If necessary, temporary work shall be installed to provide for the condition. Authorization for interrupting service shall be obtained in writing from the Contract Representative. Any interruption of normal service shall be performed during an overtime period to be scheduled with the Contract Representative. Costs for overtime work shall be included in the Bid.

1.7 REQUIREMENTS

- A. Installation Instructions: Obtain manufacturer's printed installation instructions to aid in properly executing work on major pieces of equipment. Install equipment in accordance with manufacturer's recommendations.
- B. Objectionable Noise, Fumes and Vibration:
 - 1. Mechanical and electrical equipment shall operate without creating objectionable noise, fumes, or vibration, as determined by the Engineer.
 - 2. If such objectionable noise, fumes, or vibration is produced and transmitted to occupied portions of building by apparatus, piping, ducts, or any other part of mechanical and electrical work, make necessary changes and additions, as approved, without extra cost to Owner.
- C. Equipment Design and Installation:
 - 1. Uniformity: Unless otherwise specified, equipment or material of same type or classification, used for same purposes, shall be product of same manufacturer.
 - 2. Design: Equipment and accessories not specifically described or identified by

manufacturer's catalog number shall be designed in conformity with ASME, IEEE, or other applicable technical standards, suitable for maximum working pressure, and with neat and finished appearance.

3. Installation: Erect equipment aligned, level and adjusted for satisfactory operation. Install so that connecting and disconnecting of piping and accessories can be made readily, and so that parts are easily accessible for inspection, operation, maintenance and repair. Minor deviations from indicated arrangements may be made, as approved.

D. Hanging of Equipment, Ductwork and Piping:

1. Support equipment, ductwork and piping from the top chord of bar joists at the "Panel Points" or from the top flange of beams. Piping 2-inch (50 mm) nominal and smaller may be supported from the bottom chord of the bar joists at the "Panel Points" or from the bottom flange of the beams.

- E. Protection of Equipment and Materials: Responsibility for care and protection of materials and mechanical work rests with the Contractor until the entire project has been completed, tested and the project is accepted by the Contract Representative.

F. Foundations:

1. Ceiling Mounting: Where ceiling mounting is indicated or specified, use suspended platform or strap hangers, bracket or shelf, whichever is most suitable for equipment and its location. Construct of structural steel members, steel plates, or rods, as required; brace and fasten to building structure or to inserts as approved, or as detailed.
2. Where floor mounting is indicated, locate equipment on 4 inch (102 mm) high reinforced concrete pad of adequate size with anchors and base plates as required. The corners of pads shall be chamfered 1 inch (25 mm). Pad and steel sizes and location shall be coordinated with the approved equipment.

1.8 ELECTRIC WORK

- A. Provide motors, pilot lights, controllers, limit switches, and other related items for equipment provided under Division 23.
- B. Except as noted, required line switches, fused switches, and other related items and necessary wiring to properly connect equipment to motors and switches shall be furnished and installed under the Electrical portion of the Contract Documents.
- C. Provide complete wiring system for automatic temperature controls as specified under Section Division 23 Section "Instrumentation and Controls for Mechanical Systems."
- D. Wiring shall conform to the requirements of the National Electrical Code.

1.9 SUBMITTALS

- A. After award of Contract and before installation, submit for approval Shop Drawings, bulletins, Product Data, Samples, and other related items per Section 01330 "Submittal Procedures."

1.10 SUBSTITUTIONS

- A. Comply with provisions of the Instructions to Bidders and General Conditions.
 - 1. Unless otherwise specified, the following provisions shall apply: If a manufacturer's name, trade name or proprietary designation is used in the Contract Documents, the time for submission for review of proposed substitutions shall be at least 5 working days prior to the Bid date. After that time, no substitutions will be reviewed.
- B. The first item listed under "Acceptable Manufacturers," "Approved Manufacturers," or "Manufacturers" is the design basis.
 - 1. Other manufacturers listed may be used in the Base Bid, but conformance with details of the Specifications, as well as dimensional and electrical data, shall be verified by the Contractor.
 - 2. Engineer/Engineer has not verified that each listed manufacturer has the ability to provide an acceptable substitution for the basis-of-design product. Contractor may not assume that substitutions will be approved.
 - 3. Modifications required as a result of differences between the design basis item and the submitted and approved item must be approved by the Engineer and made at the Contractor's expense. As an example, if a rooftop HVAC unit is submitted and approved and if the unit's dimensions and weight are different from those of the unit which was used as the design basis, the Contractor shall be responsible for building structural modifications required to accommodate the submitted and approved unit, at no additional cost to the Owner.
 - 4. When, in the Engineer's opinion, engineering services are necessary for the coordination of substituted items, the Contractor shall reimburse the Owner for the cost of these services.
 - 5. For items which have no manufacturers listed, any item conforming with the Contract Documents is acceptable.
- C. Substitutions from manufacturers or providers which are not listed may be proposed within the time allowed in the General Conditions of the Specifications.
 - 1. The exception to this is products for which the list of manufacturers or providers is limited by the wording "no substitutions" or similar wording.

1.11 COORDINATION

- A. Coordinate scheduling, submittals, and Work of the various Sections of Specifications to assure efficient and orderly sequence of installation of interdependent construction elements, with provisions for accommodating items installed later.
- B. Verify that utility requirement characteristics of operating equipment are compatible with building utilities. Coordinate work of various Divisions having interdependent responsibilities for installing, connecting to, and placing in service, such equipment.
- C. Coordinate space requirements and installation of mechanical and electrical work which are indicated diagrammatically on Drawings. Follow routing shown for pipes, ducts, and conduit,

as closely as practicable; place runs parallel with line of building. Utilize spaces efficiently to maximize accessibility for other installations, for maintenance, and for repairs.

- D. In finished areas, conceal pipes, ducts, and wiring within the construction. Coordinate locations of fixtures and outlets with finish elements.
- E. Coordinate completion and clean-up of work of separate Sections in preparation for Substantial Completion.
- F. After Owner occupancy of premises, coordinate access to site for correction of defective work and work not in accordance with Contract Documents, to minimize disruption of Owner's activities.

1.12 SEISMIC DESIGN

- A. This project requires special provisions for the support and restraint of natural gas piping. These provisions shall be incorporated in accordance with the following:
 - 1. The requirements of this Section are complementary to requirements listed elsewhere for the fastening and support of piping, ductwork, and equipment. Nothing indicated on the Drawings or in other Sections of these Specifications shall be interpreted as a reason to waive the requirements of this Section.
 - 2. Piping shall be adequately supported and restrained to resist seismic forces in accordance with the applicable edition of NFPA 54 for gas piping.

1.13 CLEANING

- A. Remove debris from site daily.
- B. Material and pieces of equipment shall be turned over to the Contract Representative free of dust and dirt, both inside and out.
- C. At the completion of the Project, equipment shall have a clean, neat appearance of factory finish by cleaning or repainting as required.
- D. At the completion of the Project, surfaces exposed to view shall have a clean, neat appearance of finish free from smudges and scratches by cleaning or repainting as required.

1.14 STARTING SYSTEMS

- A. Coordinate schedule for start-up of various equipment and systems.
- B. Notify Owner 7 days prior to start-up of each item.
- C. Verify that each piece of equipment or system has been checked for proper lubrication, drive rotation, belt tension, control sequence, or other conditions which may cause damage.
- D. Verify that tests, meter readings, and specified electrical characteristics agree with those required by the equipment or system manufacturer.

- E. Verify that wiring and support components for equipment are complete and tested.
- F. Execute start-up under supervision of responsible manufacturer's representative in accordance with manufacturer's instructions.
- G. When specified in individual Specification Sections, require manufacturer to provide authorized representative to be present at site to inspect, check, and approve equipment or system installation prior to start-up, and to supervise placing equipment or system in operation.
- H. Submit a written report that equipment or system has been properly installed and is functioning correctly.

1.15 FACTORY START-UP AND START-UP REPORTS

- A. Provide factory start-up of mechanical equipment listed below. Factory start-up shall be performed by a factory authorized representative of the equipment manufacturer. When factory start-up is successfully completed for each piece of mechanical equipment listed below, submit a formal start-up report to the Engineer for approval. Start-up report shall be formatted in accordance with equipment manufacturer's recommendations. Start-up report shall be typed, not hand written, and shall be submitted in a clean and legible form.
- B. Equipment requiring factory start-up
 - 1. Boilers
 - 2. Boiler controllers

1.16 ADJUSTMENTS AND OWNER'S INSTRUCTIONS

- A. After completion of the installation work called for in the Contract Documents, furnish necessary mechanics or engineers for the adjustment and operation of the systems, to the end that the systems are perfectly adjusted and turned over to the Contract Representative in perfect working order. Further instruct the Contract Representative in the care and operation of the installation, providing framed instruction charts, directions, and other related items.
- B. Instructors providing Owner training shall be experienced and familiar with the jobsite.

1.17 TESTING

- A. After the entire installation is completed and ready for operation, test the systems as outlined in Division 23 Section "Testing, Adjusting and Balancing for HVAC." These tests are supplementary to detailed tests specified herein or directed. The Contract Representative will provide water and electric current for the test. Provide necessary labor, test pump, gauges, meters, other instruments, and materials. Perform tests in the presence of the Engineer or his representative.
- B. Perform other tests specified in individual Sections of this Specification.

1.18 COMPLETION OF SYSTEMS

- A. The following mechanical systems shall not be complete until the following conditions are satisfied:
1. Ductwork Systems:
 - a. Ductwork and related components and accessories shall be completely installed and insulated as specified.
 - b. Ductwork leakage testing shall be completed and leakage testing reports shall be submitted and approved.
 - c. Ductwork shall be balanced and a balancing report shall be submitted and approved.
 - d. Control of dampers shall be completed.
 2. Piping Systems:
 - a. Piping, valves and accessories shall be completely installed, insulated and labeled as specified.
 - b. Piping pressure testing be completed and pressure testing reports shall be submitted and approved.
 - c. Piping systems shall be balanced and a balancing report submitted and approved.
 - d. Control installation shall be completed.
 3. Equipment:
 - a. Equipment, including but not limited to boilers, pumps and rooftop units shall be completely installed.
 - b. Equipment start-up reports shall be completed, submitted and approved.
 - c. Equipment balancing shall be completed and the balancing report shall be submitted and approved.
 - d. Control installation and training shall be completed.
 4. Automatic Temperature Controls (ATC):
 - a. ATC system shall be completely installed.
 - b. Control startup and training shall be completed.
 - c. Controls shall operate in an automatic mode for a minimum of 2 months during heating system operation without substantial deficiencies.

1.19 OPERATING AND MAINTENANCE MANUALS

- A. Submit electronic copy of operating and maintenance manuals to the Engineer for review. Indicate where in the final bound copy there will be physical divider tabs.
- B. Furnish approved operating and maintenance manuals to the Contract Representative as follows: 1 bound copy in 3-ring binders, and one electronic copy on a USB 3.0 flash drive.
- C. For maintenance purposes, provide approved Submittals, parts lists, specifications, and

manufacturer's maintenance bulletins for each piece of equipment. For materials used which have been submitted to the Engineer for approval but do not require regular maintenance, such as piping, ductwork, and insulation, provide one copy of approved Submittals.

- D. Provide name, address and telephone number of the manufacturer's representative and service company, for each piece of equipment or material so that service or spare parts can be readily obtained.

1.20 WARRANTY

- A. Provide guarantees and warranties for work under this Contract as indicated in the general requirements of the Contract. Warrant the work for a period of 2 years from the date of substantial completion.
- B. Provide manufacturers' standard warranties and guarantees for work by the mechanical trades. However, such warranties and guarantees shall be in addition to and not in lieu of other liabilities which the manufacturer and the Mechanical Contractor may have by law or by other provisions of the Contract Documents.
- C. Guarantee that elements of the systems provided under this Contract are of sufficient capacity to meet the specified performance requirements as set forth in these Specifications or as indicated on the Drawings.
- D. Upon receipt of notice from the Contract Representative of failure of any part of the mechanical systems or equipment during the warranty period, the Mechanical Subcontractor shall replace the affected part or parts.
- E. Furnish a written guarantee covering the above requirements before submitting the application for final payment.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 230500

SECTION 230513 – COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Common requirements for electric motors furnished on equipment specified in other Sections, including single phase and three phase electric motors.
- B. Starters.
- C. Thermal Overload Protection.

1.2 REFERENCES

- A. Division 00 Section “General Conditions”: Requirements for references and standards.
- B. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
- C. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
- D. NEMA MG 1 - Motors and Generators.
- E. NFPA 70 - National Electrical Code.
- F. UL 508A - Industrial Control Panels.
- G. UL 674 - UL Standard for Safety Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.
- H. UL 1836 - UL Standard for Safety for Electric Motors for Use in Class I, Division 2 and Class II, Division 2 Hazardous (Classified) Locations.

1.3 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Company specializing in manufacturing the Products specified in this Section with minimum 3 years' experience.
- B. Installer Qualifications: Company specializing in performing the work of this Section with minimum 3 years' experience.

1.4 REGULATORY REQUIREMENTS

- A. Conform to UL Component Recognition for appropriate sizes.
- B. Conform to NFPA 70 and local energy code.

1.5 DELIVERY, STORAGE, AND PROTECTION

- A. Division 01 Section “Product Requirements”: Transport, handle, store, and protect products.
- B. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

PART 2 - PRODUCTS

2.1 MOTORS

- A. Acceptable Manufacturers:
 - 1. Baldor-Reliance – a division of ABB Motors and Mechanical Inc.
 - 2. Century Electric Motors – a brand of Regal Beloit Corp.
 - 3. General Electric – a brand of General Electric Power Conversion.
 - 4. Marathon Motors – a brand of Regal Beloit Corp.
 - 5. Siemens Industry Inc.
 - 6. Simotics – a brand of Siemens Industry Inc.
 - 7. Teco-Westinghouse Motor Company.
 - 8. Toshiba International Corp.
 - 9. U.S. Motors (division of Emerson Motor Technologies).
 - 10. WEG Electric Corp.
- B. General Construction and Requirements:
 - 1. Motors Less Than 250 Watts, for Intermittent Service: Equipment manufacturer’s standard and need not conform to these Specifications.
 - 2. Motors shall have integral thermal overload protection.
 - 3. Single Phase Motors for general applications: PSC (permanent split capacitor) where available.
 - 4. Open drip-proof type except where specifically noted otherwise.
 - 5. Design for continuous operation in 40 degrees C environment.
 - 6. Design for temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
 - 7. Explosion-Proof Motors: UL approved for hazard classification.
 - 8. Visible Nameplate: Indicating manufacturer’s name and model number, motor horsepower, RPM, frame size, voltage, phase, cycles, full load amps, insulation system class, service factor, maximum ambient temperature, temperature rise at rated horsepower, minimum efficiency.
- C. Single Phase Power - Permanent-split Capacitor Motors:
 - 1. Starting Torque: Exceeding one fourth of full load torque.
 - 2. Starting Current: Up to six times full load current.
 - 3. Multiple Speed: Through tapped windings.

4. Open Drip-proof or Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, prelubricated sleeve or ball bearings, automatic reset overload protector.

D. Single Phase Power - Capacitor Start Motors:

1. Starting Torque: Three times full load torque.
2. Starting Current: Less than five times full load current.
3. Pull-up Torque: Up to 350 percent of full load torque.
4. Breakdown Torque: Approximately 250 percent of full load torque.
5. Motors: Capacitor in series with starting winding; provide capacitor-start/capacitor-run motors with two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
6. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated bearings.
7. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

E. Single Phase Power - Split Phase Motors:

1. Starting Torque: Less than 150 percent of full load torque.
2. Starting Current: Up to seven times full load current.
3. Breakdown Torque: Approximately 200 percent of full load torque.
4. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve or ball bearings.
5. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

F. Three Phase Power - Squirrel-cage Motors:

1. Starting Torque: Between 1 and 1-1/2 times full load torque.
2. Starting Current: Six times full load current.
3. Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics.
4. Design, Construction, Testing, and Performance: Conform to NEMA MG 1 for Design B energy-efficient motors.
5. Insulation System: NEMA Class B or better.
6. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
7. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum AFBMA 9, L-10 life of 200,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
8. Sound Power Levels: To NEMA MG 1.
9. Part Winding Start Above 254T Frame Size: Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.

10. Weatherproof Epoxy Sealed Motors: Epoxy seal windings using vacuum and pressure with rotor and starter surfaces protected with epoxy enamel; bearings double shielded with waterproof non-washing grease.
11. Nominal Efficiency: To NEMA MG 1, energy efficient for motor sizes 10 and larger.

2.2 STARTERS AND OVERLOADS

A. Acceptable Manufacturers:

1. Franklin Control Systems.
2. Allen-Bradley (division of Rockwell Automation).
3. Cutler Hammer (division of Eaton Corporation).
4. General Electric.
5. Siemens.
6. Square D (division of Schneider Electric).

B. Provide motor starters for motors provided under this Division of these Specifications.

C. Franklin Control Systems "BAS" building automation HVAC starters are the basis of design. Features of starters/contactors, disconnects, and temperature controls shall be combined in a single package using these starters. Coordination with Automatic Temperature Controls supplier and installer is required to reduce total project costs.

1. 3-phase starter features include:
 - a. Multi-tap control power transformer (CPT) for universal control voltage.
 - b. Motor circuit protector disconnect (MCP) with high interrupt rating and lockable operator handle.
 - c. Contactors rated as high as 2.5 million electrical operations and 25 million mechanical operations.
 - d. Anti-cycling feature.
 - e. Solid-state electronic overloads with wide adjustment range and highly accurate digital motor protection, including protection for phase loss, phase unbalance, stall and locked rotor conditions. Class 1-30.
 - f. Digital keypad, featuring an H-O-A (Hand, Off, Auto) panel with large, clearly labeled push buttons including a front panel reset function and high-intensity LED indicators for settings.
 - g. Damper and valve actuator control, to open the actuator before starting the fan or pump motor.
 - h. Permissive auto control to disable auto inputs. Commonly used with a high pressure limit switch.
 - i. Universal control inputs, including auto dry input, and wet input for voltages from 20 to 138 VAC or VDC.
 - j. Power failure reset.
 - k. Fireman's override.
 - l. NEMA 1 enclosure with prepunched knockouts. NEMA 3R, 4, 4X, and 12 as required.
 - m. BACnet embedded communications option available.
 - n. UL Listed assembly.

- o. 5-year warranty.
 - p. Factory printed label or engraved nameplate, designating the equipment served.
2. Single-phase starter (Franklin Control Systems BAS-1P series) features include:
- a. Manually operated quick-make toggle mechanism lockable in the “Off” position, which shall also function as the motor disconnect.
 - b. Hand/Auto switch, concealed behind sliding cover to discourage tampering.
 - c. Capability to operate in both manual and automatic control modes. In automatic mode, the starter shall have the capability to integrate with a building automation system by providing terminals for run input, run status output, and fault output.
 - d. Control terminals integrated in the starter.
 - e. Power, run status, and fault LED pilot lights.
 - f. Interposing run relay and current sensing status output relay.
 - g. Voltage and dry inputs for auto run command.
 - h. System override mode (fireman’s, occupancy, or manual).
 - i. Solid-state electronic overload with wide adjustment range and highly accurate digital motor protection, including protection for stall and locked rotor conditions. Class 10. Concealed adjustment behind sliding cover.
 - j. Surface mount enclosure, UL Type 1, single gang box installation, with sliding covers for concealed items.
 - k. Power Input: 1-phase, 110-240 VAC, 1-16 Amps, 0.1-1 HP (75 to 745 W).
 - l. Universal Control Inputs: Voltage auto-run 10-130 VAC/DC to energize. Dry auto-run normally-open dry contact closure.
 - m. Control Outputs: Proof of run and fault, normally-open 0.3 Amps at 125 VAC, 1 Amp at 24 VAC.
 - n. Ambient operating temperature -5 to 140 degrees F (-20 to 60 degrees C).
 - o. UL 508A Listed.
 - p. 5-year warranty.

D. Feature Descriptions:

- 1. Fireman’s Override Input: Causes the starter to run the motor in any mode (Hand, Off or Auto) regardless of other inputs or lack of inputs either manual or auto. The purpose of the Fireman’s Override input is to act as a smoke purge function. Fireman’s Override has priority over the Emergency Shutdown input.
- 2. Emergency Shutdown Input: Disables the starter from operating in either Hand or Auto mode regardless of other inputs either manual or auto.
- 3. Phase Failure Protection: Initiates when phase loss is greater than 70 percent for 3 seconds or phase unbalance is greater than 50 percent for more than 5 seconds.
- 4. Cycling Fault Protection: Activates whenever the starter is cycled at a rate of more than 1000 cycles in a one hour period. This feature shall be selectable to be disabled. Cycling fault shall cause overload LED to blink rapidly.

- E. Contactors in starters shall be general purpose NEMA rated for connected H.P. (definite purpose starters not acceptable). Coordinate control voltage with Controls Contractor. Provide auxiliary contacts where required for interlocking of electrical equipment. Provide 2-speed motor starters where indicated or required.

- F. Single phase motors shall have one of the following factory wired methods of motor protection:
 - 1. Integral thermal overload protection in motor and cord with plug and receptacle in unit casing.
 - 2. Integral thermal overload protection in motor and disconnecting switch mounted in or on casing as specified with equipment.
 - 3. Switch with thermal overload protection for unprotected motors with switch serving as disconnect device.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Division 01 Section "Quality Requirements": Manufacturer's instructions.
- B. Install securely on firm foundation. Mount ball bearing motors with shaft in any position.
- C. Coordinate with Electrical portion of the Contract Documents.
- D. Check line voltage and phase and direction of rotation, and ensure agreement with nameplate.
- E. Install guards in accordance with Codes and OSHA requirements.
- F. Adjust motor overload devices based on motor amperage ratings and field measurements of running amps, to ensure protection of the motor and eliminate nuisance trips.
- G. Disconnect Switch Mounting Height: Install at height above finished floor in accordance with NFPA 70.
 - 1. In most instances, the center of the grip of the disconnect switch operating handle in its highest position shall be no more than 79 inches (2.0 m) above finished floor or working platform.
 - 2. Switches and circuit breakers installed adjacent to the equipment served (and within 79 inches (2.0 m) above finished floor or working platform.

END OF SECTION 230513

SECTION 230519 – METERS AND GAUGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Pressure gauges and Pressure gauge taps.
- B. Thermometers and thermometer wells.
- C. Thermowell heat transfer paste.

1.2 RELATED SECTIONS

- A. Division 23 Section “Hydronic Piping.”
- B. Division 23 Section “Instrumentation and Control for Mechanical Systems.”
- C. Division 23 Section “Hydronic Pumps.”

1.3 REFERENCES

- A. ASME B40.1 - Gauges - Pressure Indicating Dial Type - Elastic Element.
- B. ASME MFC-3M - Measurement of Fluid Flow in Pipes Using Orifice, Nozzle and Venturi.
- C. ASTM D217 - Standard Test Methods for Cone Penetration of Lubricating Grease.
- D. ASTM D566 - Standard Test Method for Dropping Point of Lubricating Grease.
- E. ASTM E1 - Standard Specification for ASTM Thermometers.
- F. ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Company specializing in manufacturing the Products specified in this Section with minimum 3 years' experience.

1.5 SUBMITTALS

- A. Division 01 Section “Submittal Procedures”: Procedures for submittals.
- B. Product Data: Provide manufacturers data and list which indicates use, operating range, total range, accuracy, and location for manufactured components.

1.6 OPERATION AND MAINTENANCE DATA

- A. Include instructions for calibrating instruments.

1.7 ENVIRONMENTAL REQUIREMENTS

- A. Division 01 Section "Submittal Procedures": Environmental conditions affecting products on site.
- B. Do not install instruments when areas are under construction, except for required rough-in, taps, supports and test plugs.

PART 2 - PRODUCTS

2.1 PRESSURE GAUGES

- A. Manufacturers:
 - 1. Weiss.
 - 2. Ametek.
 - 3. Dwyer.
 - 4. Terrice.
- B. Gauges, Hot Water Heating Systems: Weiss Series 4PG-1 industrial pressure gauge, dry non-filled type, with phosphor bronze bourdon tube, silver brazed connecting joints, brass socket, bushed stainless rotary movement, 1/4-inch NPT connection, white aluminum dial with black markings, black aluminum pointer with front slotted adjustment or approved equal.
 - 1. Case: Cast aluminum or stainless steel.
 - 2. Lens: Push-in Lexan polycarbonate, or clear glass or acrylic with stainless steel ring, per manufacturer's standard.
 - 3. Bourdon Tube: Phosphor bronze.
 - 4. Dial Size: 4 to 4-1/2 inch (101 to 114 mm).
 - 5. Connection: Lower or lower back, 1/4-inch or 1/2-inch NPT, as selected by Contractor.
 - 6. Accuracy: 1 percent of full scale range, per ANSI-ASME B40.1 Grade 1A.
 - 7. Scale and Range: 0-60 psig typical, select for application.
- C. Verify suitability of range for each application. Best selection is for typical reading to be close to mid-scale.

2.2 PRESSURE GAUGE TAPPINGS

- A. Ball Valve: Provide under Division 23 Section "Hydronic Piping."
- B. Pulsation Damper:
 - 1. Manufacturers:
 - a. Weiss.
 - b. Ametek.
 - c. Dwyer.
 - d. Terrice.
 - 2. Pressure snubber, brass with 1/4 inch (6 mm) NPT connections.

2.3 THERMOMETERS - DIAL

A. Manufacturers:

1. Weiss.
2. Ametek.
3. Ernst.
4. Terice.

B. Thermometer: Weiss Model 45VA, ASTM E1, stainless steel or cast aluminum case, adjustable angle with front recalibration, vapor actuated, black scale on white-finished metal background, black pointer, sealed lens, brass stem.

1. Size: 4 to 4-1/2 inch (101 to 114 mm) dial.
2. Lens: Snap-in Lexan polycarbonate with o-ring, or clear glass with rubber ring.
3. Bulb: Copper. Provide extended bulb for socket extension in insulated pipe.
4. Extended Bulb: Where required, provide extended capillary tube with braided copper protection.
5. Connection: Separable socket.
6. Accuracy: 1 scale division throughout range.
7. Calibration: Both degrees F and degrees C.
8. Scale Range: 30 to 240 degrees F (0 to 115 degrees C) for hot water heating systems.
9. Graduations: 2 degrees F.

C. Provide dial type except where liquid-in-glass type is indicated.

2.4 THERMOMETERS – LIQUID-IN-GLASS TYPE

A. Manufacturers:

1. Weiss.
2. Ametek.
3. Ernst.
4. Terice.

B. Where thermometers are indicated, liquid-in-glass type may be substituted.

C. Thermometer: Weiss Vari-angle industrial thermometer, ASTM E1, adjustable angle, red liquid, lens front tube, case with black textured finish, adjustable joint with positive locking device or approved equal. Case and joint may be GE Valox polyester with 40 percent glass/mineral reinforcement, or cast aluminum.

1. Size: 7-inch (178 mm) scale.
2. Window: Clear glass, secured with spring action.
3. Stem: Brass, 3/4-inch (20 mm) NPT, 3 1/2 inch (89 mm) long. Provide extended stem for socket extension in insulated pipe.
4. Accuracy: ASTM E77, 1 percent of scale range.
5. Calibration: Both degrees F and degrees C.
6. Scale Range: 30 to 240 degrees F (0 to 115 degrees C) for hot water heating systems.
7. Graduations: 2 degrees F.

2.5 THERMOMETER SUPPORTS

- A. Socket (Thermometer Well) for Piping: Brass separable sockets for thermometer stems, with extensions for insulated piping. Provide with Honeywell viscous heat transfer paste.

2.6 THERMOWELL HEAT TRANSFER PASTE

A. Manufacturers:

1. MG Chemicals.
2. Honeywell.
3. Trexco.

B. Description:

1. Formulation: Silicone or synthetic base, containing metal oxides.
2. Thermal Conductivity: At least 4.5 Btu-in./(hr-ft²-°F) (0.65 W/(m-K)).
3. Temperature Range: To 392 degrees F (200 degrees C).
4. Flash Point: 500 degrees F (260 degrees C).
5. Dropping Point: ASTM D566, greater than 500 degrees F (260 degrees C).
6. Specific Gravity: 2.3 minimum at 77 degrees F (25 degrees C).
7. Consistency: ASTM D217, 310 to 320.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Division 00 – General Conditions: Manufacturer's instructions.
- B. Install 1 pressure gauge per pump, with taps on suction and discharge of pump; pipe to gauge.
- C. Install gauge taps in piping; refer to Division 23 Section “Hydronic Piping.”
- D. Install pressure gauges with pulsation dampers. Provide valve to isolate each gauge; see “Pressure Gauge Tappings” in this Section. Extend nipples to allow clearance from insulation.
- E. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inches (64 mm) for installation of thermometer sockets. Ensure sockets allow clearance from insulation.
- F. Fill thermometer sockets with heat transfer paste.
- G. Install thermometer sockets adjacent to controls systems thermostat, transmitter, or sensor sockets.
- H. Provide instruments with scale ranges selected according to service with largest appropriate scale.

- I. Install gauges and thermometers in locations where they are easily read from normal operating level, with thermometer in upright orientation. Install vertical to 45 degrees off vertical.
- J. Adjust gauges and thermometers to final angle, clean windows and lenses, and calibrate to zero.

END OF SECTION 230519

SECTION 230529 – HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Pipe and equipment hangers and supports.

1.2 RELATED SECTIONS

- A. Division 23 Section “Vibration and Seismic Controls for HVAC Piping and Equipment.”
- B. Division 23 Section “HVAC Piping Insulation.”
- C. Division 23 Section “Hydronic Piping.”

1.3 REFERENCES

- A. ASME B31.1 - Power Piping.
- B. ASME B31.2 - Fuel Gas Piping.
- C. ASME B31.9 - Building Services Piping.
- D. ASTM A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
- E. ASTM A653 G90 SS Gr. 33 - Specification for Steel Sheet, Zinc Coated (Galvanized) by the Hot Dipped Process.
- F. ASTM B633 - Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
- G. ASTM F708 - Design and Installation of Rigid Pipe Hangers.
- H. MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.
- I. MSS SP69 - Pipe Hangers and Supports - Selection and Application.
- J. MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices.
- K. NFPA 70 - National Electrical Code

1.4 SUBMITTALS

- A. Submit under provisions of Division 01 Section “Submittal Procedures.”
- B. Shop Drawings: Indicate system layout with location and detail of trapeze hangers.
- C. Product Data: Provide manufacturers catalog data including load capacity.

- D. Design Data: Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.
- E. Manufacturer's Installation Instructions: Indicate special procedures and assembly of components.

1.5 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum 3 years' experience.

1.6 REGULATORY REQUIREMENTS

- A. Conform to applicable Codes for support of piping.
- B. Supports for Electrical: In conformance with NFPA 70 and the Electrical portion of the Contract Documents.

PART 2 - PRODUCTS

2.1 HANGERS, SUPPORTS, & PIPE CLAMPS

- A. Approved Manufacturers (first manufacturer is basis of design):

- 1. Strut Hangers:

- a. Unistrut (division of Tyco).
- b. Anvil International.
- c. Eaton B-Line.
- d. Hydra-Zorb Company.
- e. Thomas & Betts - Superstrut line.
- f. Tolco (division of Cooper B-Line).

- 2. Adjustable Swivel Band Hangers:

- a. Carpenter & Paterson.
- b. Anvil International.
- c. Eaton B-Line.
- d. Tolco (division of Cooper B-Line).

- 3. Clevis Hangers:

- a. Eaton B-Line.
- b. Anvil International.
- c. Carpenter & Paterson.
- d. Tolco (division of Cooper B-Line).

4. J-Hangers:
 - a. Eaton B-Line.
 - b. Carpenter & Paterson.
 - c. Thomas & Betts - Superstrut line.
 - d. Tolco (division of Cooper B-Line).
 - e. Unistrut (division of Tyco).
 5. Cushion Clamps:
 - a. Hydra-Zorb Company.
 - b. Eaton B-Line.
 - c. Thomas & Betts - Superstrut line.
 - d. Tolco (division of Cooper B-Line).
 - e. Unistrut (division of Tyco).
 6. Insulated Pipe Couplings:
 - a. Eaton B-Line - Armafix line.
 - b. Hydra-Zorb Company.
 7. No substitutions.
- B. Horizontal Piping Supports: Provide struts for trapeze hangers for single or multiple pipes. Where individual piping runs are hung with individual hangers, adjustable swivel band hangers, clevis hangers, or j-hangers may be used.
- C. Strut hangers shall be standard 1-5/8 inches x 1-5/8 inches (41x41 mm) size.
- D. Pipe hanger rods and nuts shall be plated to match the hangers. Nuts shall be self-locking type, or provide double nuts tightened to lock together. Rods shall be threaded one end, or continuous threaded. Provide washers at each nut.
- E. Cushion Clamps for Un-insulated Lines: Plastic cushion shall be Dupont Hytel plastic, 5555HS plastic elastomer, warranted from -40 to 275 degrees F (-40 to 135 degrees C).
- F. Copper-plated hangers are plated for identification only. Traditional thin copper plating on steel substrate does not provide adequate protection from galvanic corrosion due to contact between dissimilar metals.
1. Where copper-plated supports are specified for use with copper piping, either copper plating or a copper-colored finish such as Eaton B-Line's Dura-Copper epoxy coating is acceptable. Copper coating is for identification, and does not protect dissimilar metals. Dura-copper epoxy protects dissimilar metals, and may be used in contact with copper piping.
 2. Where copper piping is used with steel hangers and supports, provide protection from galvanic corrosion such as epoxy or thick plastic or vinyl factory coating, or plastic-lined cushion clamps.

- G. For Insulated Lines Clamped to Strut: Insulated pipe coupling insert with the same thickness as the insulation. Protects insulation from crushing, and provides continuous insulation and vapor barrier thru the hanger or clamp. Hydra-Zorb Company's Klo-Shure product provides plastic pipe support and rigid outer band, for field insulation into the coupling. Eaton's Armafix product provides insulation with rigid outer band, for field insulation glued to the ends of the insert.

2.2 PIPE SUPPORTS

A. Hydronic Piping:

1. Conform to ASME B31.9, ASTM F708, MSS SP58, MSS SP69 and MSS SP89.
2. Hangers for Pipe Sizes 1/2 to 1-1/2 inch (13 to 38 mm): Malleable iron, adjustable swivel, split ring.
3. Hangers for Cold Pipe Sizes 2 inches (50 mm) and Over: Carbon steel, adjustable, clevis.
4. Hangers for Hot Pipe Sizes 2 to 4 inches (50 to 100 mm): Carbon steel, adjustable, clevis.
5. Hangers for Hot Pipe Sizes 5 inches (125 mm) and Over: Adjustable steel yoke, cast iron roll, double hanger.
6. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
7. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 inches (150 mm) and Over: Steel channels with welded spacers and hanger rods, cast iron roll.
8. Wall Support for Pipe Sizes to 3 inches (76 mm): Cast iron hook.
9. Wall Support for Cold Pipe Sizes 4 inches (100 mm) and Over: Welded steel bracket and wrought steel clamp.
10. Wall Support for Hot Pipe Sizes 4 inches (100 mm) and Over: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.
11. Vertical Support: Steel riser clamp.
12. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
13. Floor Support for Hot Pipe Sizes to 4 inches (100 mm): Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
14. Floor Support for Hot Pipe Sizes 5 inches (125 mm) and Over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
15. Copper Pipe Support: Carbon steel ring, adjustable, copper colored for identification.

2.3 INSERTS

A. Manufacturers:

1. Eaton B-Line.
2. Grinnell.

- B. Inserts: Malleable iron case of steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.

3.2 INSERTS

- A. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- B. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches (100 mm).
- C. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
- D. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

3.3 PIPE HANGERS AND SUPPORTS

- A. Support horizontal piping as scheduled.
- B. Install hangers to provide minimum 1/2-inch (13 mm) space between finished covering and adjacent work.
- C. Place hangers within 12 inches (300 mm) of each horizontal elbow.
- D. Use hangers with 1-1/2 inch (38 mm) minimum vertical adjustment.
- E. Support horizontal cast iron pipe adjacent to each hub, with 5 feet (1.5 m) maximum spacing between hangers.
- F. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- G. Support riser piping independently of connected horizontal piping.
- H. Provide copper colored hangers and supports for copper piping, for identification.
- I. Design hangers for pipe movement without disengagement of supported pipe.
- J. Prime coat exposed steel hangers and supports with rust-resistant paint.
- K. Do not support pipes from other pipes or equipment.
- L. Size pipe hangers to accommodate continuous piping insulation.

3.4 SUPPORTING OTHER TRADES

- A. Supports furnished under Division 23 of the Specifications may also be used to support plumbing piping and electrical and control conduits, if this Subcontractor is willing to allow this. Supports shared with other trades shall be designed to accommodate the weight, expansion/contraction, vibration, and other requirements of the other trades' items without detriment to the function, accessibility, and serviceability of the HVAC items or those of the other trades. Provide flexible sections of piping and conduit as required to allow each trade's items to expand and contract along with the other trades, and to absorb vibration caused by the other trades.
- B. Electrical lighting fixtures and equipment, and items such as ceilings, may not be supported from supports furnished under this Section.
- C. Prevent contact between components of other trades, such as suspended ceiling support wires, and HVAC supports which may transmit vibration to the occupied space.

3.5 SCHEDULES

PIPE SIZE		HANGER ROD MAX. HANGER SPACING		DIAMETER	
Inches	(mm)	Feet	(m)	Inches	(mm)
Steel and Copper Piping					
1/2 to 1-1/4	12 to 32	6.5	2	3/8	9
1-1/2 to 2	38 to 50	10	3	3/8	9
2-1/2 to 3	62 to 75	10	3	1/2	13
4 to 6	100 to 150	10	3	5/8	15
8 to 12	200 to 300	14	4.25	7/8	22

END OF SECTION 230529

SECTION 230548 – VIBRATION CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Vibration isolation.

1.2 RELATED SECTIONS

- A. Division 23 Section “Hydronic Pumps.”

1.3 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this Section with minimum 3 years’ experience.

1.4 PERFORMANCE REQUIREMENTS

- A. Provide Minimum Static Deflection of Isolators for Equipment as scheduled in Part 3 of this Section.

1.5 REQUIREMENTS

- A. Outdoor Equipment: Provide restraint to withstand the force of a 100 mph (44.7 m/s) wind applied to any exposed surface of the isolated equipment. Provide bolt holes for attachment to equipment and to supports.

1.6 SUBMITTALS

- A. Submit under provisions of Division 01 Section “Submittal Procedures”.
- B. Product Data: Provide schedule of vibration isolator type with location and load on each. Indicate static deflection expected under the actual load, and minimum static deflection.
- C. Manufacturer's Installation Instructions: Indicate special procedures and setting dimensions.

1.7 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Division 01 Section “Closeout Procedures.”
- B. Record actual locations of hangers including attachment points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Mason Industries, Inc.

- B. Amber/Booth Co.
- C. Kinetics Noise Control.
- D. Korfund Dynamics Corp.
- E. Vibration Eliminator Co.
- F. Vibration Mountings and Controls, Inc.

2.2 GENERAL

- A. Metal parts installed outdoors shall be corrosion resistant after fabrication. Galvanizing shall meet ASTM Salt Spray Test Standards and Federal Test Standard No. 14.
- B. Isolator types are scheduled to establish minimum standards. At the Contractor's option, labor-saving devices may be an integral part of isolators, to provide initial lift of equipment to operating height, to hold piping at fixed elevations during installation and initial filling, and similar installation advantages. Accessories and features shall not degrade the isolation performance of the isolators.
- C. Static deflections indicated are the minimum under actual load. Isolators selected solely on the basis of rated deflections are not acceptable.

2.3 VIBRATION ISOLATORS

- A. Spring Hanger:
 - 1. Spring Isolators: Color code springs for load carrying capacity.
 - 2. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 0.3 and 0.6 of maximum deflection.
 - 3. Housings: Incorporate rubber hanger with threaded insert.
 - 4. Misalignment: Capable of 20 degree hanger rod misalignment.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install spring hangers without binding.
- C. Prior to making piping connections to equipment with operating weights substantially different from installed weights, block up equipment with temporary shims to final height. When full load is applied, adjust isolators to load to allow shim removal.
- D. Connect wiring to isolated equipment with flexible hanging loop.
- E. Connect hanger rods for vibration isolated supports to structural beams or joists where

available, not from the floor slab or roof deck between beams and joists. Provide intermediate support members as required.

- F. If any rotating equipment causes excessive noise or vibration when properly installed on the specified isolators, provide rebalancing, realignment, and/or other remedial work required to reduce noise and vibration levels. Excessive is defined as exceeding the manufacturer's specifications for the equipment.

3.2 MANUFACTURER'S FIELD SERVICES

- A. Examine systems under provisions of Division 01 Section "Quality Requirements".
- B. Inspect isolated equipment after installation and submit report. Include static deflections.

EQUIPMENT ISOLATION SCHEDULE

ISOLATED EQUIPMENT	BASE Type Thickness	ISOLATOR Type Deflection
HVAC Pumps, Suspended	Pump Flange	Spring Hanger 1 inch (50 mm)

END OF SECTION 230548

SECTION 230553 – IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Nameplates.
- B. Tags.
- C. Labels.
- D. Pipe Markers.

1.2 REFERENCES

- A. Division 01 Section “General Conditions”: Requirements for references and standards.
- B. ASME A13.1 - Scheme for the Identification of Piping Systems (2007 edition or newer).
- C. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

1.3 SUBMITTALS

- A. Division 01 Section “Submittal Procedures.”
- B. Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- C. Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- D. Product Data: Provide manufacturers catalog literature for each product required.

1.4 PROJECT RECORD DOCUMENTS

- A. Record actual locations of tagged valves; include valve tag numbers.

1.5 OPERATION AND MAINTENANCE DATA

- A. Include valve tag chart.

PART 2 - PRODUCTS

2.1 NAMEPLATES

- A. Manufacturers:
 - 1. Seton Identification Products.
 - 2. E.R. Perry Signs & Engraving.

3. Brimar Industries, Inc., PipeMarker division.
 4. No substitutions.
- B. Plastic Nameplates: Laminated 3-layer plastic with beveled edges and engraved letters on contrasting background color, 1/16 inch (1.58 mm) thick. Letters shall be black on light backgrounds, or white on dark backgrounds, as applicable. Service temperature range -40 to 175 degrees F (-40 to 79 degrees C); minimum application temperature for adhesive 50 degrees F (10 degrees C). Suitable for average outdoor lifespan of at least 2-3 years.
- C. Aluminum Nameplates: For higher temperature applications, and for outdoor applications when manufacturer does not recommend their plastic nameplates for use outdoors, provide aluminum nameplates, with integral anodized or painted surface color coating and natural aluminum engraved letters, 1/32-inch (0.78 mm) thick. Service temperature range -40 to 350 degrees F (-40 to 177 degrees C); minimum application temperature for adhesive 50 degrees F (10 degrees C). Suitable for average outdoor lifespan of at least 2-3 years.
- D. Colors: Select background color as appropriate for the application. Color for general applications shall be white (except that aluminum nameplate standard color shall be black). Color for general warnings shall be red or yellow. Colors for fluid services shall comply with ASME A13.1-2007. Comply with ASME/ANSI standards and other regulations as applicable.
- E. Provide with factory adhesive, and with side holes for fastener attachment as applicable. Mechanical fasteners are required for applications which are outdoors or otherwise exposed to weather or sunlight, or in moist areas such as kitchens and locker rooms, or on cooled surfaces subject to condensation, or on surfaces with operating temperatures above 150 degrees F (65 degrees C). Where nameplate is on an irregular surface and cannot make complete contact, provide mechanical fasteners or ties in addition to adhesive.

2.2 TAGS

- A. Plastic Tags:
1. Manufacturers:
 - a. Seton Identification Products.
 - b. E.R. Perry Signs & Engraving.
 - c. Brimar Industries, Inc., PipeMarker division.
 - d. No substitutions.
 2. Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inches (38 mm) diameter.
- B. Metal Tags:
1. Manufacturers:
 - a. Seton Identification Products.
 - b. Brady Worldwide, Inc.
 - c. Brimar Industries, Inc., PipeMarker division.

- d. No substitutions.
- 2. Brass with stamped letters; tag size minimum 1-1/2 inches (38 mm) diameter with smooth edges.
- C. Information Tags:
 - 1. Manufacturer: Seton Identification Products.
 - 2. Clear plastic with printed "Danger," "Caution," or "Warning" and message; size 3-1/4 x 5-5/8 inches (83 x 143 mm) with grommet and self-locking nylon ties.
- D. Tag Chains and Hooks: Brass or stainless steel compatible with tag material for general applications. Brass where in contact with copper piping or other copper-alloy materials.
- E. Tag Chart: Typewritten letter size list in anodized aluminum frame with plexiglass cover.

2.3 LABELS

- A. Manufacturer: Seton Identification Products.
- B. Description: Polyester, size 1.9 x 0.75 inches (48 x 19 mm), adhesive backed with printed identification.

2.4 PIPE MARKERS

- A. Color and Lettering: Conform to ASME A13.1.
- B. Plastic Pipe Markers:
 - 1. Manufacturers:
 - a. Seton Identification Products.
 - b. Brady Worldwide, Inc.
 - c. Brimar Industries, Inc., PipeMarker division.
 - d. No substitutions.
 - 2. Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering. Larger sizes may have maximum sheet size with spring fastener.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.
- B. Prepare surfaces in accordance with manufacturer's recommendations for stencil painting.

3.2 INSTALLATION

- A. Division 00 Section “General Conditions”: Manufacturer's instructions.
- B. Install identifying devices after completion of coverings and painting.
- C. Install plastic or aluminum engraved nameplates with corrosion-resistant mechanical fasteners, or adhesive, as specified. In outdoor locations, where lifetime of nameplates is limited, fasteners shall be removable screws or bolts for ease of nameplate replacement.
- D. Install labels with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer. For unfinished canvas covering, apply paint primer before applying labels.
- E. Install tags using corrosion resistant chain. Number tags consecutively by location.
- F. Identify items of mechanical equipment such as boilers and pumps with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.
- G. Identify control panels and major control components outside panels with plastic nameplates.
- H. Identify valves in main and branch piping with metal tags.
- I. Tag automatic controls, instruments, and relays. Key to control schematic.
- J. Identify piping, concealed or exposed, with plastic pipe markers. Use tags on piping 3/4 inch (20 mm) diameter and smaller. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet (6 m) on straight runs including risers and drops, at each branch and riser take-off, adjacent to each valve and tee, at each side of penetration of structure or enclosure, and at each obstruction.
- K. Secure valve tag chart on an easily accessible wall in the mechanical room or in a location as otherwise directed by the Engineer.

3.3 COORDINATION WITH EXISTING EQUIPMENT

- A. Where an existing equipment identification system is involved, the new system shall be coordinated and compatible with the existing system.
- B. Where an existing valve tag chart is involved, the new tags shall be coordinated with the existing chart.

END OF SECTION 230553

SECTION 230593 – TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Testing, Adjustment, and Balancing of Air Systems.
- B. Testing, Adjustment, and Balancing of Hydronic Piping Systems.
- C. Measurement of Final Operating Condition of HVAC Systems.

1.2 REFERENCES

- A. AABC - National Standards for Total System Balance.
- B. ADC - Test Code for Grilles, Registers, and Diffusers.
- C. ASHRAE 111 - Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-conditioning, and Refrigeration Systems.
- D. NEBB - Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.
- E. SMACNA - HVAC Systems Testing, Adjusting, and Balancing.

1.3 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. ASHRAE: American Society of Heating, Refrigerating and Air Conditioning Engineers.
- C. NEBB: National Environmental Balancing Bureau.
- D. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.
- E. TAB: Testing, Adjusting, and Balancing.

1.4 SUBMITTALS

- A. Submit under provisions of Division 01 Section "Submittal Procedures."
- B. Submit name of TAB Agency for approval within 14 days after award of Contract.
- C. Design Review Reports:
 - 1. Submit prior to commencement of construction.
 - 2. Review the Contract Documents, and indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.

D. Preliminary Report Submittals:

1. Prior to commencing work of this Section, and no more than 14 days after approval of TAB Agency submittals, submit report forms or outlines indicating adjusting, balancing, and equipment data required, with columns of design data filled in. By means of plan views, equipment profiles, and similar graphical descriptions, indicate where measurements will be taken.
2. Submit the procedures to be used.

E. Field Reports: Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Architect/Engineer and for inclusion in operating and maintenance manuals.

F. Provide reports in letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.

G. Include detailed procedures, agenda, sample report forms and copy of AABC National Project Performance Guaranty prior to commencing system balance.

H. Test Reports: Indicate data on AABC National Standards for Total System Balance forms, or forms prepared following ASHRAE 111, or NEBB forms, or forms containing information indicated in Schedules.

1.5 QUALITY ASSURANCE

A. Perform total system balance in accordance with AABC National Standards for Field Measurement and Instrumentation, Total System Balance; or ASHRAE 111; or NEBB Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.

1.6 QUALIFICATIONS

A. Agency: Company specializing in the testing, adjusting, and balancing of systems specified in this Section with minimum 3 years' experience and certified by AABC or NEBB, or equivalent experience which would qualify for membership in these testing organizations. Agency shall be one of those listed under paragraph 3.1 AGENCIES in this Section.

B. Perform Work under supervision of AABC Certified Test and Balance Engineer, NEBB Certified Testing, Balancing and Adjusting Supervisor, or registered Professional Engineer experienced in performance of this Work and licensed at the place where the Project is located.

C. Certification by the National Balancing Council (NBC) (an affiliate of the National Comfort Institute (NCI)) will not be allowed as a substitute for the specified qualifications.

D. The approved Agency shall be in no way affiliated with the installing Subcontractor.

1.7 SEQUENCING

A. Sequence work to commence after completion of systems or portions of work, and schedule

completion of work before Substantial Completion of Project.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 AGENCIES

- A. Tekon Technical Consultants, Rochester, NH. Contact: Charles Corlin, (603) 335-3080.
- B. Hood T.A.B. LLC, Andover, MA. Contact: Michael Hood, (978) 474-7595.
- C. Maine Air Balance, Bangor, ME. Tel. (207) 922-4342.
- D. NETB Associates LLC, East Kingston, NH. Contact: Frank Collamore, (978) 270-7547.
- E. No Substitutions.

3.2 EXAMINATION

- A. Verify that systems are complete and operating correctly in accordance with sequence of operations before commencing work. Ensure the following conditions:
 - 1. Systems are started and operating in a safe and normal condition.
 - 2. Temperature control systems are installed complete and operable.
 - 3. Proper thermal overload protection is in place for electrical equipment.
 - 4. Duct systems are clean of debris.
 - 5. Access doors are closed and duct end caps are in place.
 - 6. Duct system leakage is minimized.
 - 7. Hydronic systems are flushed, filled, and vented.
 - 8. Pumps are rotating correctly.
 - 9. Proper strainer baskets are clean and in place.
 - 10. Service and balance valves are open.
- B. Submit field reports. Report to the responsible Subcontractors, defects and deficiencies noted during performance of services which prevent system balance. Submit list of locations where the Contractor needs to provide additional balancing devices.
- C. Beginning of work means acceptance of existing conditions.

3.3 PREPARATION

- A. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Architect/Engineer to facilitate spot checks during testing.

3.4 INSTALLATION TOLERANCES

- A. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 5 percent of design for return and exhaust systems.

- B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.
- C. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

3.5 ADJUSTING

- A. Ensure recorded data represents actual measured or observed conditions.
- B. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- C. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- D. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.6 AIR SYSTEM PROCEDURE

- A. Adjust combustion air systems to provide required combustion air quantities.
- B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.
- C. Measure static air pressure conditions in combustion air ducts, and measure boiler room pressure differential to outdoors.
- D. Adjust combustion air automatic dampers for design conditions. Adjust at minimum position and maximum position, and use manual dampers and actuator limit stops to minimize differences.
- E. Coordinate with Division 23 Sections "Instrumentation and Control for Mechanical Systems" and "Condensing Boilers."

3.7 WATER SYSTEM PROCEDURE

- A. Adjust water systems to provide required or design quantities.
- B. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.
- C. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.
- D. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing.

- E. Coordinate with Division 23 Section “Instrumentation and Controls for Mechanical Systems” for calibration of pump static pressure sensors and determination of pressure setpoints.

3.8 PROJECT CLOSEOUT

- A. Check and adjust systems approximately 6 months after final acceptance and submit report.

3.9 SCHEDULES

- A. Equipment Requiring Testing, Adjusting, and Balancing:

- 1. Boilers
- 2. HVAC Pumps
- 3. Combustion Air to Boilers

- B. Report Forms:

- 1. Title Page:

- a. Name of Testing, Adjusting, and Balancing Agency
- b. Address of Testing, Adjusting, and Balancing Agency
- c. Telephone number of Testing, Adjusting, and Balancing Agency
- d. Project name
- e. Project location
- f. Project Architect
- g. Project Engineer
- h. Project Contractor
- i. Project altitude
- j. Report date

- 2. Summary Comments:

- a. Design versus final performance
- b. Notable characteristics of system
- c. Description of systems operation sequence
- d. Summary of outdoor and exhaust flows to indicate amount of building pressurization
- e. Nomenclature used throughout report
- f. Test conditions

- 3. Instrument List:

- a. Instrument
- b. Manufacturer
- c. Model number
- d. Serial number
- e. Range
- f. Calibration date

4. Electric Motors:
 - a. Manufacturer
 - b. Model/Frame
 - c. HP/BHP
 - d. Phase, voltage, amperage; nameplate, actual, no load
 - e. RPM
 - f. Service factor
 - g. Starter size, rating, heater elements
 - h. Sheave Make/Size/Bore

5. Pump Data:
 - a. Identification/number
 - b. Manufacturer
 - c. Size/model
 - d. Impeller
 - e. Service
 - f. Design flow rate, pressure drop, BHP
 - g. Actual flow rate, pressure drop, BHP
 - h. Discharge pressure
 - i. Suction pressure
 - j. Total operating head pressure
 - k. Shut off, discharge and suction pressures
 - l. Shut off, total head pressure

6. Boiler Data:
 - a. Water flow rate
 - b. Water pressure drop
 - c. Water pressure and temperature in boiler
 - d. Water inlet and outlet temperatures at full firing rate
 - e. Relief valve capacity and pressure setting
 - f. Outdoor air temperature
 - g. Reset water command temperature
 - h. Status of other boilers during testing

7. Combustion Test:
 - a. Boiler manufacturer
 - b. Model number
 - c. Serial number
 - d. Fuel type
 - e. Firing rate
 - f. Overfire draft
 - g. Gas pressure at meter outlet
 - h. Gas flow rate
 - i. Heat input
 - j. Burner manifold gas pressure

- k. Percent carbon monoxide (CO₂)
 - l. Percent carbon dioxide (CO₂)
 - m. Percent oxygen (O₂)
 - n. Percent excess air
 - o. Flue gas temperature at outlet
 - p. Ambient temperature
 - q. Net stack temperature
 - r. Percent stack loss
 - s. Percent combustion efficiency
 - t. Heat output
 - u. Stack size and configuration
8. Combustion Air Data:
- a. Identification/location
 - b. Design air flow
 - c. Actual air flow to boiler by duct traverse
 - d. Actual air flow in main upstream of all boilers by duct traverse
 - e. Firing status of all boilers during test
 - f. Outside air temperature
9. Duct Traverse:
- a. Duct size
 - b. Area
 - c. Design velocity
 - d. Design air flow
 - e. Test velocity
 - f. Test air flow
 - g. Duct static pressure
 - h. Air temperature
 - i. Air correction factor

END OF SECTION 230593

SECTION 230713 – DUCT INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Ductwork Insulation.
- B. Insulation jackets.

1.2 RELATED SECTIONS

- A. Division 23 Section “Identification for HVAC Piping and Equipment.”
- B. Division 23 Section “Metal Ducts”

1.3 REFERENCES

- A. Division 00 Section “General Conditions”: Requirements for references and standards.
- B. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- C. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
- D. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
- E. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
- F. ASTM C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
- G. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
- H. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- I. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials.
- J. ASTM E119 (UL 263) - Standard Test Methods for Fire Tests of Building Construction and Materials.
- K. NAIMA - National Insulation Standards.
- L. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.
- M. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

- N. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

1.4 SUBMITTALS

- A. Division 01 Section "Submittal Procedures".
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this Section with minimum 3 years' experience.
- B. Applicator Qualifications: Company specializing in performing the work of this Section with minimum 3 years' experience.

1.6 REGULATORY REQUIREMENTS

- A. Materials: Flame spread/smoke developed rating of 25/50 in accordance with ASTM E84, NFPA 255 and UL 723. For elastomeric foam insulation, rating shall apply for thicknesses up to 2 inches (50 mm).
- B. Insulation materials shall be asbestos free. No fibers with dimensions similar to asbestos fibers shall be released from any material.

1.7 DELIVERY, STORAGE, AND PROTECTION

- A. Division 01 Section "Product Requirements": Transport, handle, store, and protect products.
- B. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.
- C. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.8 ENVIRONMENTAL REQUIREMENTS

- A. Division 01 Section "Product Requirements": Environmental conditions affecting products on site.
- B. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- C. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Glass and Mineral Fiber Products:

1. Knauf Insulation.
2. Certainteed Corporation.
3. Johns Manville.
4. Owens Corning.
5. No substitutions.

B. Glass Fiber Insulation Sealing Tapes:

1. Venture Tape – product line of 3M Company.
2. 3M Company.
3. Ideal Tape Co., division of American Biltrite Inc.
4. Nashua Tape Products, division of Berry Plastics Corp.
5. No substitutions.

C. Accessories:

1. Ceel-Co division of Johns Manville (product: plastic jacket systems).
2. Foster Products, division of Specialty Construction Brands, Inc., a subsidiary of H.B. Fuller (mastics, sealants, reinforcing membranes, and accessories).
3. Johns Manville (products: Super-Seal acrylic polymer coatings, Zeston plastic jacket systems).
4. Pabco/Childers Metals, division of ITW Insulation Systems (products: metal jacket systems, and accessories).
5. Vac Systems International (product: Tough Coat acrylic polymer mechanical insulation repair coating).
6. Venture Tape Corporation (product: Jacket for outdoor insulation).

2.2 GLASS FIBER, RIGID

A. Insulation: ASTM C612; rigid, noncombustible blanket. Supplied in board form.

1. 'K' ('Ksi') value: ASTM C518, 0.24 at 75 degrees F (0.036 at 24 degrees C).
2. Maximum service temperature: 450 degrees F (232 degrees C).
3. Maximum moisture absorption: 1.0 percent by volume.
4. Density: 3.0 lb/cu. ft. (48 kg/cu m).

B. Vapor Barrier Jacket:

1. ASTM C1136, kraft paper reinforced with glass fiber yarn and bonded to aluminized film. Facing as required for the application.
 - a. Aluminum Faced: FSK (foil-scrim-kraft) construction
 - b. White Faced: ASJ (all-service jacket) construction.

2. Moisture vapor transmission: ASTM E96; 0.02 perm.
3. Suitable for insulation surface temperatures up to 150 degrees F (66 degrees C).
4. Overlap longitudinal laps and butt strips.
5. Secure insulation with mechanical fasteners to substrate, and seal jacket with pressure sensitive tape.

C. Vapor Barrier Tape: See article "Glass Fiber Insulation Sealing Tape" in this Section.

D. Indoor Vapor Barrier Finish:

1. Cloth: Untreated; 9 oz/sq yd (305 g/sq m) weight, glass fabric.
2. Vinyl emulsion type acrylic, compatible with insulation, [black] [white] color.

2.3 GLASS FIBER, SEMI-RIGID

A. Insulation: ASTM C612; semi-rigid, noncombustible blanket, with fibers oriented perpendicular to insulation surface to provide compressive strength while maintaining flexibility. Supplied in roll form, suitable for application on rounded shapes such as pipes, tanks, ducts, vessels, and other similar round and irregular shapes.

1. 'K' ('Ksi') value: ASTM C518, 0.24 at 75 degrees F (0.036 at 24 degrees C).
2. Maximum service temperature: 450 degrees F (232 degrees C).
3. Maximum moisture absorption: 1.0 percent by volume.
4. Density: 2.5 lb/cu. ft. (40 kg/cu m).

B. Vapor Barrier Jacket:

1. ASTM C1136, kraft paper with glass fiber yarn and bonded to aluminized film. Facing as required for the application.
 - a. Aluminum Faced: FSK (foil-scrim-kraft) construction
 - b. White Faced: ASJ (all-service jacket) construction.
2. Moisture vapor transmission: ASTM E96; 0.02 perm.
3. Suitable for insulation surface temperatures up to 150 degrees F (66 degrees C).
4. Overlap longitudinal laps and butt strips.
5. Secure with outward clinch expanding staples and vapor barrier mastic and pressure sensitive tape.

C. Vapor Barrier Tape: See article "Glass Fiber Insulation Sealing Tape" in this Section.

D. Indoor Vapor Barrier Finish:

1. Cloth: Untreated; 9 oz/sq yd (305 g/sq m) weight, glass fabric.
2. Vinyl emulsion type acrylic, compatible with insulation, [black] [white] color.

2.4 GLASS FIBER, PREFORMED PIPE COVERING

- A. Insulation: ASTM C547; rigid molded, noncombustible.
 - 1. 'K' ('Ksi') value: ASTM C177, 0.24 Btu-in/(hr-sq.ft-°F) at 75 degrees F (0.035 W/m-K at 24 degrees C).
 - 2. Maximum service temperature: 850 degrees F (454 degrees C).
 - 3. Maximum moisture absorption: 0.2 percent by volume.
- B. Vapor Barrier Jacket:
 - 1. ASTM C1136, White kraft paper with glass fiber yarn, bonded to aluminized film.
 - 2. Moisture vapor transmission: ASTM E96; 0.02 perm-inches.
- C. Tie Wire: 0.048 inch (1.22 mm) stainless steel with twisted ends on maximum 12 inch (300 mm) centers.
- D. Vapor Barrier Lap Adhesive: Compatible with insulation.
- E. Vapor Barrier Tape: Provide self-adhesive butt strips furnished by the insulation manufacturer, with finish to match the insulation outer finish.
- F. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.
- G. Indoor Vapor Barrier Finish:
 - 1. Cloth: Untreated; 9 oz/sq yd (305 g/sq m) weight.
 - 2. Vinyl emulsion type acrylic, compatible with insulation, white color.

2.5 GLASS FIBER INSULATION SEALING TAPE

- A. Self-adhesive reinforced tape with integral vapor barrier, pressure sensitive acrylic-based or rubber-based adhesive, and release liner strip. Width 3 inch (76 mm) nominal.
- B. Manufactured by VentureTape, by the insulation manufacturer, or by one of the other tape manufacturers listed in the article "Manufacturers" in this Section.
- C. Types:
 - 1. White or aluminum outer surface to match the insulation.
 - 2. Kraft paper reinforced with glass fiber yarn and bonded to vapor barrier layer.
 - a. Aluminum Finish with FSK: VentureTape 1525CW.
 - b. White Finish with ASJ: VentureTape 1540CW
 - c. White Finish with PSK: VentureTape 1531CW.
 - 3. Performance:
 - a. Peel Adhesion: PSTC-101 with 20 minute dwell, 45 oz/in. (12.5 N / 25 mm).

- b. Shear Adhesion: PSTC-107, 2.2 psi (15.2 kPa) after 24 hours.
- c. Tensile Strength: PSTC-131: 40 lb/in. (180.8 N / 25 mm).
- d. Elongation: PSTC 131, 6 percent maximum.
- e. Service Temperature: -40 to 240 degrees F (-40 to 116 degrees C).
- f. UL 723 listed or classified (flame/smoke rating).

2.6 PVC JACKET

- A. ASTM D1784. One piece molded type fitting covers and sheet material, off-white color.
 1. Service temperature: 0 to 150 degrees F (-18 to 66 degrees C).
 2. Moisture vapor transmission: ASTM E96; 0.002 perm-inches.
 3. Thickness: 30 mil (0.76 mm).
 4. Connections: Brush on welding adhesive, or pressure sensitive color matching vinyl tape.
 5. Covering Adhesive Mastic: Compatible with insulation.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Division 01 Section "Instructions to Bidders": Verification of existing conditions before starting work.
- B. Verify that ductwork has been tested before applying insulation materials.
- C. Verify that surfaces are clean, foreign material removed, and dry.
- D. Verify that insulation materials are clean and dry. Discard any materials that exhibit signs of moisture damage, contamination, mold, mildew, or other biological growth.

3.2 INSTALLATION

- A. Division 01 Section "General Conditions": Manufacturer's instructions.
- B. Install in accordance with NAIMA National Insulation Standards.
- C. In addition to new ductwork, provide insulation for surfaces of existing ductwork that is uninsulated. Field-verify scope of existing ductwork.
- D. Provide insulation for surfaces of ductwork, as indicated and specified. Insulation values shall meet or exceed the requirements of ASHRAE 90.1-2010, State Energy Codes, and Table I, whichever is greater. In addition, comply with the other requirements of this Section.
- E. Ductwork: Provide glass fiber rigid insulation with vapor barrier jacket.
- F. Where rigid glass fiber insulation is scheduled, semi-rigid glass fiber insulation may be used on round and flat oval ducts and irregular shapes, and preformed pipe insulation may be used on

small diameter round ducts.

- G. Ductwork 8 Feet (2.4 meters) or Less Above Floor: Finish with PVC jacket and fitting system.
- H. Insulated Ductwork:
 - 1. Provide insulation with vapor barrier jackets.
 - 2. Finish with tape and vapor barrier jacket.
 - 3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
 - 4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.
 - 5. Where service access is required, bevel and seal ends of insulation.
- I. External Duct Insulation Application:
 - 1. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.
 - 2. Secure insulation without vapor barrier with staples, tape, or wires.
 - 3. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift ductwork off trapeze hangers and insert spacers.
 - 4. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
 - 5. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.
- J. Inspection Plates and Test Holes: Provide, where required, in ductwork or casings for balance measurements. Test holes shall be factory fabricated, airtight, and noncorrosive with screw cap and gasket. Extend cap through insulation.
- K. Install insulation after ductwork and equipment have been tested and approved.
- L. Ensure that surface is clean and dry prior to installation. Ensure that insulation is dry before and during application. Finish with system at operating conditions.
- M. Finish insulation neatly at hangers, supports and other protrusions.
- N. Locate insulation or cover seams in least visible locations.
- O. Repair separation of joints or cracking of insulation due to thermal movement or poor workmanship.
- P. Insulate standing seams, supporting angles, and flanges on insulated ductwork, with thickness equal to the duct and edges shall be finished and vapor sealed.
- Q. Insulation shall be continuous and shall include the insulating of register, grille and diffuser connection plenums/boots.
- R. Mechanical fasteners shall not be riveted or screwed to the duct and shall not penetrate the metalwork.

3.3 FIELD INSPECTION

- A. Visually inspect to ensure that materials used conform to Specifications. Inspect installations progressively for compliance with requirements.

TABLE I
DUCTWORK INSULATION MATERIAL AND WALL THICKNESS

DUCTWORK TYPE	INSULATION MATERIAL	VAPOR BARRIER REQUIRED	INSULATION WALL THICKNESS
Combustion air ductwork	Glass Fiber, Rigid	Yes	2 layers of 1inch (25.4mm) with staggered joints

END OF SECTION 230713

SECTION 230719 – HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Piping insulation.
- B. Jackets and accessories.
- C. Shields, Inserts, and Saddles.

1.2 RELATED SECTIONS

- A. Division 23 Section “Identification for HVAC Piping and Equipment.”
- B. Division 23 Section “Hangers and Supports for HVAC Piping and Equipment”: Placement of hangers and hanger inserts.

1.3 REFERENCES

- A. Division 01 Section “General Conditions”: Requirements for references and standards.
- B. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)).
- C. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus.
- D. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement.
- E. ASTM C449/C449M - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
- F. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
- G. ASTM C547 - Standard Specification for Mineral Fiber Preformed Pipe Insulation.
- H. ASTM C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
- I. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
- J. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- K. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials.

- L. NAIMA National Insulation Standards.
- M. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.
- N. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

1.4 SUBMITTALS

- A. Submit under provisions of Division 01 Section "Submittal Procedures".
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this Section with minimum 3 years' experience.
- B. Applicator Qualifications: Company specializing in performing the work of this Section with minimum 3 years' experience.

1.6 REGULATORY REQUIREMENTS

- A. Conform to maximum flame spread/smoke developed rating of 25/50 in accordance with ASTM E84, NFPA 255 and UL 723. For elastomeric foam insulation, rating shall apply for thicknesses up to 2 inches (50 mm).
- B. Insulation materials and accessories shall be asbestos-free. No fibers with dimensions similar to asbestos fibers shall be released from any material.

1.7 DELIVERY, STORAGE, AND PROTECTION

- A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

1.8 ENVIRONMENTAL REQUIREMENTS

- A. Maintain ambient conditions required by manufacturers of each product.
- B. Maintain temperature before, during, and after installation for minimum of 24 hours.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Glass and Mineral Fiber Products:
 - 1. Knauf Insulation.
 - 2. Certainteed Corporation.

3. Johns Manville.
4. Owens Corning.
5. No substitutions.

B. Hydrous Calcium Silicate Products:

1. IIG Industrial Insulation Group LLC, a Calsilite/Johns Manville joint venture. Thermo-12 Gold product line.
2. Johns Manville.

C. Removable, Reusable Insulation Covers:

1. Advance Thermal Corp.
2. Pacor, Inc.
3. Thermal Science Technologies.
4. Thermaxx LLC.
5. No substitutions.

D. Accessories:

1. Ceel-Co division of Johns Manville (product: plastic jacket systems).
2. Foster Products, division of Specialty Construction Brands, Inc., a subsidiary of H.B. Fuller (mastics, sealants, reinforcing membranes, and accessories).
3. Johns Manville (products: Super-Seal acrylic polymer coatings, Zeston plastic jacket systems).
4. Pabco/Childers Metals, division of ITW Insulation Systems (products: metal jacket systems, and accessories).
5. Pittsburgh Corning (product: cellular glass insulation for high-density inserts).
6. Proto Corporation (product: plastic jacket systems).

2.2 GLASS FIBER AND MINERAL WOOL

A. Insulation: ASTM C547; rigid molded, noncombustible.

1. 'K' ('Ksi') value: ASTM C177, 0.24 Btu-in/(hr-sq.ft- degrees F) at 75 degrees F (0.035 W/m-K at 24 degrees C).
2. Maximum service temperature: 850 degrees F (454 degrees C).
3. Maximum moisture absorption: 0.2 percent by volume.

B. Vapor Barrier Jacket:

1. ASTM C1136, White kraft paper with glass fiber yarn, bonded to aluminized film.
2. Moisture vapor transmission: ASTM E96; 0.02 perm-inches.

C. Tie Wire: 0.048 inch (1.22 mm) stainless steel with twisted ends on maximum 12 inch (300 mm) centers.

D. Vapor Barrier Lap Adhesive: Compatible with insulation.

E. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.

- F. Indoor Vapor Barrier Finish:
 - 1. Cloth: Untreated; 9 oz/sq yd (305 g/sq m) weight.
 - 2. Vinyl emulsion type acrylic, compatible with insulation, white color.
- G. Outdoor Vapor Barrier Mastic: Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
- H. Outdoor Breather Mastic: Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
- I. Insulating Cement: ASTM C449/C449M.

2.3 REMOVABLE, REUSABLE INSULATION COVERS

- A. Service Rating: Maximum equipment temperature 700 degrees F (371 degrees C).
- B. Warranty: 5-year materials and labor.
- C. Insulation:
 - 1. Fiberglass mat insulation.]
 - 2. Insulation thickness shall be as required to limit exterior temperature to 120 degrees F (49 degrees C).
- D. Jacket:
 - 1. PTFE-fiberglass composite jacketing, industrial grade, 13.5 oz/sq. yd (458 g/m²) minimum. Room-side surface in well-vented indoor locations, or cold-equipment-side surface of jacketing may be either PTFE-fiberglass or silicone-fiberglass.
 - 2. Breather vents and drain orifices, brass or stainless steel.
 - 3. Stitching: Double-sewn lock stitching with non-melting thread.
 - 4. Insulation shall be sewn integral to jacket to prevent shifting.
 - 5. Insulating mat shall be placed in overlapping pattern to minimize convection currents.
 - 6. Jacket shall completely encapsulate insulation.
 - 7. Cut jacket material edges shall be folded under and concealed.
 - 8. Provide a permanently attached aluminum or stainless steel nameplate on each jacket to identify its location, size and tag number.
- E. Fastening:
 - 1. Jackets shall be fastened using hook and loop (“Velcro” type) straps and 1-inch (25 mm) slide buckles. Hog rings, staples, wires, and other devices are not acceptable.
 - 2. Jacket pieces which match mating seams shall include an extended 2-inch (50 mm) flap constructed from the exterior fabric and shall be secured using hook and loop closure parallel to the seam.

2.4 SHIELDS, INSERTS, AND SADDLES

A. Shields:

1. Carpenter and Paterson Figure 265GS, or equal.
2. Galvanized or electro-galvanized steel, minimum 12 inch length, minimum 120-degree arc, minimum 18 ga.
3. Provide contact adhesive to glue shields to the insulation.

B. Snap-On Shields:

1. Eaton B-Line "Snap-N Shield".
2. Snap-N Shield is an acceptable substitute for metal shields when installed with strut trapeze hangers on horizontal piping.
3. Paintable polypropylene plastic 12 inch long preformed shields, snap-on design for attachment to strut.
4. Gluing is not required with Snap-N Shield.
5. Provide black or white color to match the insulation in areas exposed to public view.

C. Inserts:

1. Configuration: Minimum 6 inches (150 mm) long, of same thickness and contour as adjoining insulation; may be factory fabricated.
2. Insert Material: ASTM C533, hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.

D. Saddles:

1. Factory fabricated of curved carbon steel plate, of same overall thickness and contour as adjoining insulation. Sides designed for welding to pipe. Center support plate for pipe sizes 12 inches (300 mm) and larger.

2.5 PVC JACKET

A. ASTM D1784, one piece molded type fitting covers and sheet material, off-white color.

1. Service temperature: 0 to 150 degrees F (-18 to 66 degrees C).
2. Moisture vapor transmission: ASTM E96; 0.002 perm-inches.
3. Thickness: 30 mil (0.76 mm).
4. Connections: Brush on welding adhesive, tacks, or pressure sensitive color matching vinyl tape.
5. Covering Adhesive Mastic: Compatible with insulation.

2.6 MANUFACTURER'S STAMP OR LABEL

- ### A.
- Every package or standard container of insulation, jackets, cements, adhesives, and coatings delivered to the project site for use shall have the manufacturer's stamp or label attached giving name of manufacturer, brand, and description of material. Insulation packages and containers shall be asbestos-free.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that piping has been tested before applying insulation materials.
- B. Verify that surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION

- A. Install in accordance with NAIMA National Insulation Standards where applicable.
- B. Provide insulation for surfaces of piping as indicated and specified.
- C. Insulation values shall meet or exceed the requirements of ASHRAE 90.1-2010, applicable State Energy Codes, and Table I, whichever is greater. In addition, comply with the other requirements of this Section.
 - 1. International Energy Conservation Code (IECC): The Commercial Energy Efficiency chapter of the Code allows the use of ASHRAE 90.1 insulation thicknesses instead of the Minimum Pipe Insulation table which is in that chapter of the IECC. This Specification does not reference the table in IECC.
- D. Piping systems requiring insulation, types of insulation required, and insulation thickness shall be as listed in Table I herein. For piping not listed in Table 1, insulate to meet Code requirements, using suitable specified materials, subject to Engineer's approval. Except for flexible unicellular insulation, insulation thicknesses as specified in Table I shall be one inch (25 mm) greater for insulated piping systems located outside the building and in unconditioned spaces. Unless otherwise specified, insulate fittings, flanges, and valves, except valve stems, hand wheels, and operators. Use factory pre-molded, precut, or field-fabricated insulation of the same thickness and conductivity as used on adjacent piping. Insulation exterior shall be factory cleanable, grease resistant, non-flaking, and non-peeling.
- E. Exposed Piping: Locate insulation and cover seams in least visible locations.
- F. Insulated Pipes Conveying Fluids Below Ambient Temperature: Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints.
- G. For hot piping conveying fluids over 140 degrees F (60 degrees C), insulate flanges and unions at equipment.
- H. Glass Fiber Insulated Pipes Conveying Fluids above Ambient Temperature:
 - 1. Provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples.
 - 2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.

- I. Large Valve Bodies and Other Fittings: Large valves and other fittings requiring service access may be insulated with removable, reusable equipment covers with “Velcro” closures.
- J. Branches to Gauges, Sensors, Drains, and Vents: Insulate branches to gauges, sensors, drains, and vents as for active sections of piping. For piping with operating temperatures above ambient, insulate to at least 6 inches (150 mm) from the active main. For temperature devices, insulate to include the sensing bulb or other element.
- K. Shields, Inserts, and Saddles:
 - 1. Application: Provide shields at hangers. Provide inserts for piping 2 in. (50 mm) nominal size or larger. Provide saddles for piping 6 in. (150 mm) nominal size and larger.
 - 2. Shield location: Between insulation jacket and hanger.
 - 3. Insert location: Between support shield and piping and under the finish jacket.
 - 4. Saddle location: Between support shield and piping.
 - 5. Tack-weld saddles to the pipe. Fill air spaces within the saddle with insulation material.
 - 6. Glue shields to outside of insulation after system is filled and run at operating temperature.
 - 7. Align mid-length of shields, inserts, and saddles with the hanger centerline.

3.3 FIELD-APPLIED JACKETS

- A. Piping 9 feet (2.7 meters) or Less Above Floor: Finish with PVC jacket and fitting covers.

3.4 UNIFORM INSTALLATION

- A. Systems shall use a single insulation type throughout the installation.

3.5 PREPARATION

- A. Insulate piping after system tests have been completed and surfaces to be insulated have been cleaned of dirt, rust, and scale and dried. Ensure full range of motion of equipment actuators. Modify insulation to avoid obstruction of valve handles, safety reliefs, and other components requiring movement. Allow adequate space for pipe expansion. Install insulation with jackets drawn tight and cement down on longitudinal and end laps. Do not use scrap pieces where a full length section will fit. Insulation shall be continuous through sleeves, wall and ceiling openings. Extend surface finishes to protect surfaces, ends, and raw edges of insulation. Apply coatings and adhesives at the manufacturer’s recommended coverage per gallon. Individually insulate piping. Provide a moisture and vapor seal where insulation terminates against metal hangers, anchors and other projections through the insulation on surfaces for which a vapor seal is specified. Keep insulation dry during the application of any finish. Bevel and seal the edges of exposed insulation. Unless otherwise indicated, do not insulate the following:
 - 1. Valve hand wheels.
 - 2. Balancing valve test ports and adjustment devices.
 - 3. Strainer blowdown valves.
 - 4. Drain valves and air vent bodies.
 - 5. Vibration isolating connections.

6. Adjacent insulation.
7. ASME stamps.

3.6 PIPING INSULATION

- A. Pipe Insulation: Place sections of insulation around the pipe and joints tightly butted into place. The jacket laps shall be drawn tight and smooth. Secure jacket with fire resistant adhesive, factory applied self-sealing lap. Cover circumferential joints with butt strips, not less than 3-inches (76 mm) wide, of material identical to the jacket material. Overlap longitudinal laps of jacket material not less than 1-1/2 inches (38 mm). Adhesive used to secure the butt strip shall be the same as used to secure the jacket laps. When a vapor barrier jacket is required, as indicated in Table I, or on the ends of sections of insulation that butt against flanges, unions, valves, fittings, and joints, use a vapor-barrier coating conforming to manufacturer's weatherproof coating for outside service. Apply this vapor barrier coating at longitudinal and circumferential laps. Patch damaged jacket material by wrapping a strip of jacket material around the pipe and cementing, and coating as specified for butt strips. Extend the patch not less than 1-1/2 inches (38 mm) past the break in both directions. At penetrations by pressure gauges and thermometers, fill the voids with the vapor barrier coating for outside service. Seal with a brush coat of the same coating.
- B. Seal surfaces of fibrous insulation to prevent release of fibers.

3.7 FIELD INSPECTION

- A. Visually inspect to ensure that materials used conform to specifications. Inspect installations progressively for compliance with requirements.

TABLE I
 PIPING INSULATION MATERIAL AND WALL THICKNESS

SERVICE	INSULATION MATERIAL	VAPOR BARRIER REQUIRED	INSULATION WALL THICKNESS AT THE FOLLOWING PIPE DIAMETERS				
			<1 inch	1 inch to <1.5 inches	1.5 inches to <4 inches	4 inches to <8 inches	8 inches or Greater
Heating Systems (Hot Water Supply and Return)							
Fluid Design Operating Temperature Range							
201 degrees F to 250 deg. F	Glass Fiber	No	2.5 inches	2.5 inches	2.5 inches	3 inches	3 inches
141 degrees F to 200 deg. F	Glass Fiber	No	1.5 inches	1.5 inches	2 inches	2 inches	2 inches
105 degrees F to 140 deg. F	Glass Fiber	Yes	1 inch	1 inch	1.5 inches	1.5 inches	1.5 inches

END OF SECTION 230719

SECTION 230900 – INSTRUMENTATION AND CONTROL FOR MECHANICAL SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Direct Digital Control (DDC) equipment.
- B. Software.
- C. Installation.

1.2 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Piping:
 - 1. Temperature Sensor Wells and Sockets.
 - 2. Pressure Sensors and Switches.

1.3 PRODUCTS FURNISHED UNDER OTHER SECTIONS

- A. Controllers furnished with some HVAC equipment (Division 23).

1.4 RELATED SECTIONS

- A. Division 23 Section “Common Work Results for HVAC.”
- B. Division 23 Section “Common Motor Requirements for HVAC Equipment.”
- C. Division 23 Section “Testing, Adjusting, and Balancing for HVAC.”
- D. Division 23 Section “Hydronic Pumps.”
- E. Division 23 Section “Condensing Boilers.”

1.5 REFERENCES

- A. ASME MC85.1 - Terminology for Automatic Control.
- B. NEMA EMC1 - Energy Management Systems Definitions.
- C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- D. NFPA 70 - National Electrical Code.
- E. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.

1.6 SYSTEM DESCRIPTION

- A. A fully integrated Automatic Temperature Control (ATC) Building Management and Control System incorporating Direct Digital Control (DDC), energy management, equipment monitoring, and control consisting of the following:
 - 1. Microcomputer-based equipment controllers interfacing directly with sensors, actuators and environmental delivery systems.
 - 2. Electric controls and mechanical devices for items indicated on Drawings and described hereinafter including dampers, valves, and motor drives.
 - 3. Microcomputer-based terminal controllers interfacing with sensors, actuators, and terminal equipment control devices.
- B. Submittals, data entry, electrical installation, programming, start up, test and validation, instruction of Owner's Contract Representative on maintenance and operation, as built documentation, and system warranty.
- C. System Summary:
 - 1. The intent of this project is to provide modifications to the existing ATC system with electric actuators.
 - 2. Boiler integral controllers, shall be interfaced with the DDC system, such that monitoring and setpoint adjustment shall be accomplished through the graphical user interface at the operator workstation.
- D. Note: The terms "BMS", "ATC", and "DDC" are used somewhat interchangeably throughout this Section.

1.7 DEFINITIONS

- A. Note: The terms ATC, BAS, and DDC may be used interchangeably in this Section and on the Drawings, to indicate the overall control system.
- B. Definitions:
 - 1. ATC: Automatic temperature control.
 - 2. BACnet: A control network technology platform for designing and implementing interoperable control devices and networks.
 - 3. BAS: Building Automation System.
 - 4. DDC: Direct digital control.
 - 5. I/O: Input/output.
 - 6. MS/TP: Master slave/token passing.
 - 7. PC: Personal computer.
 - 8. PID: Proportional plus integral plus derivative.
 - 9. RTD: Resistance temperature detector.

1.8 SUBMITTALS

- A. Submit in accordance with Division 01 Section "Submittal Procedures."

- B. Qualification Data: For Installer and manufacturer.
 - C. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
 - 1. Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
 - 2. 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: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
 - 2. Schematic flow diagrams showing fans, coils, dampers, valves, and control devices.
 - 3. Wiring Diagrams: Power, signal, and control wiring.
 - 4. Details of control panel faces, including controls, instruments, and labeling.
 - 5. Written description of sequence of operation.
 - 6. Wiring diagrams for control units with termination numbers.
 - 7. Schematic diagrams and floor plans for field sensors and control hardware.
 - 8. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control units.
 - E. Field quality-control test reports.
 - F. Operation and Maintenance Data.
- 1.9 CODES AND APPROVALS
- A. The complete temperature control installation shall be in strict accordance to the national and local electrical codes and the electrical Division of these Specifications. Devices designed for or used in line voltage applications shall be UL listed. Microprocessor based remote and central devices shall be UL916 Listed.
 - B. Electronic equipment shall conform to the requirements of FCC regulation Part 15, Section 15 governing radio frequency electromagnetic interference and be so labeled.
- 1.10 QUALITY ASSURANCE
- A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.
 - B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

- C. Comply with ASHRAE Standard 135 (BACnet) for DDC system components.

1.11 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Division 01 Section "Project Requirements."
- B. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, provide shipping of control devices to equipment manufacturer, in a timely manner coordinated with the equipment manufacturer.
- C. Components to be Installed under Other Sections: For components to be installed under other Sections of the Specifications, provide delivery of components to appropriate Subcontractors, provide installation instructions, and supervise their installation.

1.12 COORDINATION

- A. Coordinate location of thermostats and other exposed control sensors with Contract Drawings before installation.
- B. Coordinate line-voltage power supplies with Electrical portions of the Contract Documents.

1.13 WARRANTY

- A. Components, system software, parts, and assemblies furnished under this Section shall be guaranteed against defects in materials and workmanship for 2 years from acceptance date.
- B. Labor to troubleshoot, repair, reprogram, or replace system components shall be provided at no charge to the Owner during the warranty period.
- C. Corrective software modifications made during warranty service periods shall be updated on user documentation and on user and manufacturer archived software disks.

PART 2 - PRODUCTS

2.1 ACCEPTABLE SUPPLIERS

- A. Acceptable Manufacturers and Installers: Shall be capable of, and have at least 3 years' experience in, programming existing controllers in the existing ATC system, and of providing controllers fully compatible and interoperable with the existing ATC system.
- B. The Temperature Control Contractor (or Subcontractor) shall hereinafter be referred to as the ATC Contractor.

2.2 SYSTEM REQUIREMENT

- A. Provide complete direct digital and electronic control system consisting of temperature sensors, thermostats, control valves, dampers, operators, indicating devices, interface equipment, and

other apparatus required to operate mechanical system and to perform functions specified.
Provide controls for the following:

1. Boilers.
2. Boiler pumps.
3. Combustion air dampers and controls, new and existing.
4. Provide hardware and software required for remote monitoring of the ATC system through modem or ethernet interface.

2.3 DATA INPUTS AND OUTPUTS

- A. Input/output sensors and devices shall be closely matched to the requirements of the remote panel for accurate, responsive, noise-free signal input/output. Control input response shall be high-sensitivity and matched to the loop gain requirements for precise and responsive control.
- B. Provide water sensors with a separable copper, monel or stainless-steel well.
- C. Control relays and analog output transducers shall be compatible with equipment controllers output signals. Relays shall be suitable for the loads encountered. Analog output transducers shall be designed for precision closed loop control with pneumatic repeatability error no greater than 1/2 percent.

2.4 TEMPERATURE CONTROL CENTRAL HARDWARE

- A. Equipment controllers shall be 16 bit microprocessor based with EPROM operating system (O.S.). ATC programs and data files shall be non-volatile EEPROM or flash memory to allow simple additions and changes. Each equipment controller shall have an on-board real-time clock with battery backup of a minimum of 30 days.
 1. Equipment controllers shall be provided where indicated or specified with capacity to accommodate input/output (I/O) points required for the application plus spare points specified. These panels shall be configured with analog and digital inputs and outputs, and pulse counting totalizers and such that the primary input, the output and control logic shall be resident in a single microprocessor to provide network independent stand-alone closed loop ATC.
 2. Panel electronics shall be installed in suitable enclosures. Equipment room panels shall have hinged doors and shall also contain the load relays, transducers, and associated equipment.
- B. Terminal Equipment Controllers shall be EEPROM based and modularity expandable to accommodate additional points if required for future functional changes or enhancements, and with I/O selected for the application plus specified spares. Terminal controllers shall be capable of processing sensor signals of the applications specified, and shall have capability to drive digital (on-off), pulse width modulation, and true analog (0-10V) outputs. Terminal Controller enclosures shall be compact, finished steel to fit within or on terminal equipment. Each terminal controller shall have complete standalone capability.

2.5 CONTROLLER SOFTWARE

- A. Energy Management application programs and associated data files shall be in non-volatile memory.
 - 1. Optimum Start shall delay equipment start-up based on global outdoor temperature, space temperature, and system response to assure that comfort conditions are reached at scheduled occupancy. The optimum start program shall operate fully stand-alone in the local equipment controllers.
 - 2. A load reset program shall be provided to assure that only the minimum amount of heating, cooling, and electrical energy is supplied to satisfy zone temperature requirements.

- B. Control Software:
 - 1. Each equipment controller shall contain up to 20 unique user modifiable time programs.
 - 2. Control Application Software shall be customized strictly to meet the detailed requirements of the "Sequence of Operation" specified on the Drawings. Equipment controllers and terminal controllers shall be fully programmable. Initial software shall be fully modifiable, and not restricted by vendor's specific configuration guidelines. Equipment controllers control software shall be designed via a graphic programming facility, the detailed graphic design of which shall be provided as system documentation. Control strategies shall be advanced as noted with stabilizing setpoint ramps and procedures to assure slow loading of variable load equipment and economizer modes to prevent unsafe overshoot of controlled pressure and unsafe undershoot of mixed air temperatures during start-up and transition periods.

- C. Management Software:
 - 1. Each equipment controllers shall be provided with a trend archive of at least the last 200 events (digital transitions or analog value changes) of any user selected group of up to 20 points. A stored event shall include date and time, and value or status. Point events shall be displayable at local panels as trend logs for evaluation of control system performance.
 - 2. Each equipment controller shall monitor analog input points and specified digital points for off-normal conditions. Each alarm shall have an "alarm delay" attribute which shall determine how long (in seconds) a point must be in an off-normal state prior to being considered in an alarm state.

- D. Communications Software: Each equipment controllers shall have a full master peer-to-peer communications module to support global data sharing, hierarchical control, and global control strategies specified.

2.6 DATA COMMUNICATIONS

- A. Equipment controllers shall be interconnected via a primary communications network. Terminal controllers shall also be connected together via secondary networks to provide data concentration and parallel processing. Networks shall support sensor sharing, global application programs, and bus-to-bus communications without the presence of a host PC.

- B. The equipment controller's communications network shall support true peer protocol such that loss of any single device will not cause total bus failure.

2.7 GENERAL

- A. ATC setpoints, reset schedules, time programs, historical trends shall be displayable at local ATC panels and on the system's operator workstations.
- B. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.
 - 1. Binary Inputs: Allow monitoring of on-off signals without external power.
 - 2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
 - 3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
 - 4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with 3-position (on-off-auto) override switches and status lights.
 - 5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA).
 - 6. Tri-State Outputs: Provide two coordinated binary outputs for control of 3-point, floating-type electronic actuators.
 - 7. Universal I/Os: Provide software selectable binary or analog outputs.
- C. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:
 - 1. Output ripple of 5.0 mV maximum peak to peak.
 - 2. Combined 1 percent line and load regulation with 100-microsecond response time for 50 percent load changes.
 - 3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.
- D. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:
 - 1. Minimum dielectric strength of 1000 V.
 - 2. Maximum response time of 10 nanoseconds.
 - 3. Minimum transverse-mode noise attenuation of 65 dB.
 - 4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.8 CONTROL CABLE

- A. Electronic and fiber-optic cables for control wiring shall be provided under this Section.

2.9 ELECTRONIC SENSORS

- A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as

required.

B. Thermistor Temperature Sensors and Transmitters:

1. Accuracy: Plus or minus 0.5°F (0.3°C) at calibration point.
2. Wire: Twisted, shielded-pair cable.
3. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches (64-mm).

C. Pressure Transmitters/Transducers:

1. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
 - a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
 - b. Output: 4 to 20 mA.
 - c. Duct Static-Pressure Range: 0- to 5-inch wg (0 to 1240-Pa).
2. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig (1034-kPa) operating pressure and tested to 300-psig (2070-kPa); linear output 4 to 20 mA.
3. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.

2.10 STATUS SENSORS

- A. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.
- B. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.
- C. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4-20 mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.
- D. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.
- E. Water-Flow Switches: Bellows-actuated snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

2.11 BOILER CONTROLS

- A. Provide integration of the boilers into the existing sequence of controls, to stage the boilers in sequence with existing boilers, and to control combustion air dampers in the same manner as the existing boilers do.

- B. Provide switching of each boiler control, to enable selected boiler(s) to enable each boiler to serve the selected portion of the building.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that power supply and data outlet is available to control units and operator workstation.

3.2 ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. Provide electrical materials and installation under this Section.
- B. Wiring and conduits shall be properly supported and run in a neat and workmanlike manner. Wiring and conduits exposed and in equipment rooms shall run parallel to or at right angles to the building structure. Wiring and conduits within enclosures shall be neatly bundled and anchored to prevent obstruction to devices and terminals. Wiring, conduits, wall boxes, and accessories shall conform to Electrical portions of the Contract Documents.
- C. The ATC Contractor shall be responsible for electrical installation, including any low voltage and line voltage wiring which is required for a fully functional control system and not indicated on the Electrical Drawings.
- D. Wiring shall be in accordance with local and national Codes and regulations.
- E. Requirements and standards shall be as specified in the Electrical portions of the Contract Documents, and as indicated in paragraphs below.
 - 1. Provide interface wiring (line and low voltage) and fiber-optic cables as required to complete ATC system installation.
 - 2. Provide signal and communication cable.
 - a. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
 - b. Install exposed cable in raceway.
 - c. Install concealed cable in raceway.
 - d. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.
 - e. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
 - f. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
 - g. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
- F. Control wiring in boiler room shall be installed in conduit which shall comply with the requirements of the Electrical portions of the Contract Documents.

- G. Electronic low-voltage wiring shall be #18 AWG minimum THHN and shielded if required.
- H. Power for any temperature control panels required in addition to those indicated on the Drawings shall be the responsibility of this Section. Power to temperature control panels shall be through “stand-by” power circuits which are powered through the building’s emergency generator, if this is consistent with existing control panels.

3.3 INSTALLATION

- A. For components to be installed under other Sections of the Specifications, provide delivery of components to appropriate Subcontractors, provide installation instructions, and supervise their installation.
- B. Install hydronic instrument wells, valves, and other accessories according to Division 23 Section "Hydronic Piping."
 - 1. Sensors shall be immersion type in wells unless otherwise specified or indicated.
 - 2. Enlarge piping at wells to prevent excess interference with flow.
 - 3. Locate wells to ensure insertion in active flowing section of piping or tank.
 - 4. Fill sensor wells with Honeywell thermal heat transfer paste to ensure good conduction.
- C. Provide labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."
- D. Enter computer programs and data files into the related computers including control programs, initial approved parameters and settings, and English descriptors.
- E. Maintain CD copies of data file and application software for reload use in the event of a system crash or memory failure. 1 copy shall be delivered to the Contract Representative during training session, and 1 copy shall be archived in the ATC Contractor's local software vault.
- F. Install software in control units and operator workstation(s). Implement features of programs to specified requirements and as appropriate to sequence of operation.
- G. Connect and configure equipment and software to achieve sequence of operation specified.

3.4 FIELD QUALITY CONTROL

- A. Coordinate with the requirements of Division 01 Section “General Commissioning Requirements”.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- C. Perform the following field tests and inspections and prepare test reports:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.

2. Test and adjust controls and safeties.

D. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
5. Check temperature instruments and material and length of sensing elements.
6. Check control dampers. Verify that they open and close fully and without restriction.
7. Check DDC system as follows:
 - a. Verify that DDC controller power supply is from emergency power supply, if applicable.
 - b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
 - c. Verify that DDC controllers are protected from power supply surges.

- E. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.5 ADJUSTING

A. Calibrating and Adjusting:

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

- b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
- 7. Temperature:
 - a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
 - b. Calibrate temperature switches to make or break contacts.
- 8. Provide diagnostic and test instruments for calibration and adjustment of system.
- 9. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.
- B. Adjust initial temperature set points.

3.6 VALIDATION

- A. The ATC Contractor shall completely check out, calibrate, and test connected hardware and software to insure that the system performs in accordance with the approved submittals for specifications and sequences of operations.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain Mechanical instrumentation and controls. Refer to Division 01 Section "Demonstration and Training."

3.8 TRAINING

- A. Training shall be by the ATC Subcontractor and shall utilize specified manuals and as-built documentation.
- B. Operator training shall include one two-hour session encompassing:
 - 1. Sequence of Operation review.
 - 2. Selection of displays and reports.
 - 3. Use of the specified functions.
 - 4. Troubleshooting of sensors.
 - 5. Contract Representative questions/concerns.
- C. The training session shall be conducted at project substantial completion, in accordance with the Contract Representative's schedule.

END OF SECTION 230900

SECTION 231123 - FACILITY NATURAL-GAS 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. Pipes, tubes, and fittings.
 - 2. Piping specialties.
 - 3. Piping and tubing joining materials.
 - 4. Pressure regulators.
 - 5. Dielectric fittings.

1.3 DEFINITIONS

- A. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Piping specialties.
 - 2. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
 - 3. Pressure regulators. Indicate pressure ratings and capacities.
 - 4. Dielectric fittings.

1.5 INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For pressure regulators to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Steel Support 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.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.
- B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

1.9 PROJECT CONDITIONS

- A. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:
 - 1. Notify Contract Representative no fewer than two days in advance of proposed interruption of natural-gas service.
 - 2. Do not proceed with interruption of natural-gas service without Contract Representative's written permission.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Minimum Operating-Pressure Ratings:
 - 1. Piping and Valves: 100 psig minimum unless otherwise indicated.
 - 2. Service Regulators: 65 psig minimum unless otherwise indicated.
- B. Natural-Gas System Pressure within Buildings: Field verify to equal existing, but not more than 2 psig.

2.2 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.
 - 1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 - 2. Wrought-Steel Welding Fittings: ASTM A234/A234M for butt welding and socket welding.

3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - a. Material Group: 1.1.
 - b. End Connections: Threaded or butt welding to match pipe.
 - c. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
 - d. Bolts and Nuts: ASME B18.2.1, carbon steel or stainless steel.

2.3 PIPING SPECIALTIES

- A. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.4 JOINING MATERIALS

- A. Joint Compound and Tape: Suitable for natural gas.
- B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.5 MANUAL GAS SHUTOFF VALVES

- A. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
 1. CWP Rating: 125 psig.
 2. Threaded Ends: Comply with ASME B1.20.1.
 3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
 4. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
 5. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.
- B. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.
 1. CWP Rating: 125 psig.
 2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
 3. Service Mark: Initials "WOG" shall be permanently marked on valve body.
- C. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Apollo Flow Controls; Conbraco Industries, Inc.

2. Body: Bronze, complying with ASTM B584.
3. Ball: Chrome-plated bronze.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Threaded-body packnut design with adjustable-stem packing.
7. Ends: Threaded, flared, or socket.
8. CWP Rating: 600 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

D. Two-Piece, Regular-Port Bronze Ball Valves with Bronze Trim: MSS SP-110.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Apollo Flow Controls; Conbraco Industries, Inc.
2. Body: Bronze, complying with ASTM B584.
3. Ball: Chrome-plated bronze.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE.
6. Packing: Threaded-body packnut design with adjustable-stem packing.
7. Ends: Threaded, flared, or socket.
8. CWP Rating: 600 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.6 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Appliance Pressure Regulators: Comply with ANSI Z21.18.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Maxitrol Company.
2. Body and Diaphragm Case: Die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.

4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
9. Maximum Inlet Pressure: 1 psig.

2.7 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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Capitol Manufacturing Company.
 - c. Matco-Norca.
 - d. WATTS.
 2. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric Flanges:
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Capitol Manufacturing Company.
 - b. Matco-Norca.
 2. Description:
 - a. Standard: ASSE 1079.
 - b. Factory-fabricated, bolted, companion-flange assembly.
 - c. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
 - d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Close equipment shutoff valves before turning off natural gas to premises or piping section.
- B. Inspect natural-gas piping according to NFPA 54 to determine that natural-gas utilization devices are turned off in piping section affected.
- C. Comply with NFPA 54 requirements for prevention of accidental ignition.

3.3 INDOOR PIPING INSTALLATION

- A. Comply with NFPA 54 for installation and purging of natural-gas piping.
- B. 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.
- C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. 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.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Locate valves for easy access.
- H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.
- I. Install piping free of sags and bends.
- J. Install fittings for changes in direction and branch connections.
- K. Verify final equipment locations for roughing-in.

- L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
- M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
 - 1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
- P. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- Q. Connect branch piping from top or side of horizontal piping.
- R. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
- S. Do not use natural-gas piping as grounding electrode.
- T. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
- U. Install pressure gage downstream from each line regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

3.4 VALVE INSTALLATION

- A. Install manual gas shutoff valve for each gas appliance ahead of equipment connector.
- B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

3.5 PIPING JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. 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:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

F. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

3.6 HANGER AND SUPPORT INSTALLATION

A. Install seismic restraints on piping as required by Code.

B. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

C. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.

3.7 CONNECTIONS

A. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

B. Install piping adjacent to appliances to allow service and maintenance of appliances.

- C. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
- D. Sediment Traps: Install tee fitting with removable-capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.8 LABELING AND IDENTIFYING

- A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.

3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Test, inspect, and purge natural gas according to NFPA 54 and authorities having jurisdiction.
- C. Natural-gas piping will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 231123

SECTION 232113 – HYDRONIC PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Pipe and Pipe Fittings For:
 - 1. Heating water piping system.
 - 2. Equipment drains and overflows.

- B. Valves:
 - 1. Ball valves.
 - 2. Butterfly valves.
 - 3. Check valves.

1.2 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Access Doors.

1.3 RELATED SECTIONS

- A. Division 23 Section “Hangers and Supports for HVAC Piping and Equipment.”
- B. Division 23 Section “Identification for HVAC Piping and Equipment.”
- C. Division 23 Section “HVAC Piping Insulation.”
- D. Division 23 Section “Hydronic Specialties.”
- E. Division 23 Section “HVAC Water Treatment”: Pipe cleaning.

1.4 REFERENCES

- A. ASME - Boiler and Pressure Vessel Codes, SEC 9 - Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.
- B. ASME B16.3 - Malleable Iron Threaded Fittings Class 50 and 300.
- C. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
- D. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
- E. ASME B31.9 - Building Services Piping.
- F. ASME B36.10M - Welded and Seamless Wrought Steel Pipe.
- G. ASTM A53 - Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless.

- H. ASTM A234 - Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.
- I. ASTM A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
- J. ASTM A312 - Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
- K. ASTM A403 - Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
- L. ASTM B32 - Solder Metal.
- M. ASTM B88 - Seamless Copper Water Tube.
- N. AWS D1.1 - Structural Welding Code.
- O. AWWA C110 - Ductile - Iron and Grey -Iron Fittings 3 in. through 48 in. (75 mm through 1200 mm), for Water and Other Liquids.
- P. AWWA C111 - Rubber-Gasket Joints for Ductile Iron and Grey-Iron Pressure Pipe and Fittings.
- Q. AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids.
- R. MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices.

1.5 SUBMITTALS

- A. Submit under provisions of Division 01 Section "Submittal Procedures."
- B. Product Data: Include data on pipe materials, pipe fittings, valves, and accessories. Provide Manufacturers catalogue information. Indicate valve data and ratings.
- C. Welders Certificate: Include welder's certification of compliance with ASME SEC 9 and AWS D1.1.
- D. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.

1.6 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Division 01 Section "Closeout Procedures."
- B. Record actual locations of valves.

1.7 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Division 01 Section "Operation and Maintenance Data."

- B. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.8 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum 3 years' experience.
- B. Installer: Company specializing in performing the work of this Section with minimum 3 years' experience.
- C. Welders: Certify in accordance with ASME SEC 9 and AWS D1.1.
- D. Pressed Pipe Fittings: Submit documentation of fitting-manufacturer training of installers or their on-site supervisors, with names of individuals.

1.9 REGULATORY REQUIREMENTS

- A. Conform to ASME B31.9 code for installation of piping system.
- B. Welding Materials and Procedures: Conform to ASME SEC 9 and applicable state labor regulations.
- C. Provide certificate of compliance from authority having jurisdiction indicating approval of welders.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Division 01 Section "Product Requirements."
- B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- C. Provide temporary protective coating on cast iron and steel valves.
- D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 - PRODUCTS

2.1 HEATING WATER PIPING, ABOVE GROUND

- A. Steel Pipe: ASTM A53, Schedule 40 for sizes less than 12 inch, 0.375 inch wall for sizes 12 inch and over, black.
 - 1. Fittings: ASTM B16.3, malleable iron or ASTM A234, forged steel welding type fittings.
 - 2. Joints: Schedule 40 threaded for pipe sizes 2 inch and smaller, and AWS D1.1, welded

for pipe sizes over 2 inch.

3. Grooved and Shouldered Pipe End Couplings: As specified in this Section, with grooved steel pipe, is an acceptable alternate to the above for water service operating at temperatures from -30 to 230 degrees F, utilizing grade E, EPDM gasket compound.

B. Copper Tubing: ASTM B88, Type L hard drawn.

1. Allowed only for pipe sizes 2 inch and smaller.
2. Fittings: ASME B16.18, cast brass, or ASME B16.22, solder wrought copper.
3. Joints: Solder fittings.

2.2 EQUIPMENT DRAINS AND OVERFLOWS

A. Steel Pipe: ASTM A53, Schedule 40 galvanized.

1. Fittings: Galvanized cast iron, or ASTM B16.3 malleable iron.
2. Joints: Threaded, or grooved mechanical couplings.

B. Copper Tubing: ASTM B88, Type L, hard drawn.

1. Fittings: ASME B16.18, cast brass, or ASME B16.22 solder wrought copper.
2. Joints: Solder fittings.

2.3 SOLDER MATERIALS:

A. Manufacturers:

1. Harris (Product: Stay-Brite).
2. Lucas-Milhaupt (Product: Silvabrite).
3. No substitutions.

B. Nominal Composition: Alloy of silver and tin (3-6 percent Ag, remainder Sn). Antimony-free.

C. Physical Properties:

1. Color: Bright Silver
2. Solidus: 430 degrees F
3. Liquidus: 430 degrees F
4. Electrical Conductivity: 16.4 percent IACS
5. Shear Strength: 10,600 psi
6. Tensile Strength: 14,000 psi
7. Elongation: 48 percent

D. Specification Compliance:

1. NSF 51
2. ASTM B32-89, Alloy Grade Sn96
3. Federal Spec. QQ-S-571E, Class Sn 96 with exception to QPL paragraph 3.1
4. J-STD-006, Sn96Ag04A

E. Flux:

1. Harris (Product: Stay Clean Paste Flux, Stay Clean Liquid Flux (used with 4 inch or larger copper tubing also stainless steels), or Bridgit Water Soluble Paste Flux).
2. Canfield (Product: Aqua-Brite or AB Cream Flux). Glycerin-based, water soluble.

2.4 UNIONS, FLANGES, AND COUPLINGS

A. Unions for Pipe 2 inch and Under:

1. Ferrous Piping: 150 psig malleable iron, threaded.
2. Copper Pipe: Bronze, soldered joints.

B. Flanges for Pipe Over 2 Inch:

1. Ferrous Piping: 150 psig forged steel, slip-on.
2. Copper Piping: Bronze.
3. Gaskets: 1/16 inch thick preformed neoprene or EPDM, reinforced as required for the system operating pressure, up to relief valve setting.

C. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

2.5 PIPE HANGERS AND SUPPORTS

A. See Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

2.6 VALVES

A. Manufacturers:

1. Apollo.
2. Center Line – butterfly valves.
3. Crane.
4. Flomatic.
5. Hammond.
6. Jenkins.
7. Metraflex.
8. Milwaukee.
9. Nibco.
10. Watts.
11. No substitutions.

B. Ball Valves:

1. Up To and Including 3 inch:
 - a. Bronze two piece body, chrome plated brass ball, teflon seats and stuffing box ring, lever handle, solder or threaded ends.

- b. 150 lb S.W.P., 600 lb W.O.G.
 2. Over 3 Inch:
 - a. Cast steel body, chrome plated steel ball, teflon seat and stuffing box seals, lever handle, flanged.
 - b. 150 lb S.W.P., 285 lb W.O.G.
 3. Stem Extensions: Provide ball valves in insulated piping with stem extensions to allow for continuous thickness of field-installed insulation.
- C. Butterfly Valves:
 1. Body: Cast or ductile iron with resilient replaceable EPDM seat, wafer or lug ends, extended neck.
 2. Disc: Aluminum bronze or chrome plated ductile iron.
 3. Operator: 10 position lever handle for shut-off service, infinite position lever handle with memory stop for throttling service, handwheel and gear drive for sizes 8" (203 mm) and larger.
 4. Pressure rating shall be 150 psi at 225 degrees F.
- D. Gate Valves Over 2 inch (50 mm):
 1. Iron body, bronze trim, bolted bonnet, rising stem, handwheel, outside screw and yoke, solid wedge disc with bronze seat rings, flanged ends.
 2. 125 lb S.W.P., 200 lb W.O.G.
- E. Swing Check Valves:
 1. Up To and Including 2 inch: Bronze body, bronze trim, bronze rotating swing disc, with composition disc, solder or threaded ends.
 2. Over 2 inch: Iron body, bronze trim, bronze or bronze faced rotating swing disc, renewable disc and seat, flanged ends.
- F. Spring Loaded Check Valves:
 1. Up To and Including 1-1/2 inch: Bronze body, stainless steel trim, center-guided PTFE resilient disc, with stainless steel spring, threaded ends.
 2. Over 1-1/2 inch: Iron body, bronze trim, center-guided disc, with stainless steel spring, resilient seal bonded to body, wafer style body, or globe body with flanged lug or threaded ends.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Ream pipe and tube ends. Remove burrs.
- B. Remove scale and dirt on inside and outside before assembly.

- C. Prepare piping connections to equipment with flanges or unions.
- D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.
- E. After completion, fill, clean, and treat systems. Refer to Division 23 Section "HVAC Water Treatment."

3.2 INSTALLATION

- A. Install in accordance with Manufacturer's instructions.
- B. Install components furnished under other Section and Divisions of the Specifications. Such items may include but are not limited to: Sensors furnished under Division 23 Section "Instrumentation and Control for Mechanical Systems."
- C. Pipe used shall be new material, and threads on piping shall be full length and clean cut with inside edges reamed smooth to full inside bore.
- D. Minimum pipe size allowed for hydronic piping shall be 3/4 inch. Piping less than 3/4 inch shall not be allowed for these piping systems.
- E. Route piping in orderly manner, parallel to building structure, and maintain gradient.
- F. Install piping to conserve building space, and not interfere with use of space.
- G. Group piping whenever practical at common elevations.
- H. Erect piping to provide for the easy passage and noiseless circulation of water under working conditions.
- I. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level. Slope water piping 1 inch in 40 feet and arrange to drain at low points. Slope piping up in direction of water flow.
- J. On closed systems, equip low points with 3/4 inch drain valves and hose nipples. Provide, at high points of mains, collecting chambers and high capacity float operated automatic air vents, with ball valves on their inlets to valve off after initial system startup. Provide, at high points of branches, manual air vents with air chambers.
- K. Use main sized saddle type branch connections for directly connecting branch lines to mains in steel piping if main is at least 1 pipe size larger than the branch for up to 6 inch mains and if main is at least 2 pipe sizes larger than branch for 8 inch and larger mains. Do not project branch pipes inside the main pipe.
- L. Caulking of threads will not be allowed on any piping.
- M. Pipe joint compound shall be put on male threads only.

- N. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
- O. Dissimilar Metals: Use non-conducting dielectric connections whenever jointing dissimilar metals. Cast red-brass (not yellow brass) or bronze-bodied fittings such as valves and couplings may be used when joining steel to copper, steel to stainless steel, or copper to stainless steel. Steel and stainless steel may connect directly to iron, but copper may not connect directly to iron.
- P. Where welded joints are required, steel piping shall be installed by the use of the oxyacetylene or electric welding process, except immediate connections to accessible equipment may be threaded. Piping shall have butt welds with welding fittings, standard factory fabricated tees, elbows, reducers, caps, and accessories. Branch outlets 2 inch (50.8 mm) and smaller shall be made by the use of approved welding type half-couplings, "Weldolet" or "Threadolet" fittings.
 - 1. Piping smaller than 2 inch may be installed at the Contractor's option with welding type, or threaded type fittings, except that piping regardless of size concealed in trenches or inaccessible building construction (for example, concealed behind sheetrock walls or concealed above sheetrock ceilings) shall be welded.
 - 2. Offsets shall be installed with long radius welding elbows.
 - 3. Welding shall be executed only by certified welding mechanics in accordance with the best practice of the trade.
- Q. In the erection of mains, use special care in the support, working into place without springing or forcing, and proper allowance made for expansion.
- R. Pipes shall be anchored, guided, and otherwise supported, where necessary, to prevent vibration or to control expansion.
- S. Make such offsets as are shown and required to place the pipes and risers in proper position to avoid other work.
- T. Take branch lines off bottom of mains or at 45 degree bottom angle, as space permits.
- U. Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.
- V. Install a sufficient number of unions or flanged fittings to facilitate making possible future alterations or repairs.
- W. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.

3.3 VALVES

A. Valve Type Selection:

1. Use Butterfly Valves, OS&Y gate valves, or Ball Valves with lever handles at boiler supply and return connections to provide easy viewing of valve position in accordance with applicable State boiler rules and regulations.
2. Use ball or butterfly valves for shut-off and to isolate equipment, part of systems, or vertical risers.
3. Use Bronze Ball Valves for general shut-off service in heating system piping 3 inch and smaller.
4. Use Bronze Ball Valves for drain valves with hose connections. Provide valve of size indicated; if size isn't indicated, provide at least 3/4 inch valve size. Provide outlet fitting for standard "garden hose" with 3/4 inch hose threads. Provide brass cap with retainer chain. Compression-type "boiler drain valves" are not allowed.
5. Use Spring-Loaded Check Valves at pump discharges.

B. With the exception of valves which must be properly sized to ensure design flow rates (such as balancing valves), valves shall be line sized.

C. Install valves with stems upright or horizontal, not inverted.

3.4 CLEANING

A. After satisfactory completion of pressure tests, before permanently connecting equipment, strainers, and the like, clean equipment thoroughly, blow and flush piping for a sufficient length of time as directed, so that interiors will be free of foreign matter. Perform cleaning in the presence of an authorized representative of the Engineer. Provide a minimum of 10 days notification to the Engineer prior to system cleaning.

B. Fill, vent and circulate the system with approved solution in accordance with equipment (boiler, piping, coils, and others) manufacturer's recommendation, allowing it to reach design or operating temperatures. After circulating for 6 hours, drain the system completely and remove and clean strainer screens. Perform cleaning in the presence of an authorized representative of the Engineer. Provide a minimum of 10 days notification to the Engineer prior to system cleaning.

C. Fill and vent system as required.

D. Manually vent heat transfer units and high points of the system.

E. Adjust the pressure reducing valve to provide minimum of 5 psig pressure at the highest point of the system.

F. After system has been completely filled, start zone pumps and circulate cold water for a short time to dislodge small air bubbles, and return them to air extraction device.

G. Raise water temperature to 200 degrees F (93 degrees C) while operating pumps.

- H. Stop pump and vent radiation and high points of the system. Normal operation may now be started at any time.

3.5 TESTING

- A. No joint or section of piping shall be left untested.
- B. Before testing piping systems, remove, or otherwise protect from damage, control devices, air vents, and other parts which are not designed to stand test pressures.
- C. Test piping for leaks under 100 psig air pressure with soap suds prior to hydrostatic testing.
- D. Test piping hydrostatically to 1-1/2 times the maximum systems operating pressure, but in no case to less than 75 psig, for at least 4 consecutive hours, during which time pressure shall remain constant without pumping.
- E. Test and obtain Engineer's approval before painting, covering, or concealing piping, including swing joints.

END OF SECTION 232113

SECTION 232118 – HYDRONIC SPECIALTIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Air vents.
- B. Strainers.
- C. Balancing Valves.
- D. Combination Pump Discharge Valves.

1.2 RELATED SECTIONS

- A. Division 23 Section “Hydronic Piping.”
- B. Division 23 Section “HVAC Water Treatment”: Pipe cleaning.

1.3 REFERENCES

- A. ASME - Boilers and Pressure Vessel Codes, SEC 8-D-Rules for Construction of Pressure Vessels.
- B. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

1.4 SUBMITTALS

- A. Submit under provisions of Division 01 Section “Submittal Procedures.”
- B. Product Data: Provide product data for manufactured products and assemblies required for this project. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description, model and dimensions.
- C. Submit inspection certificates for pressure vessels from authority having jurisdiction.
- D. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.

1.5 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Division 01 Section “Closeout Procedures.”

1.6 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Division 01 Section “Operation and Maintenance Data.”

- B. Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.7 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this Section with minimum 3 years' experience.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Division 01 Section "Product Requirements."
- B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- C. Provide temporary protective coating on cast iron and steel valves.
- D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 - PRODUCTS

2.1 AIR VENTS

- A. Manual Type: Short vertical sections of 2 inch (50 mm) diameter pipe to form air chamber, with 1/8 inch (3 mm) brass needle valve at top of chamber.
- B. Float Type:
 - 1. Manufacturers:
 - a. Bell & Gossett.
 - b. Caleffi.
 - c. Taco.
 - d. Thrush.
 - 2. Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.
- C. Washer Type:
 - 1. Manufacturers:
 - a. Bell & Gossett.
 - b. Caleffi.

c. Taco.

2. Brass with hydrosopic fiber discs, vent ports, adjustable cap for manual shut-off, and integral spring loaded ball check valve.

2.2 STRAINERS

A. Manufacturers:

1. Sarco.
2. Armstrong.
3. Bell & Gossett.
4. Flo-Fab.
5. Wheatley.

B. Size 2 inch and Under: Screwed brass or iron body for 175 psig working pressure, Y pattern with 1/32 inch stainless steel perforated screen.

C. Size 2-1/2 inch and Larger: Flanged iron body for 175 psig working pressure, Y pattern with 3/64 inch stainless steel perforated screen.

2.3 BALANCING VALVES AND COMBINATION BALANCING/SHUT-OFF VALVES.

A. Manufacturers:

1. Bell & Gossett.
2. Armstrong.
3. Griswold Controls.
4. Nexus Valve.
5. Taco.
6. Watts.
7. Wheatley.

B. Valves shall conform to one of the following:

1. Fixed-Orifice Manual Balancing Valve: Calibrated, ball type balance valve with precision machined orifice, readout valves equipped with integral check valves and gasketed caps, calibrated nameplate and indicating pointer with memory stop. Readout valves measure the pressure differential across the fixed orifice plate or venturi. Valve shall be designed for positive shut-off.
2. Variable-Orifice Manual Balancing Valve: Cast iron or bronze, globe style, balance valve with handwheel with vernier type ring setting and memory stop, readout valves equipped with integral check valves and gasketed caps. Readout valves measure the pressure differential across the variable opening between valve plug and valve seat. Valve shall be designed for positive shut-off. Drain valve, if furnished with this valve, may be positioned properly to substitute for the separate drain valve indicated.

C. Cast iron, wafer type, orifice insert flow meter for 250 psig working pressure, with read-out valves equipped with integral check valves with gasketed caps.

- D. Size balancing valves to allow a reading of 2 to 5 ft wg pressure drop at design flow rates. Submittals shall include a chart of valve selections, indicating room number, terminal heating device tag, flow rate, pressure drop, and differential pressure reading.
- E. Insulation: Valves may be furnished with prefabricated thermal insulation. Flame spread reading shall be 25 or less per ASTM E84. R-value shall be 4 hr-sq.ft- F/Btu or greater. Install in accordance with Division 23 Section "HVAC Piping Insulation."

2.4 COMBINATION PUMP DISCHARGE VALVES

- A. Combination valves which include the features of check, shutoff, and flow measuring valves, commonly known as "Triple Duty", "Multipurpose", or "Multi-function" valves, are not allowed.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install specialties in accordance with manufacturer's instructions.
- B. Provide manual air vents at system high points and as indicated. Where large air quantities can accumulate, provide enlarged air collection standpipes.
- C. Provide valved drain and hose connection on strainer blow down connection.
- D. Provide separate check, balancing, and shutoff valves on discharge side of centrifugal pumps.
- E. Install balancing valves with upstream straight pipe as recommended by the manufacturer.
- F. Install balancing valves with the readout valves fully accessible, including space required for insertion of metering probes.
- G. Relief Valves: Provide on boilers. Pipe relief valve outlet to nearest floor drain or as indicated.

END OF SECTION 232118

SECTION 232123 – HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Vertical in-line pumps.

1.2 RELATED SECTIONS

- A. Division 23 Section “Common Motor Requirements for HVAC Equipment.”
- B. Division 23 Section “Vibration Controls for HVAC Piping and Equipment.”
- C. Division 23 Section “HVAC Piping Insulation.”
- D. Division 23 Section “Hydronic Piping.”
- E. Division 23 Section “Hydronic Specialties”
- F. Electrical Drawings - characteristics and wiring connections.

1.3 REFERENCES

- A. UL 778 - Motor Operated Water Pumps.
- B. NFPA 70 - National Electrical Code.

1.4 PERFORMANCE REQUIREMENTS

- A. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading throughout the entire operating range in parallel or individual operation, and operate within 25percent of midpoint of published maximum efficiency curve.

1.5 SUBMITTALS

- A. Submit under provisions of Division 01 Section “Submittal Procedures.”
- B. Product Data: Provide certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable. Include electrical characteristics and connection requirements.
- C. Manufacturer's Installation Instructions: Indicate hanging and support requirements and recommendations.

1.6 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Division 01 Section “Execution Requirements.”

- B. Operation and Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.7 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing, assembly, and field performance of pumps with minimum 3 years' experience.
- B. Alignment: Base mounted pumps shall be aligned by a qualified millwright.

1.8 REGULATORY REQUIREMENTS

- A. Products Requiring Electrical Connection: Listed and classified by UL as suitable for the purpose specified and indicated.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Pumps, General:
 1. Taco.
 2. Armstrong.
 3. Bell & Gossett.
 4. Flo-Fab.
 5. Grundfos.
 6. Wilo.

- B. No Substitutions.

2.2 GENERAL

- A. Statically and dynamically balance rotating parts.
- B. Construction shall permit complete servicing without breaking piping or motor connections.
- C. Pumps shall operate at 1750 rpm unless indicated or specified otherwise.
- D. Pump connections shall be flanged.
- E. Wetted parts shall be compatible with circulated fluid.

2.3 VERTICAL IN-LINE PUMPS

- A. Type: Vertical, single stage, close coupled, radially or horizontally split casing, for in-line mounting, for 175 psig (1200 kPa) working pressure.
- B. Casing: Cast iron, with suction and discharge gage port, casing wear ring, seal flush connection, drain plug, flanged suction and discharge.

- C. Impeller: Bronze or stainless steel, fully enclosed, keyed directly to motor shaft or extension.
- D. Shaft: Carbon steel with stainless steel impeller cap screw or nut and bronze sleeve.
- E. Seal: Carbon rotating against a stationary ceramic seat, 225 degrees F (107 degrees C) maximum continuous operating temperature.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Verify that electric power is available and of the correct characteristics.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.
- C. Decrease piping from line size with long radius reducing elbows or reducers.
- D. Pump inlet conditions shall be as recommended by the pump manufacturer to eliminate system effects.
 - 1. Provide proper straight lengths of inlet piping and long-radius elbows at pump inlets.
 - 2. Where straight piping length is not possible, provide suction diffusers. Suction diffusers shall have adequate space provided for strainer removal. Remove fine-mesh start-up strainers after system startup, and hang at pump for Architect/Engineer's approval.
- E. Support piping adjacent to pump such that no weight is carried on pump casings. Provide necessary brackets or hanger supports as required to relieve the stress on the pumps and piping. Refer to Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment".
- F. Provide line sized shut-off valve and strainer on pump suction, and properly sized soft seat spring-loaded check valve and balancing/flow-measuring/shutoff valve on pump discharge.
- G. Install a single pressure gauge on each pump, piped to suction and discharge with ball valves.
- H. Lubricate pumps before start-up.
- I. Provide labor and materials required to ensure that pump impellers are adequately sized to provide flow rates as indicated. This shall include, but not be limited to, trimming impellers.

END OF SECTION 232123

SECTION 232500 – HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Cleaning of piping systems.
- B. Chemical treatment.

1.2 SUBMITTALS

- A. Submit under provisions of Division 01 Section “Submittal Procedures.”
- B. Product Data: Provide chemical treatment materials, chemicals, and equipment including electrical characteristics and connection requirements.
- C. Manufacturer's Field Reports: Indicate start-up of treatment systems when completed and operating properly. Indicate analysis of system water after cleaning and after treatment.
- D. Submit certificate of compliance from authority having jurisdiction indicating approval of chemicals and their proposed disposal.

1.3 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Division 01 Section “Operation and Maintenance Data.”
- B. Operation and Maintenance Data: Include data on chemical feed pumps, agitators, and other equipment including spare parts lists, procedures, and treatment programs. Include step by step instructions on test procedures including target concentrations.

1.4 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum 3 years’ experience. Company shall have local representatives with water analysis laboratories and full time service personnel.
- B. Installer: Company specializing in performing the work of this Section with minimum 3 years’ experience and approved by manufacturer.

1.5 REGULATORY REQUIREMENTS

- A. Conform to applicable code for addition of non-potable chemicals to building mechanical systems, and for discharge to public sewage systems.
- B. Products Requiring Electrical Connection: Listed and classified by UL as suitable for the purpose specified and indicated.

1.6 MAINTENANCE SERVICE

- A. Furnish service and maintenance of treatment systems for 6 months from Date of Substantial Completion.

1.7 MAINTENANCE MATERIALS

- A. Provide maintenance materials under provisions of Division 01 Section "Product Requirements."
- B. Provide sufficient chemicals for treatment and testing during warranty period.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Chemical Treatment Systems Products, and Services:
 - 1. Barclay Water Management, Inc., Watertown, MA office.
 - 2. Nalco Company, Windham, ME office.
 - 3. Secondwind Water Systems, Inc., Manchester, NH office.
- B. Chemical Treatment Products:
 - 1. Nu-Calgon.
 - 2. Cascade Water Services, Inc.
 - 3. Culligan.
 - 4. DuBois Chemicals.
 - 5. H-O-H Water Technology, Inc.
 - 6. Wesco Chemicals, Inc.

2.2 MATERIALS

- A. System Cleaner:
 - 1. Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products.
- B. Closed System Treatment (Water):
 - 1. Sequestering agent to reduce deposits and adjust pH; polyphosphate.
 - 2. Corrosion inhibitors; liquid boron-nitrite, sodium nitrite and borax, sodium totyltriazone, low molecular weight polymers, phosphonates, sodium molybdate, or sulphites.
 - 3. Conductivity enhancers; phosphates or phosphonates.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Systems shall be operational, filled, started, and vented prior to cleaning. Use water meter to record capacity in each system.
- B. Place terminal control valves in open position during cleaning.
- C. Verify that electric power is available and of the correct characteristics.

3.2 CLEANING SEQUENCE

- A. Concentration:
 - 1. As recommended by manufacturer.
 - 2. 1 pound per 100 gallons of water contained in the system.
 - 3. 1 pound per 100 gallons of water for hot systems and 1 pound per 50 gallons of water for cold systems.
- B. Hot Water Heating Systems:
 - 1. Apply heat while circulating, slowly raising temperature to 160 degrees F and maintain for 12 hours minimum.
 - 2. Remove heat and circulate to 100 degrees F or less; drain systems as quickly as possible and refill with clean water.
 - 3. Circulate for 6 hours at design temperatures, then drain.
 - 4. Refill with clean water and repeat until system cleaner is removed.
- C. Use neutralizer agents on recommendation of system cleaner supplier and approval of Engineer/Engineer.
- D. Remove, clean, and replace strainer screens.
- E. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

3.3 INSTALLATION

- A. Install in accordance with manufacturer's instructions.

END OF SECTION 232500

SECTION 233113 – METAL DUCTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Metal Ductwork.

1.2 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. Division 23: Sensors and airflow measuring stations furnished under Division 23 Section “Instrumentation and Control for Mechanical Systems”; gauges and meters.

1.3 RELATED SECTIONS

- A. Division 23 Section “Testing, Adjusting and Balancing for HVAC.”
- B. Division 23 Section “Duct Insulation”: External insulation.

1.4 REFERENCES

- A. ASTM A90 - Standard Test Method for Weight of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
- B. ASTM A653 - Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- C. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
- D. AWS D9.1 - Welding of Sheet Metal.
- E. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
- F. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems.
- G. SMACNA - HVAC Duct Construction Standards - Metal and Flexible (SMACNA HVACDCS).
- H. UL 181 - Factory-Made Air Ducts and Connectors.

1.5 PERFORMANCE REQUIREMENTS

- A. No variation of duct configuration or sizes is permitted except by written permission from the Architect. Size proposed substitutions of round ducts in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts.

1.6 SUBMITTALS

- A. Submit under provisions of Division 01 Section “Submittal Procedures”.

- B. Shop Drawings: Indicate duct fittings, particulars such as gauges, sizes, welds, and configuration. Submit prior to start of work.
- C. Product Data: Provide data for duct materials, duct liner and duct connectors.
- D. Test Reports: Submit testing apparatus, procedures, and preliminary forms prior to performing tests. On final reports, indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA HVAC Air Duct Leakage Test Manual.

1.7 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Division 01 Section "Closeout Procedures."
- B. Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Indicate additional fittings used.

1.8 QUALITY ASSURANCE

- A. Perform Work in accordance with SMACNA HVACDCS.

1.9 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this Section with minimum 3 years' experience.
- B. Installer: Company specializing in performing the work of this Section with minimum 3 years' experience.

1.10 REGULATORY REQUIREMENTS

- A. Construct ductwork to NFPA 90A, NFPA 90B and NFPA 96 standards.

1.11 ENVIRONMENTAL REQUIREMENTS

- A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.
- B. Maintain temperatures during and after installation of duct sealants.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Manufactured Ductwork - Round:
 - 1. McGill AirFlow LLC, a subsidiary of United McGill Corporation.
 - 2. Aero Heating & Ventilating, Inc.; Portland, ME.
 - 3. Air Purchases, Inc.; Manchester, NH – spiral duct lengths.
 - 4. Atlantic Air Products LLC; Bow, NH.

5. Central City Sheet Metal; Brewer, Caribou, and Gorham, ME.
6. Hahnel Brothers; Bangor and Lewiston, ME.
7. Lindab, Inc. – duct fittings only.
8. Macy Industries, Inc.; Hookset, NH.
9. Monroe Metal Mfg. Inc.; Monroe, NC.
10. Northeastern Sheet Metal Inc.; Goffstown, NH.
11. Semco Inc., division of the Flakt Woods Group.
12. S.G. Torrice Co.; Wilmington, MA – spiral duct lengths.
13. Sheet Metal Connectors Inc.; Minneapolis, MN.
14. Spiral Manufacturing Co. Inc.; Minneapolis, MN.
15. Total Air Supply; Nashua, NH – spiral duct lengths.

B. Manufactured Ductwork - Transverse Duct Connection System:

1. Ductmate.
2. HFC Enterprises; Baldwin Park, CA – Dura Flange product line, for round and flat oval ducts only.

C. Sealants:

1. Hardcast, a division of Carlisle Corporation.
2. 3M Company.
3. Ductmate.
4. Foster.
5. McGill AirSeal LLC, a subsidiary of United McGill Corporation.
6. Mon-Eco Industries, Inc - Eco product line.
7. Polymer Adhesive Sealant Systems.

2.2 MATERIALS

A. Galvanized Steel Ducts:

1. Steel sheet metal components of galvanized ductwork in this Specification Section shall be galvanized steel sheet, lock-forming quality, having G60 or heavier zinc coating conforming to ASTM A653 rating system and tested in accordance with ASTM A90.
2. Sheet metal gauge shall be not less than 26 gauge (0.56 mm).

B. Aluminum Ducts: ASTM B209; aluminum sheet, alloy 3003-H14. Aluminum Connectors and Bar Stock: Alloy 6061-T6 or of equivalent strength.

C. Fasteners: Rivets, bolts, or sheet metal screws.

D. Sealants: See Duct Sealant portion of this Specification.

E. Hanger Rod: ASTM A36; galvanized steel; threaded both ends, threaded one end, or continuously threaded.

2.3 DUCTWORK FABRICATION

- A. Fabricate and support in accordance with SMACNA HVACDCS, as specified or as indicated on the drawings. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.
- B. SMACNA Duct Construction Manuals:
 - 1. The SMACNA recommendations shall be considered as mandatory requirements.
 - 2. Substitute the word "shall" for the word "should" in these manuals.
 - 3. Where the Contract Specifications differ from SMACNA recommendations, the more stringent requirements (as determined by the Architect) shall take precedence.
 - 4. Details on the Contract Drawings take precedence over SMACNA standards.
- C. Sheet metal shall be galvanized steel as specified in Part 2 paragraph "Materials" in this Section, unless otherwise indicated or specified.
- D. Construct Tees, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline.
 - 1. Where space is too restricted for full-radius elbows, provide mitered (square-throat) elbows with single wall turning vanes. Do not use air foil turning vanes.
 - 2. Mitered elbows in round or flat-oval ductwork shall be factory-manufactured.
 - 3. Radiused elbows with throat radius 1/2 times width of duct (centerline radius 1 width of duct) may be used instead of mitered elbows, but only where space is too restricted for full radius.
 - 4. Fittings not conforming to these requirements will be ordered removed and replaced with proper fittings.
- E. Increase duct sizes gradually, not exceeding 15 degrees divergence or convergence (per side) wherever possible; maximum 30 degrees divergence (per side) upstream of equipment and 45 degrees convergence (per side) downstream.
- F. Fabricate continuously welded round and oval duct fittings two gauges heavier than duct gauges indicated in SMACNA Standard. Joints shall be minimum 4 inch (100 mm) cemented slip joint, brazed or electric welded. Prime coat welded joints.
- G. Provide standard 45 degree lateral wye takeoffs unless otherwise indicated where 90 degree conical tee connections may be used.
- H. Longitudinal locks or seams known as "button-punch-snap-lock" and other "snap-lock" types will not be permitted in rectangular duct. Snap-lock longitudinal seams may be used on round ducts up to 8 inches diameter, with screws provided to secure the seams at 24 inches (609 mm) on center maximum spacing.
- I. Exposed Ducts: Select and handle materials with care for a neat appearance.

2.4 MANUFACTURED DUCTWORK AND FITTINGS

- A. Manufactured ductwork and fittings listed below are acceptable alternatives to standard ductwork systems.
- B. Manufacture in accordance with SMACNA HVACDCS, and as specified or as indicated on the drawings. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.
- C. Galvanized steel sheet metal used in fabrication shall be not less than 26 gauge (0.551 mm) thickness. Aluminum shall be not less than 0.025 in. (0.635 mm) nominal thickness. This requirement supersedes SMACNA requirements.
- D. Round Duct and Fittings:
 - 1. Shall be suitable for at least 4 in. WG (996 Pa) positive pressure and 2 in. WG (498 Pa) negative pressure in accordance with SMACNA HVACDCS standards. This is a minimum; provide higher ratings where required.
 - 2. Fittings shall be fabricated of sheet metal at least one gauge heavier than straight duct of the same size.
 - 3. Fittings shall be factory-sealed so that no field sealing of joints between gores or segments is required. Acceptable methods of construction are fully welded, spot-welded with inner sealant, or standing-seam crimped joints.
- E. Radiused Elbows in Round Ductwork:
 - 1. In exposed ductwork shall be non-adjustable type, factory-sealed.
 - 2. In concealed ductwork may be adjustable type, with full long radius as detailed on the Drawings. Short-radius elbows are not allowed.
 - 3. Shall be constructed of the following minimum number of segments or gores: 90-degree: 4 gores; 60-degree: 3 gores; 45-degree: 3 gores; 30-degree: 2 gores; 22-1/2-degree: 2 gores.
 - 4. 1-piece stamped elbows are acceptable up to 12 inches (305 mm) diameter. Pleated elbows are acceptable up to 10 inches (254 mm) diameter.
- F. Inner tie-rod reinforcement not allowed; increase metal gauge or reinforcement as required.
- G. Transverse Duct Connection System: SMACNA "F" rated or SMACNA "J" rated rigidity class connection, interlocking angle and duct edge connection system with sealant, gasket, cleats, and corner clips. Product shall be Ductmate factory-manufactured connectors, or field-formed flanges using a specialized machine.

2.5 PRESSURE CLASSIFICATION

- A. Ratings as indicated on the Drawings or as specified. See Ductwork Pressure Class Schedule in Part 3 of this Section.

2.6 DUCT SEALING

- A. Seal ductwork as outlined in the SMACNA HVACDCS. Seal ductwork to class A (transverse joints, longitudinal seams, and duct wall penetrations), regardless of pressure class.
- B. Seal ductwork systems as required to ensure that maximum duct leakage does not exceed that allowed by the latest edition of the SMACNA HVAC Air Duct Leakage Test Manual. Allow sealant to dry in accordance with manufacturer's requirements of time and environmental conditions before ductwork systems are pressurized.
- C. Seal Pittsburgh hammered lockseams by flooding the joint with sealant prior to assembly.
- D. Seal exposed ducts by applying mastic-type or gasket-type sealer just before the joint or seam is made; remove excess sealant for a neat appearance.
- E. Fill (with matching duct sheet metal) any gaps in duct which exceed the recommendations of the sealant manufacturer, and in no case shall liquid or mastic sealant be used to fill gaps or openings which exceed 1/8 inch (3.2 mm) in any direction. Verify that system air pressure acting on a wide gap will not exert enough force to damage or loosen the sealant.
- F. Materials for Sealing: Non-flammable and non-combustible in both liquid and solid states.
 - 1. Hardcast: Flex-Grip 550 or Iron-Grip 601 mastic.
 - 2. Hardcast: gypsum-based tape and mastic, waterproof type.
 - 3. Ductmate: Flanged lateral joints with gaskets.
 - 4. Ductmate: PROseal.
 - 5. Foster: Duct-Fas or Safetee mastic sealant.
 - 6. Mon-Eco: Eco-Duct Seal 4450 (red color) or 4452 (grey color).
 - 7. Polymer Adhesives Sealant Systems: Airseal No. 11 premium sealant.

2.7 UNIFORMITY OF MATERIALS

- A. Fabricate ductwork accessories of materials similar to the ductwork in which they are installed.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Inspect existing conditions. Where existing components such as duct access doors would interfere with mounting ductwork in the highest possible position, relocate the components, and cut and patch ductwork and insulation as necessary.

3.2 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install duct-mounted components furnished under other Sections and Divisions of the Specifications.

- C. Install ducts in accordance with SMACNA HVACDCS.
- D. Duct Sizes are inside clear dimensions. For lined ducts, maintain sizes inside lining.
- E. “Fishmouth” duct connections are not allowed.
- F. Inner tie-rod reinforcement is not allowed. Increase duct sheet metal gauge or external reinforcement as required.
- G. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- H. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- I. Use crimp joints with or without bead for joining round duct sizes 8 inch (200 mm) and smaller with crimp in direction of air flow.
- J. Use double nuts and lock washers on threaded rod supports. Strap hangers shall be minimum 16 gauge (1.50 mm) x 1 inch (25 mm) galvanized straps. Hanger and support components including but not limited to “unistrut” shall be galvanized steel except that where other duct materials are used, the hanger materials shall be compatible and non-corrosive to the duct. Wire hangers are not acceptable.

3.3 SCHEDULES

A. Ductwork Material Schedule

AIR SYSTEM	MATERIAL
Combustion Air	Galvanized Steel, Aluminum

B. Ductwork Pressure Class Schedule

AIR SYSTEM	SMACNA PRESSURE CLASS
Combustion Air	2 inch (500 Pa)

END OF SECTION 233113

SECTION 235100 – BREECHINGS, CHIMNEYS, AND STACKS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Manufactured breechings for high-efficiency gas fired equipment.
- B. Manufactured stacks for high-efficiency gas fired equipment.

1.2 REFERENCES

- A. ASTM A167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
- B. ASTM A525 - Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, General Requirements.
- C. ASTM A527 - Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality.
- D. ASTM A569 - Steel, Sheet and Strip, Carbon (0.15 Maximum Percent) Hot-Rolled Commercial Quality.
- E. NFPA 54 (ANSI Z223.1) - The National Fuel Gas Code.
- F. NFPA 82 - Standard on Incinerators, Waste, and Linen Handling Systems and Equipment.
- G. NFPA 211 - Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances.
- H. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
- I. UL 959 (ANSI Z181.1) - Medium Heat Appliance Factory Built Chimneys.
- J. UL 1738 - Venting Systems for Gas-Burning Appliances, Categories II, III, and IV.

1.3 DEFINITIONS

- A. Breeching: Vent Connector.
- B. Chimney: Primarily vertical shaft enclosing at least one vent for conducting flue gases outdoors.
- C. Smoke Pipe: Round, single wall vent connector.
- D. Vent: That portion of a venting system designed to convey flue gases directly outdoors from a vent connector or from an appliance when a vent connector is not used.

- E. Vent Connector: That part of a venting system that conducts the flue gases from the flue collar of an appliance to a chimney or vent, and may include a draft control device.

1.4 DESIGN REQUIREMENTS

- A. Breechings, vents, stacks, and chimneys used for venting boilers shall be factory-built, and shall comply with NFPA 211 and be UL listed and labeled.

1.5 SUBMITTALS FOR REVIEW

- A. Division 01 Section "Submittal Procedures": Procedures for submittals.
- B. Shop Drawings: Indicate general construction, dimensions, weights, support and layout of breechings and stacks. Submit layout drawings indicating plan view and elevations where factory built units are used. Submit to indicate fittings and accessories, and provisions for thermal expansion.
- C. Product Data: Provide data indicating factory built chimneys, including dimensional details of components and flue caps, dimensions and weights, electrical characteristics and connection requirements.
- D. Clearances to Combustibles: Submit requirements for clearances. The required clearances to combustible materials for submitted products shall be equal to or less than the clearances required for the basis-of-design products.
- E. Warranty: Submit warranties, and any required warranty activation forms and instructions, prior to purchasing products. At completion of installation, and within any time limitations required by the manufacturer, assist the Owner in filling out and submitting required forms to the manufacturer.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this Section with minimum 3 years' experience.
- B. Installer Qualifications: Company specializing in performing the work of this Section with minimum 3 years' experience.
- C. Design breechings and stacks under direct supervision of a Professional Structural Engineer experienced in design of this Work and licensed at the place where the Project is located.

1.7 REGULATORY REQUIREMENTS

- A. Conform to NFPA 54 (ANSI Z223.1) code for of natural gas and liquefied petroleum (LP) gas burning appliances and equipment.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories, Inc., as suitable for the purpose specified and indicated.

PART 2 - PRODUCTS

2.1 BREECHING - DOUBLE-WALL SPECIAL VENT SYSTEM

- A. Verify approval of appliance and the appliance manufacturer's requirements, prior to submitting vent system.
- B. Manufacturers (subject to approval by the appliance manufacturer):
 - 1. Metal-Fab, Corr/Guard FCS-1.
- C. The system shall be a factory-built special gas vent and connector system, tested and listed in accordance with Underwriters Laboratories UL 1738 for use with Listed natural gas or propane burning equipment that produce flue-gas temperatures not above 550 degrees F. The system shall be listed as vents (horizontal or vertical) for gas burning appliances, suitable for ANSI Category I, II, III, and IV Gas-Burning Appliances. The system inner liner shall be fabricated from AL29-4C (or Metal-Fab's UNS S44735) superferritic stainless steel, suited for use with high efficiency condensing gas burning equipment, at least 0.015 inches thick. The outer wall shall be type 430 stainless steel, at least 0.024 inches thick. The interstitial space between inner liner and outer wall shall be filled with ceramic fiber insulation.
- D. Clearances: When connected to gas-burning appliances operating at a maximum flue-gas temperature of 550 degrees F, in the following sizes, the system shall be rated to be installed with the following clearances to combustible materials:
 - 1. Vertical, full-enclosed: 1 inch clearance.
 - 2. Vertical or horizontal, unenclosed: 1 inch clearance in inner sizes up to 12 inches.
- E. Joints in the system shall be fastened with manufacturer's closure system and sealed with manufacturer's sealant. This closure system shall be rated to be gas tight at the Listed pressure rating.
- F. Size the system in accordance with the appliance manufacturer's specifications, NFPA 54, NFPA 211, and local codes. Submit manufacturer's verification of sizing. Notify the Engineer if the manufacturer's calculated inner diameter differs from that indicated.
- G. Accessories:
 - 1. Drain Tee: Provide horizontal tee section, with bottom drain tee cap with end closure and drain piping connection. Locate tee in visible location for ease of service.
 - 2. Drain Tubing: Clear or translucent silicone or PTFE, rated service temperature 500 degrees F. Provide required length to extend to condensate neutralizer and floor drain.
 - 3. Condensate neutralization trap or cartridge, with union or clamp connections and refillable neutralizing media.
 - 4. Appliance adapter with coupler.
 - 5. Expansion fittings.
 - 6. Vee bands to connect components together, and draw bands to finish the outer jacket.
 - 7. Sealant: Metal-Fab P077 sealant, as recommended by the manufacturer.
 - 8. Supports.

9. Transition to single-wall stack.
10. Thimble for penetration of masonry chimney.

H. Warranty: Limited lifetime warranty for repair or replacement of parts.

2.2 STACK - SINGLE-WALL SPECIAL GAS VENT SYSTEM

- A. Verify approval of appliance and the appliance manufacturer's requirements, prior to submitting vent system.
- B. Manufacturers (subject to approval by the appliance manufacturer):
 1. Metal-Fab, Corr/Guard FCSSW.
- C. The system shall be a factory-built special gas vent and connector system, tested and listed in accordance with Underwriters Laboratories for use with Listed natural gas burning equipment that produce flue-gas temperatures not above 550 degrees F. The system shall be listed as vents (horizontal or vertical) for gas burning appliances, suitable for ANSI Category I, II, III, and IV Gas-Burning Appliances. The system shall be fabricated from AL 29-4C (or Metal-Fab's UNS S44735) superferritic stainless steel, suited for use with high efficiency condensing gas burning equipment, at least 0.015 inches thick.
- D. Clearances: When connected to gas-burning appliances with the following maximum continuous flue-gas temperature ratings, the system shall be rated to be installed with the following clearances to combustible materials:
 1. Vertical or horizontal, unenclosed: 2 inch clearance in inner sizes up to 12 inches.
- E. Joints in the system shall be fastened with manufacturer's closure system and sealed with manufacturer's sealant. This closure system shall be rated to be gas tight at the Listed pressure rating.
- F. Size the system in accordance with the appliance manufacturer's specifications, NFPA 54, NFPA 211, and local codes. Submit manufacturer's verification of sizing. Notify the Engineer if the manufacturer's calculated inner diameter differs from that indicated.
- G. Accessories:
 1. Expansion fittings.
 2. Vee bands to connect components together, and draw bands to finish the outer jacket.
 3. Sealant: Metal-Fab P077 sealant, as recommended by the manufacturer.
 4. Supports.
 5. Stack top guide or support plate of stainless steel to fit existing masonry chimney cap.
 6. Termination: Top stack cap with large-mesh bird screen.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NFPA 54 (ANSI Z223.1).
- C. Pitch breechings with positive slope up from fuel-fired equipment to chimney or stack.
- D. Install vent dampers, locating close to draft hood collar, and secured to breeching.
- E. Assemble and install stack sections in accordance with NFPA 82, industry practices, and in compliance with UL listing. Join sections with manufacturer's recommended acid-resistant joint sealant, vee bands, and outer draw bands.
- F. Level and plumb chimney and stacks.
- G. Clean breechings, chimneys, and stacks during installation, removing dust and debris.
- H. At appliances, provide slip joints permitting removal of appliances without removal or dismantling of breechings, breeching insulation, chimneys, or stacks.
- I. Drain Tee. Locate tee in breeching, in visible location for ease of service. Pipe with non-corrosive stainless steel ball valve, and provide discharge tubing and condensate neutralization chamber with unions for service. Pipe discharge of neutralization chamber to floor drain with air gap. Support tubing at close intervals to prevent excess sagging.

END OF SECTION 235100

SECTION 235216 - CONDENSING BOILERS

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. This Section includes packaged, factory-fabricated and assembled, gas-fired, condensing boilers, trim, and accessories for generating hydronic heating-system hot water.

1.3 SUBMITTALS

- A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
- B. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
- C. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Source quality-control test reports.
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.
- G. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this Section with minimum 3 years' experience.
- B. Installer Qualifications: Company specializing in performing the work of this Section with minimum 3 years' experience.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.

- E. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
- F. UL Compliance: Test boilers for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.
- G. Source Quality Control: Test and inspect boilers according to the ASME Boiler and Pressure Vessel Code, Section IV. Boilers shall be test fired in the factory, and a report attached permanently to the exterior cabinet of the boiler for field reference.

1.5 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

1.6 WARRANTY

- A. Warranty: As specified in Section 230500 – COMMON WORK RESULTS FOR HVAC.
- B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of boilers which fail in materials or workmanship within specified warranty period. See the Article for each type of boiler for applicable warranties.

PART 2 - PRODUCTS

2.1 BOILER TYPES

- A. Basis of Design Boiler Type:
 - 1. Stainless steel 1-pass down fired firetube type.
- B. Allowable Substitute Boiler Type:
 - 1. Alu-Fer 1-pass down fired firetube type.
- C. Boiler types shall conform to their specifications in this Section. Boilers which do not conform, or are of types other than those specified, are not allowed.

2.2 CONDENSING BOILERS – STAINLESS STEEL 1-PASS DOWN-FIRED FIRETUBE TYPE

- A. Manufacturers:
 - 1. Aereco – Benchmark Standard and Benchmark Platinum product lines.
 - 2. No substitutions.
- B. General Description: Factory-fabricated-and-assembled, factory-pressure tested, one-pass down-fired firetube condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket, flue-gas vent, combustion-air intake connections, water supply, return, condensate drain connections, and controls. Water heating service only.

- C. Certification: ASME Section IV pressure vessel code, stamped and certified.
- D. Heat Exchanger: Stainless steel, Type 439 fire tubes and tubesheets, all-welded construction.
- E. Pressure Vessel: Carbon steel, with inspection openings in accordance with ASME Section IV pressure vessel code.
- F. Burner: Natural gas, sealed combustion, forced draft. Stainless steel knitted metal fiber, vertical mounted.
- G. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber. Modulation by variable frequency drive or equivalent.
- H. Motors: Sized large enough so driven load will not require motor to operate in service factor range above 1.0.
- I. Gas Train: Combination gas valve providing slow opening and fast closing with proportional air/gas ratio control. Fast closing safety shutoff pressure regulator. Low pressure and high pressure gas safety switches. Manual shutoff valve.
- J. Ignition: Spark or proven-pilot ignition with electronic flame supervision, pre-purge and post-purge.
- K. Casing:
 - 1. Jacket: Plastic and sheet metal, fully removable without the need for tools.
 - 2. Insulation: Glass fiber insulation surrounding the heat exchanger.
 - 3. Vent Manifold: Cast aluminum or Type 316 stainless steel.
 - 4. Combustion-Air Connections: Inlet and vent duct collar.
 - 5. Mounting base to secure boiler.
 - 6. Access: For cleaning fire tubes and water-side of heat exchanger.
- L. Characteristics:
 - 1. Heating Medium: Hot water.
 - 2. Design Water Pressure Rating: 150 psig.
 - 3. Minimum Entering-Water Temperature: 50 deg F.
 - 4. Maximum Leaving-Water Temperature: 190 deg F.
- M. Trim:
 - 1. Provide devices sized to comply with ANSI B31.9, "Building Services Piping."
 - 2. Safety Relief Valve: ASME rated. Setting as scheduled on the Drawings.
 - 3. Flow switch for field installation.
 - 4. Pressure and Temperature Gage: Minimum 3-1/2 inch diameter, combination water pressure and temperature gage. Gage shall have operating ranges selected so that normal operating range is about 50 percent of full range.
 - 5. Drain Valve: Minimum NPS 3/4 hose-end ball or gate valve. Sized as required by applicable State and local Codes and regulations.

N. Controls:

1. Refer to Division 23 Section "Instrumentation and Control for HVAC."
2. Aerco "C-More" touchscreen electronic proportional integrated combination ignition limit/operator control with 2 deg. F (3.6 deg. C) accuracy, selectable differential from setpoint of 0 to 10 deg. F (0 to 18 deg. C). Lead-lag cascade ready for control of up to eight boilers of the same type, providing indoor-outdoor temperature setpoint reset and lead-lag control. Capable of receiving inputs from remote 4-20 mA setpoint and modulating control signals, compatible with the existing Raypak wall-mounted controller. Touchscreen display with full diagnostics and real-time data logging.
3. Automotive-type oxygen sensor mounted into the combustion chamber to monitor exhaust gases and adjust blower speed to maintain optimal air-fuel ratios, with warnings and alerts for out-of-range and out-of-calibration.
4. Building Automation System Interface: RS-485 Modbus protocol, capable of communicating with the existing Building Management System (BMS). Factory installed hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.
 - a. A communication protocol converter may be provided, with protocol as required by the BMS; see schedule on Drawings.
5. Controller mounting on boiler front panel with hinged door for access to the control modules.
6. Safety controls including low gas pressure, high gas pressure, manual-reset high limit, stack limit, water flow switch, flame rectification,

O. Venting:

1. Exhaust: Refer to Division 23 Section "Breechings, Chimneys and Stacks."
2. Combustion-Air Intake: Polypropylene vent pipe

P. Warranties: Periods from date of Substantial Completion, non-prorated.

1. Heat exchanger general leakage due to condensate corrosion, thermal stress, mechanical defects or workmanship: 10 years.
2. Manufacturer-labeled control panels: 2 years.
3. Igniter, flame detector and O₂ sensor: 2 years from startup.
4. Other components: 2 years from startup.

Q. Manufacturer's Field Services:

1. General: The boiler supplier's factory authorized service organization shall be responsible for performance of inspections, start-up and testing of the package boiler, and accessory equipment and materials furnished under this Section. Submit a detailed written record of the start-up performance, including burner setting data over the entire load range, to the Engineer/Engineer before final acceptance. Necessary labor, equipment, and test apparatus shall be furnished by the authorized service organization. Equipment defects discovered by the tests shall be rectified either by the service organization or boiler manufacturer.

2. Start-up shall be conducted by experienced and factory authorized technician in the regular employment of the authorized service organization, and shall include:
 - a. Demonstrate that boiler, burner, controls, and accessories comply with requirements of this Section as proposed by the boiler and accessories supplier.
 - b. Readings at different firing rates (20, 50, 75 and 100 percent) of load for the modulating burner shall be taken, with a written report of the tests submitted to the Engineer/Engineer. The reports shall include readings for each firing rate tested and include stack temperatures, O₂, CO, NO_x, and overall boiler efficiency.
 - c. Auxiliary Equipment and Accessories: Observe and check valves, draft fans, electric motors and other accessories and appurtenant equipment during the operational and capacity tests for leakage, malfunctioning, defects, and non-compliance with referenced standards or overloading as applicable.
3. Training shall include safety procedures, maintenance procedures, control operations, and diagnostic procedures. Demonstrate the inclusion of maintenance requirements throughout the operating and maintenance manuals as part of the training. Training shall be provided in a single continuous 8-hour session to accommodate Contract Representative's operator's availability on site.

2.3 CONDENSING BOILERS – ALU-FER 1-PASS DOWN-FIRED FIRETUBE TYPE

- A. Manufacturers:
 1. Cleaver Brooks – Clearfire-CE product line.
 2. No substitutions.
- B. General Description: Each unit shall be a single-pass down-fired firetube type complete with boiler fittings and automatic controls. The boiler, with its piping and wiring, shall be factory packaged. Each boiler shall be neatly finished, thoroughly tested and packaged for shipping. Boiler design and construction shall be in accordance with Section IV of the ASME Code for hot water heating boilers with a maximum working pressure of 125 psig. The boiler shall be CSA (formerly AGA/ CGA) certified as an indirect or direct vent boiler and comply with ASME CSD-1 Code requirements.
- C. Performance: The capacity of each unit shall be indicated on the Drawing schedule.
 1. Burner Turndown Ratio: 5:1.
 2. NOX Emission (maximum): 20 PPM (corrected to 3 percent O₂).
 3. CO Emissions (maximum): 10 PPM (corrected to 3 percent O₂).
 4. Electrical: 115-120 V, 60Hz, 1 phase.
 5. Noise Level: 70 dBA maximum.
- D. Noise Sound Levels: Based on ABMA test code for packaged boilers measured at 4.5 feet vertically above the bottom of the base and 3 feet horizontally in front of the end of the burner or front surface of control cabinet. Sound levels shall be dBA on the scale in reference to 0.0002 microbars.

E. Boiler Design:

1. Boiler shall be a compact, single-pass, vertical down-fired firetube type, with stainless steel tubes and tube sheets. The boiler pressure vessel shall be completely insulated with a minimum of 2 in. of insulation and shall be encased in an 18 gauge metal cabinet with powder coated finish. To prevent installation damage, the casing shall be packaged separately and shall ship loose for field installation by the manufacturer's service representative.
2. The condensing tubes shall be Cleaver-Brooks AluFer tubes, with inner (fireside) aluminum alloy finned surface, die-fitted within an outer tube of UNS S32101 Duplex Stainless Steel. Internal fins shall provide no less than 10 square feet of fireside heating surface per boiler horsepower.
3. The Vessel shall be mounted on a structural steel stand with exhaust gases collected in a polymer drain collection box complete with drain fitting for draining condensation from the products of combustion.
4. A condensate neutralizing box or cartridge with neutralizing media of limestone granules shall be shipped loose for field installation.
5. The top tubesheet shall be fully accessible by lifting the burner assembly which shall be factory-equipped with lifting hinges and pneumatic lifters. The boiler shall have a built-in hinged platform allowing the operator to access the tubesheet, burner, ignition assembly and flame rod without the use of a ladder.
6. The vessel shall be fully insulated with a minimum of 2 in. of insulation, guaranteeing external convection and radiation heat losses to the boiler room from the boiler shall be less than 0.5 percent of the rated input.
7. The condensing capability shall allow the boiler to be operated without the use of a 3-way valve for the boiler supply water temperature reset. No minimum boiler return water temperature or secondary pump or minimum flow rate shall be required.
8. Each boiler shall be constructed in accordance with the A.S.M.E. Section IV Code and bear the "H" stamp.
9. The boiler shall be designed for top water outlet and bottom rear water inlet. The standard water inlet shall be piped to the condensing end of the boiler's heat exchanger, and shall be equipped with internal baffling. In addition, the boiler shall include a high-temperature return inlet connection which allows returning 0-100 percent of the return water to the high-temperature section of the boiler. Inlet and outlet connections shall be flanged.
10. The maximum pressure drop through the boiler shall not exceed 1.4 psi with a 20 degrees F differential and less than 0.4 psi with a 60 degrees F differential.
11. A threaded air vent connection shall be furnished at the top rear of the boiler for field piping to an expansion tank or for the addition of an auto-vent valve when a bladder type expansion tank is utilized.
12. To drain the boiler, a bottom-threaded connection shall be provided at the front of the boiler and field piped by the installing contractor with a manual full-size shutoff valve to drain.

F. Burner Design:

1. General: Forced draft burner mounted in and integral with the boiler hinged top door so when the door is opened the burner head, furnace, tubesheet, and tubes are exposed. The burner door shall utilize easy removable threaded handles, and the burner shall swing

- upward on hydraulic piston arms, one on each side to provide open support of the burner assembly.
2. A drop down hinged service platform shall be furnished to provide service personnel an easy means of accessing the burner and controls for service and maintenance. When out of use, this platform shall fold up beneath the front service boiler panel.
 3. The burner shall be of the Unitized Venturi, Gas Valve, Blower, and burner head design. This pre-mix design shall utilize a variable speed fan connected to a venturi to simultaneously modulate fuel and air for a minimum 5:1 turndown ratio. The venturi design shall also act as a method for compensating for changes in barometric pressure, temperature and humidity so the excess air levels are not adversely affected by changes in atmospheric conditions. External linkages, damper motor drives and single speed fans shall not be acceptable.
 4. Burner head shall be constructed of a Fecralloy-metal fiber for solid body radiation of the burner flame. Combustion shall take place on the surface of the burner mantle, which shall be constructed of a woven fecralloy material creating a 360 degree low temperature radiant flame.
 5. Emissions: The boiler(s) burner shall be guaranteed to limit NO_x emissions to 20 PPM or less, as certified by an independent testing lab. NO_x emissions shall be at full operating conditions. Proof of such certification shall be made available to the Engineer/Engineer and Contract Representative. External flue gas recirculation shall not be accepted for emission control.
 6. Gas Train - As a minimum, the gas train shall meet the requirements of CSA and ASME CSD-1 and shall include:
 - a. Low Gas Pressure Interlock, manual reset.
 - b. High Gas Pressure Interlock, manual reset.
 - c. Upstream and downstream manual test cocks.
 - d. Ball Type manual shutoff valve upstream of the main gas valve.
 - e. Unibody double safety gas valve assembly.
 - f. Gas Pressure Regulator
 - g. Union connection to permit burner servicing.
 7. Combustion Air Proving Switch shall be furnished to ensure sufficient combustion airflow is present for burner firing.
 8. To ensure that proper draft is not blocked in the stack, the burner shall include a High Air Pressure Switch sensing the outlet pressure connection relative to stack back draft.

G. Boiler Trim:

1. Safety valve(s) shall be ASME Section IV approved side outlet type mounted on the boiler water outlet. Size shall be in accordance with code requirements and set to open at no less than the pressure rating of relief valves on the existing boilers.
2. Temperature and pressure gauge shall be mounted on the water outlet.
3. Solid State Low water cut-off probe with manual reset and test switch.
4. Outlet water supply sensing probe for operating water limit setpoint.
5. Return water-sensing probe for operating water limit setpoint.

H. Boiler Controls:

1. The Boiler shall include a Falcon Computerized Boiler Burner control which shall be an integrated, solid state digital micro- processing modulating device, complete with sequence indication, fault reset, mode selection, and parameter set-point. It shall be mounted at the front of the boiler panel for easy access and viewing.
2. Controller shall provide for both flame safeguard and boiler control and shall perform the following functions:
 - a. Burner sequencing with safe start check, pre-purge, Electronic direct spark ignition, and post purge. Flame rod to prove combustion.
 - b. Flame Supervision - The control shall provide pre-purge and post-purge and shall maintain a running history of operating hours, number of cycles, and the most recent 15 faults. The control shall be connected to a touchscreen display that will retrieve this information.
 - c. Safety Shutdown with display of error.
 - d. Modulating control of the variable speed fan for fuel/air input relative to load requirements.
 - e. Gas pressure supervision, high and low.
 - f. Combustion Air Proving Supervision.
 - g. The supply temperature and set-point temperature shall be displayed at all times on the touch screen display.
 - h. Controller shall be equipped with a touch screen display for set up, trouble shooting, and operational display, and shall include ModBus communication capability of this information.
 - i. Include the programming of system circulating pump and provide the programming of 2 heating loops.
3. The parameter input control set-points shall be factory downloaded with jobsite conditions programmed at the time of initial jobsite operation.
4. The controls shall be panel mounted and so located on the boiler as to provide ease of servicing the boiler without disturbing the controls, and located to prevent possible damage by water according to UL requirements.
5. Electrical power supply shall be 120 volts, 60 cycle, single phase for the fan and 120 volts for control circuit requirements.
6. System shall be capable of staging up to up to 8 boilers of the same type in a lead/ lag configuration. The control shall include automatic selection of needed boilers based on energy demand, an adjustable outdoor reset schedule, domestic hot water priority, and a system display. The control shall force each boiler to a lower fire before allowing any boiler to operate at high fire, allowing for inverse efficiency (lower fire rate, higher efficiency). The control shall monitor supply and return water temperature and shall communicate between boilers via RS-485 wiring.

I. Boiler Flue Venting:

1. Boiler shall be suitable for venting with a category II, III, or IV vent piping as appropriate to the installation. Venting shall be installed in accordance with applicable national and local codes.

2. For direct venting, the boiler shall be suitable for having the combustion air intake supply ducted with PVC pipe from the outside. Vibration of the boiler shall be low such that isolation components are not recommended by the manufacturer for any type of building occupancy.

J. Manufacturer's Field Services:

1. General: The boiler supplier's factory authorized service organization shall be responsible for performance of inspections, start-up and testing of the package boiler, and accessory equipment and materials furnished under this Section. Submit a detailed written record of the start-up performance, including burner setting data over the entire load range, to the Engineer/Engineer before final acceptance. Necessary labor, equipment, and test apparatus shall be furnished by the authorized service organization. Equipment defects discovered by the tests shall be rectified either by the service organization or boiler manufacturer.
2. Equipment Inspection: Boiler representative shall provide 8 hours of jobsite assistance to inspect boilers and other equipment upon arrival, verifying completeness of equipment supplied and potential damages. Shipped-loose components, such as casing, shall be mounted on the boiler by the boiler provider after the Contractor has set the boiler in the building.
3. Pre-Start-up Walk-Through: Boiler representative shall spend 8 hours at the jobsite reviewing the installation with the Mechanical Subcontractor. The walk-through shall be conducted approximately 1 week prior to start-up.
4. Start-up shall be conducted by experienced and factory authorized technician in the regular employment of the authorized service organization, and shall include:
 - a. Demonstrate that boiler, burner, controls, and accessories comply with requirements of this Section as proposed by the boiler and accessories supplier. Pre-test items prior to scheduling the final testing that will be witnessed by the manufacturer's test engineer.
 - b. Readings at different firing rates (20, 50, 75 and 100 percent) of load for the modulating burner shall be taken, with a written report of the tests submitted to the Engineer/Engineer. The reports shall include readings for each firing rate tested and include stack temperatures, O₂, CO, NO_x, and overall boiler efficiency.
 - c. Auxiliary Equipment and Accessories: Observe and check valves, draft fans, electric motors and other accessories and appurtenant equipment during the operational and capacity tests for leakage, malfunctioning, defects, and non-compliance with referenced standards or overloading as applicable.
 - d. Commissioning Requirements:
 - 1) Fireside inspection.
 - 2) Set up fuel train and combustion air system.
 - 3) Set up operating set points.
 - 4) Check safeties, including flame safeguard, LWCO, airflow, fuel pressures, and high limits.
 - 5) Set up and verify efficiencies at 20 percent, 50 percent, 75 percent, and 100 percent.
 - 6) Set up and verify burner turndown.

5. Training shall include safety procedures, maintenance procedures, control operations, and diagnostic procedures. Demonstrate the inclusion of maintenance requirements throughout the operating and maintenance manuals as part of the training. Training shall be provided in a single 8-hour continuous session to accommodate Contract Representative's operator's availability on site.

K. Operating & Maintenance Manuals:

1. Provide 2 Operating and Maintenance manuals including cut-away views of boiler and burner, schematics including fuel trains, general instructions for maintenance and inspections, complete spare parts lists and trouble-shooting procedures.
2. A wiring diagram corresponding to the boiler shall be affixed to the boiler near the electrical panel.

L. Warranty Data:

1. The pressure vessel shall be guaranteed against thermal shock for 20 years when utilized in a closed loop hydronic heating system with a temperature differential of 170 degrees F (94 degrees C) or less. The boiler pressure vessel shall be guaranteed accordingly without a minimum flow rate or return water temperature requirement. The boiler shall not require the use of flow switches or other devices to ensure minimum flow.
2. The pressure vessel, tubes and tube sheets (heat exchanger) shall be guaranteed against flue gas corrosion and materials/workmanship for a period of 10 years.
3. Parts not covered by the above warranties shall carry a 2 year warranty from startup. This shall include the electrical components and burner components.

2.4 LOW-WATER CUT OFF

A. Manufacturers:

1. McDonnell & Miller - Model 751P-MT-120.
2. Hydrolevel Company – Safgard Model 550.

B. Probe-type control to prevent burner operation when boiler water falls below safe level, with manual reset button with memory circuit to meet the requirements of ASME CSD-1, test button, green power indicator LED, red low water LED, probe to fit threaded pipe connection, and NEMA 1 enclosure. Power failures and air bubbles will not cause a lockout, and power failures will not cause the control to come out of a low-water lockout. Maximum water pressure 160 psig (1103 kPa). UL and CSA listed, FM approved.

C. Low-Water Cutoff shall mounted in piping external to the boiler, and shall be in addition to any low-water protection devices furnished integral to the boiler.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.
 - 1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
- B. Examine mechanical spaces for suitable conditions where boilers will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

- A. Install boilers level on existing raised concrete housekeeping base, set so that housekeeping base extends at least 4 inches beyond boiler base. Fasten boiler to base.
- B. Install, start, and test boilers and their accessories in accordance with the manufacturer's instructions and these Specifications. In the case of conflicting instructions, the more stringent shall apply.
- C. Install gas-fired boilers according to NFPA 54.
- D. Assemble and install boiler trim.
- E. Assemble and install boiler accessories
- F. Install electrical devices furnished with boiler but not specified to be factory mounted.
- G. Provide control wiring and conduit to field-mounted electrical devices.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to boiler with clearances and fittings to allow service and maintenance.
- C. Connect hot-water piping to supply- and return-boiler tapings with shutoff valve and union or flange at each connection. Provide a fitting to install the low-water cutoff above the boiler's heat exchanger.
- D. Pipe safety relief valves to above nearest floor drain with an air break. Piping shall be at least full size of connection. Do not combine piping from individual valves, unless recommended and sized by the boiler manufacturer.

- E. Pipe equipment drain connections to above the nearest floor drain with an air break. Piping shall be at least full size of connection. Provide an isolation valve at each connection if not factory-furnished.
- F. Pipe condensate drains to floor drain from boiler and vent stack with condensate neutralization devices.
- G. Boiler Venting:
 - 1. Connect full size to boiler connections.
 - 2. Comply with requirements in Division 23 Section "Breechings, Chimneys, and Stacks."
- H. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.
- I. Ground equipment according to Division 26 Section "Grounding and Bonding."
- J. Connect wiring according to Division 26 Section "Wire and Cable."

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 1. Perform installation and startup checks according to manufacturer's written instructions.
 - 2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.
 - b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Performance Tests:
 - 1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
 - 2. Inspections and testing shall be as described in Part 2 of this Section.
 - 3. Repeat tests until results comply with requirements indicated.
 - 4. Provide analysis equipment required to determine performance.

5. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
6. Notify Engineer in advance of test dates.
7. Document test results in a report and submit to Engineer.

3.5 START-UP, INSTRUCTION AND WARRANTY SERVICE

- A. The boiler manufacturer's representative shall provide start-up and instruction of each new boiler, including burner and boiler control system as specified herein. Start-up and instruction shall cover components assembled and/or furnished by the manufacturer, whether or not of their own manufacture.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Contract Representative's maintenance personnel to adjust, operate, and maintain boilers Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 235216

MANCHESTER COMMUNITY COLLEGE

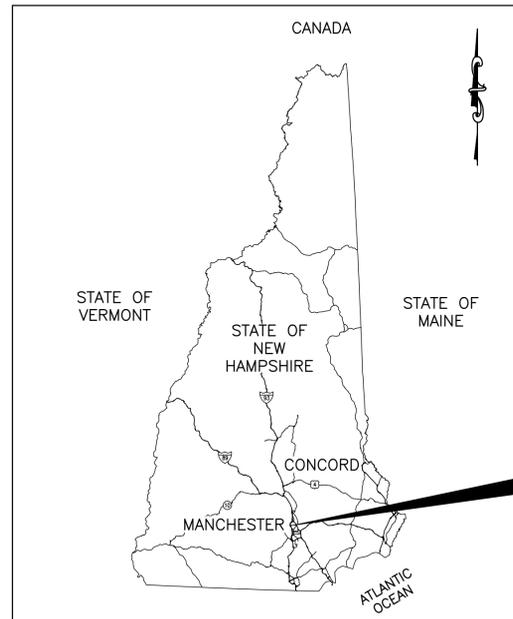
MANCHESTER, NEW HAMPSHIRE

Issued for Construction

MECHANICAL EQUIPMENT REPLACEMENT AT MANCHESTER COMMUNITY COLLEGE

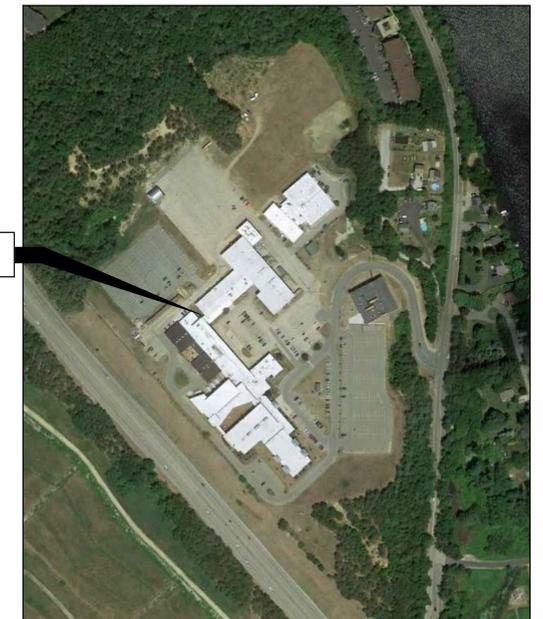
MCC-19-04

APRIL 22, 2020



PROJECT SITE MAP
SCALE: N.T.S.

DRAWING INDEX		
DRAWING	TITLE	SHEET NUMBER
G-001	COVER SHEET	01 OF 14
S-001	STRUCTURAL NOTES AND ABBREVIATIONS	02 OF 14
S-101	PARTIAL ROOF PLAN	03 OF 14
S-401	ROOF TOP EQUIPMENT FRAMING PLANS	04 OF 14
S-501	STRUCTURAL DETAILS	05 OF 14
AD-401	REMOVALS REFLECTED CEILING PLAN	06 OF 14
A-401	REFLECTED CEILING PLAN	07 OF 14
M-001	MECHANICAL NOTES, ABBREVIATIONS, AND LEGEND	08 OF 14
MD-101	ROOF DEMOLITION PLAN	09 OF 14
MD-401	MECHANICAL DEMOLITION PART PLANS	10 OF 14
M-101	ELECTRICAL / MECHANICAL ROOF PLAN	11 OF 14
M-401	MECHANICAL PART PLANS	12 OF 14
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M-601	MECHANICAL SCHEDULES	14 OF 14



VICINITY MAP
SCALE: N.T.S.

 47A York St Portland, ME 04101 207.553.7753	MANCHESTER COMMUNITY COLLEGE MANCHESTER, NH		
	MECHANICAL EQUIPMENT REPLACEMENT MCC 19-04		
0 ISSUED FOR CONSTRUCTION REV DESCRIPTION	MBD BCT DWN APP DATE	04/22/20	COVER SHEET
SIZE: ANSI D DATE: 04/19/2019 DES BY: AMV/SMC DWN BY: PML CKD BY: DHB	PROJECT NO. 372.004.001	DRAWING NO. G-001	SHEET 01 OF 14

GENERAL NOTES

- ALL DIMENSIONS AND CONDITIONS MUST BE VERIFIED IN THE FIELD. ANY DISCREPANCIES SHALL BE BROUGHT TO THE ATTENTION OF THE ENGINEER BEFORE PROCEEDING WITH THE AFFECTED PART OF THE WORK.
- ALL APPLICABLE FEDERAL, STATE, AND MUNICIPAL REGULATIONS SHALL BE FOLLOWED, INCLUDING BUT NOT LIMITED TO THE FEDERAL DEPARTMENT OF LABOR OCCUPATIONAL SAFETY AND HEALTH ACT.

DESIGN LOADING:

PER IBC 2015 & ASCE 7-10:

- DEAD LOADS:
 - ROOF: 20 PSF
- LIVE LOADS:
 - ROOF LIVE LOAD: 20 PSF
- SNOW LOADS:
 - GROUND SNOW LOAD: 70 PSF
 - TERRAIN TYPE: B
 - EXPOSURE FACTOR: 1.00
 - THERMAL FACTOR: 1.00
 - IMPORTANCE FACTOR: 1.00
 - ROOF SNOW LOADS:
 - FLAT ROOF: 49 PSF
- WIND LOADS:
 - BASIC WIND SPEED: 115 MPH
 - RISK CATEGORY: II
 - EXPOSURE CATEGORY: B
 - MWFRS ROOF LOADS: 21 PSF UPLIFT
 - C&C ROOF LOADS:
 - FIELD: ±22 PSF
 - EDGES: (3FT WIDE) ±33 PSF
 - CORNERS: (6FT WIDE) ±44 PSF
- SEISMIC LOADS:
 - SITE CLASSIFICATION: D
 - SEISMIC DESIGN CATEGORY: B
 - RISK CATEGORY: II
 - IMPORTANCE FACTOR: 1.0
 - SHORT DESIGN SPECTRAL RESPONSE: 0.279
 - 1 SEC. DESIGN SPECTRAL RESPONSE: 0.084
 - RESPONSE MODIFICATION FACTOR:
 - AT MASONRY WALLS: 2.0

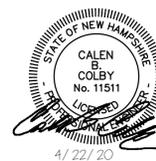
STRUCTURAL STEEL NOTES

- STRUCTURAL STEEL FABRICATION, ERECTION, AND CONNECTION DESIGN SHALL CONFORM TO AISC STEEL CONSTRUCTION MANUAL 14TH EDITION.
- STEEL FABRICATION AND ERECTION SHALL CONFORM TO AISC "CODE OF STANDARD PRACTICE FOR STEEL BUILDINGS AND BRIDGES" AISC-303
- STRUCTURAL STEEL SHALL CONFORM TO THE FOLLOWING:
 - WIDE FLANGE SHAPES ASTM A992
 - CHANNELS ASTM A36
 - PLATES AND OTHER SHAPES ASTM A36
 - SQUARE & RECTANGULAR TUBING ASTM A500, GRADE B
 - ROUND PIPES AND TUBING ASTM A53, GRADE B
 - ANCHOR RODS ASTM F1554, GRADE 36
- FIELD CONNECTIONS SHALL BE BOLTED USING ASTM A325 OR A490 HIGH STRENGTH BOLTS, UNLESS NOTED OTHERWISE.
- BOLTS ARE BEARING TYPE AND SHALL BE FULLY TENSIONED. BOLT HOLES SHALL BE STANDARD SIZES UNLESS OTHERWISE APPROVED BY THE ENGINEER OF RECORD.
- WELDING SHALL CONFORM TO AWS D1.1. WELDING ELECTRODES SHALL COMPLY WITH AWS REQUIREMENTS.
- THE DESIGN OF CONNECTIONS NOT SHOWN ON THE DRAWINGS SHALL BE PROVIDED BY THE FABRICATOR.
- ALL EXTERIOR STEEL SHALL BE HOT DIPPED GALVANIZED.
- STEEL MEMBERS SHALL BE CUT FROM FULL LENGTH STOCK. UNAUTHORIZED SPLICES WILL BE CAUSE FOR REJECTION.

ABBREVIATIONS

APPROX.	APPROXIMATELY
BOT.	BOTTOM
B.O.	BOTTOM OF
CL	CENTER LINE
CLR	CLEAR
COL.	COLUMN
CONC	CONCRETE
DIA., Ø	DIAMETER
DIM.	DIMENSION
DWG.	DRAWING
EA.	EACH
EL.	ELEVATION
EQ.	EQUAL
EW	EACH WAY
EXIST.	EXISTING
EXT.	EXTERIOR
FDN	FOUNDATION
GA.	GAGE
GR	GRADE
HORIZ.	HORIZONTAL
HT.	HEIGHT
MAX.	MAXIMUM
MIN.	MINIMUM
O.C.	ON CENTER
OPP HAND	OPPOSITE HAND
PL	PLATE
REQ'D, REQ.	REQUIRED
SIM.	SIMILAR
STD	STANDARD
T & B	TOP AND BOTTOM
T.O.	TOP OF
T.O.S.	TOP OF STEEL
TYP.	TYPICAL
U.N.O.	UNLESS NOTED OTHERWISE
VERT.	VERTICAL
V.I.F.	VERIFY IN FIELD
W/	WITH
W.P.	WORK POINT

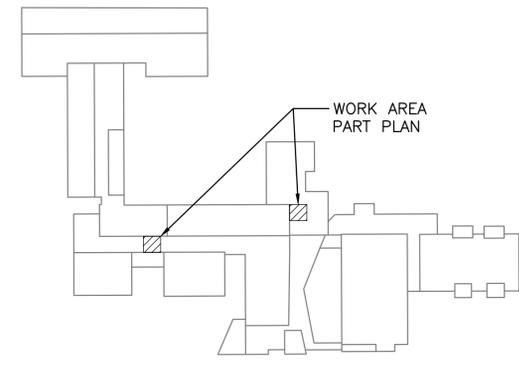
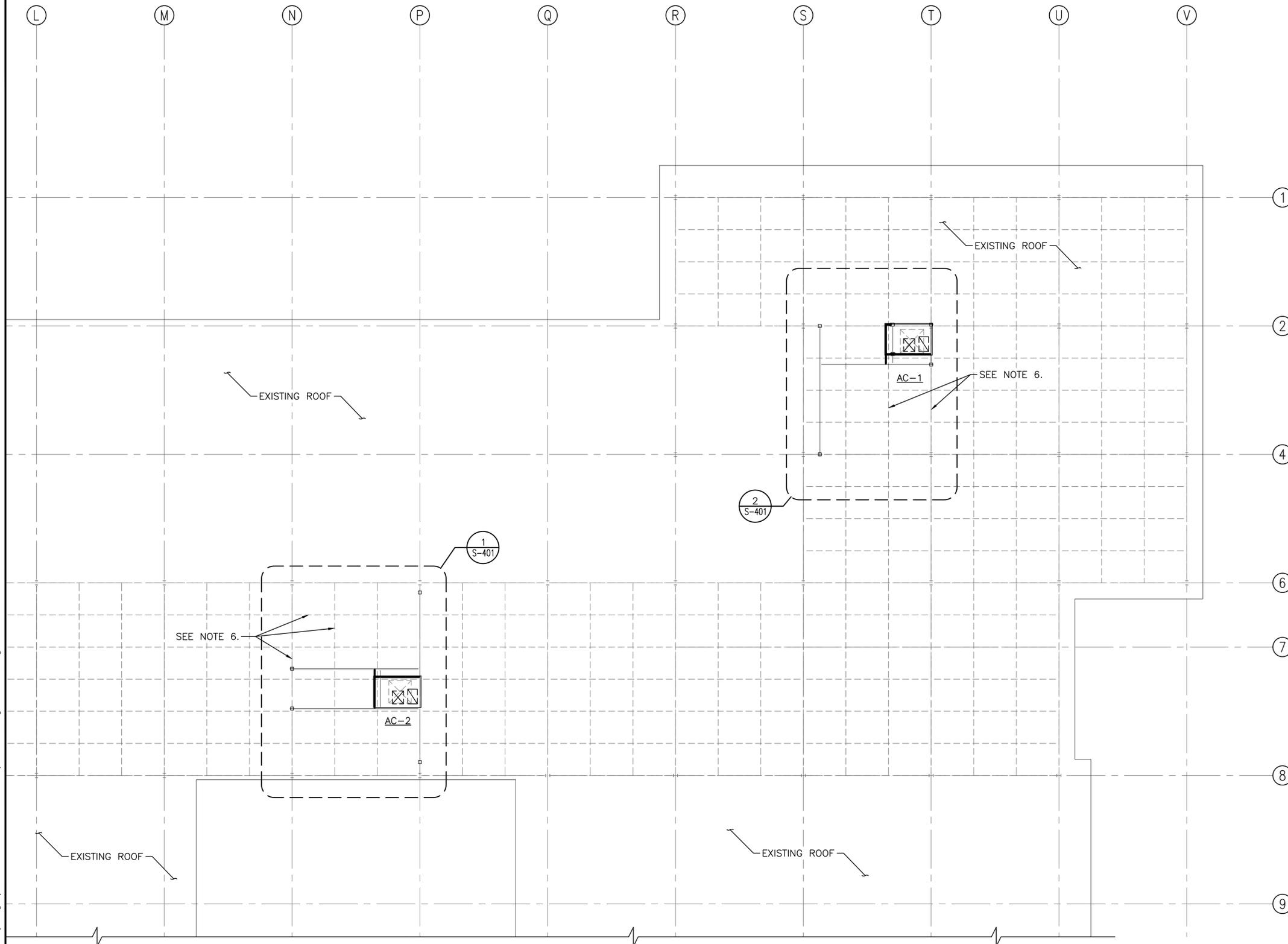
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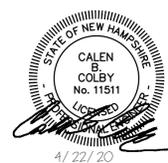
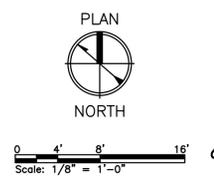
				MANCHESTER COMMUNITY COLLEGE MANCHESTER, NH	
				MECHANICAL EQUIPMENT REPLACEMENT MCC 19-04	
				STRUCTURAL NOTES AND ABBREVIATIONS	
0	ISSUED FOR CONSTRUCTION	TJG	SJT	04/22/20	
REV	DESCRIPTION	DWN	APP	DATE	
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		DATE:	04/19/2019		372.004.001
		DES BY:	JAL		SHEET
		DWN BY:	TJG		02 OF 14
		CKD BY:	SJT		S-001

- NOTES:**
- SEE S-001 FOR STRUCTURAL NOTES.
 - SEE S-501 FOR STRUCTURAL DETAILS.
 - EXISTING CONDITIONS SHALL BE VERIFIED PRIOR TO STARTING THE WORK.
 - SEE MECHANICAL DRAWINGS FOR ROOF TOP EQUIPMENT LOCATIONS AND DETAILS.
 - FIELD DRILL HOLES FOR UNIT INSTALLATION.
 - CLIENT TO CONFIRM EXISTING STRUCTURAL ROOF FRAMING BELOW.



KEY PLAN
SCALE: NTS

PARTIAL ROOF PLAN
SCALE: 1/8" = 1'-0"



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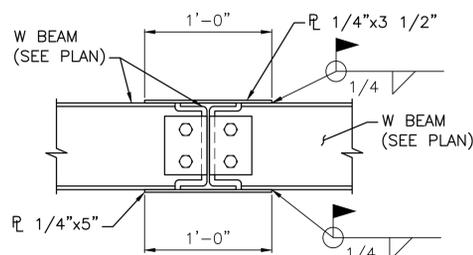
REV	DESCRIPTION	DWN	APP	DATE
0	ISSUED FOR CONSTRUCTION	TJG	SJT	04/22/20

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MECHANICAL EQUIPMENT REPLACEMENT MCC 19-04	
PARTIAL ROOF PLAN	
PROJECT NO. 372.004.001	DRAWING NO. S-101
SHEET 03 OF 14	

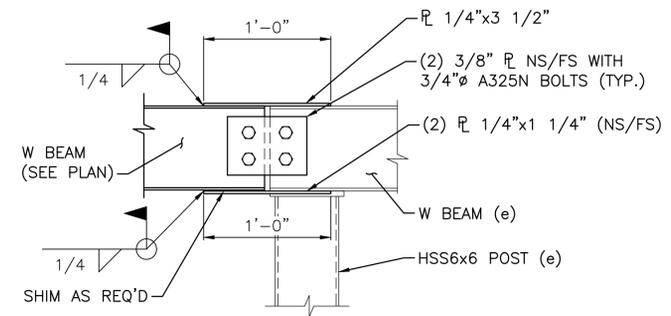
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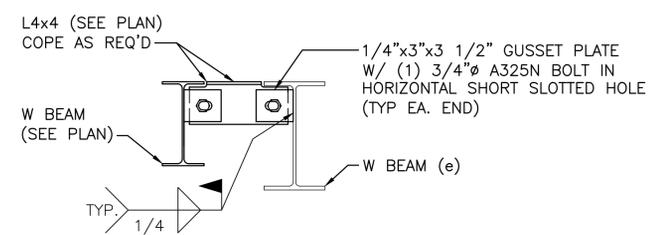
3 TYPICAL BEAM TO BEAM MOMENT CONNECTION DETAIL

S-501 SCALE: 1-1/2" = 1'-0" S-401



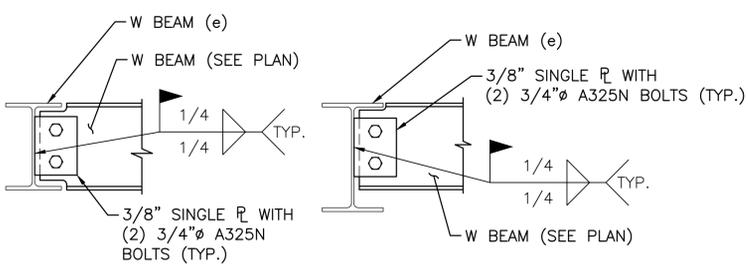
4 TYPICAL BEAM TO BEAM ON POST MOMENT CONNECTION DETAIL

S-501 SCALE: 1-1/2" = 1'-0" S-401



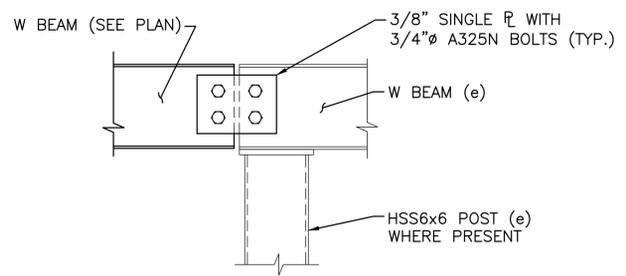
5 TYPICAL ANGLE TO BEAM CONNECTION

S-501 SCALE: 1-1/2" = 1'-0" S-401



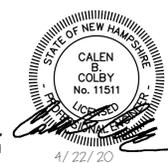
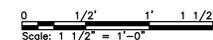
1 TYPICAL BEAM TO BEAM CONNECTIONS

S-501 SCALE: 1-1/2" = 1'-0" S-401



2 BEAM SPLICE DETAIL

S-501 SCALE: 1-1/2" = 1'-0" S-401



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MANCHESTER COMMUNITY COLLEGE MANCHESTER, NH	
MECHANICAL EQUIPMENT REPLACEMENT MCC 19-04	
STRUCTURAL DETAILS	
SIZE: ANSI D	PROJECT NO. 372.004.001
DATE: 04/19/2019	DRAWING NO. S-501
DES BY: JAL	SHEET 05 OF 14
DWN BY: TJG	
CKD BY: SJT	

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NOTES:

1. SEE MECHANICAL DRAWINGS FOR MORE INFORMATION.

KEYED NOTES:

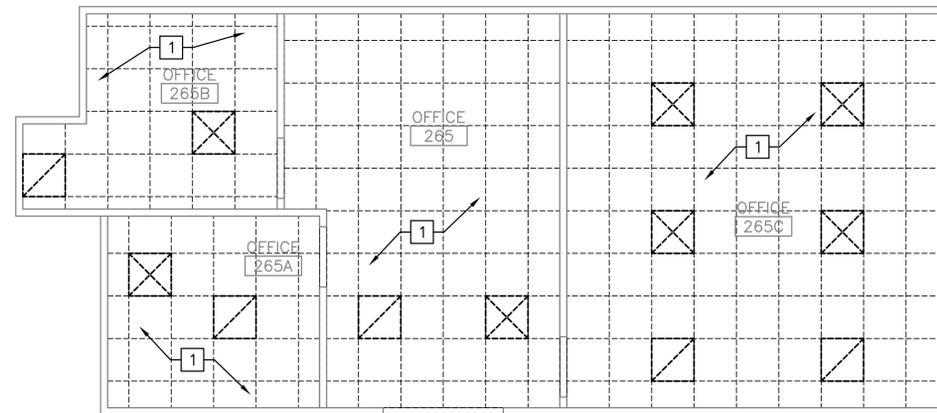
- 1 REMOVE EXISTING 2X2 ACOUSTIC CEILING PANELS AND RETURN UNDAMAGED UNITS TO OWNER. DEMOLISH SUSPENSION GRID. COORDINATE WITH ELECTRICAL CONTRACTOR TO TEMPORARILY SUPPORT LIGHT FIXTURES. DO NOT DISTURB SPRINKLER HEADS. SUSPENSION WIRES AND WALL ANGLE MAY BE RETAINED IF NOT DAMAGED.

LEGEND:

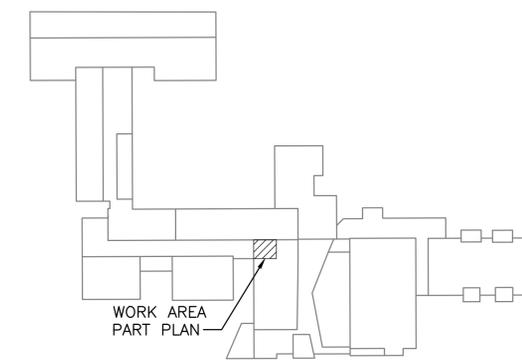
 REMOVE EXISTING SUPPLY DIFFUSER, COMPLETE.

 REMOVE EXISTING RETURN DIFFUSER, COMPLETE.

 REMOVE EXISTING SUSPENDED CEILING ASSEMBLY, COMPLETE



1 REFLECTED CEILING DEMOLITION PART PLAN @ AC-2
AD-401 SCALE: 1/4" = 1'-0"



KEY PLAN
SCALE: NTS



0 2' 4' 8'
Scale: 1/4" = 1'-0"

				MANCHESTER COMMUNITY COLLEGE MANCHESTER, NH			
				MECHANICAL EQUIPMENT REPLACEMENT MCC 19-04			
				REMOVALS REFLECTED CEILING PLAN			
0	ISSUED FOR CONSTRUCTION	JDR	RTM	04/22/20			
REV	DESCRIPTION	DWN	APP	DATE			
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				DRAWING NO. AD-401			
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NOTES:

- SEE MECHANICAL DRAWINGS FOR MORE INFORMATION.

KEYED NOTES:

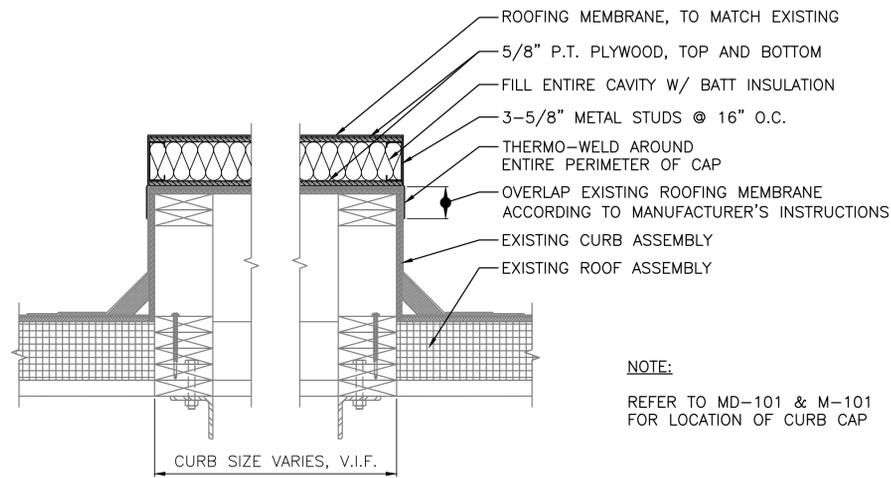
- SUPPLY AND INSTALL ALL NEW MAIN RUNNERS AND CROSS T'S AND ACCESSORIES IN ORIGINAL TYPE AND LOCATIONS AFTER ALL ABOVE-CEILING WORK HAS BEEN ACCOMPLISHED. PROCURE AND INSTALL 2X2 ACOUSTIC PANELS IN IDENTICAL PATTERN, MATERIAL, AND REGULAR EDGE AS ORIGINAL.

LEGEND:

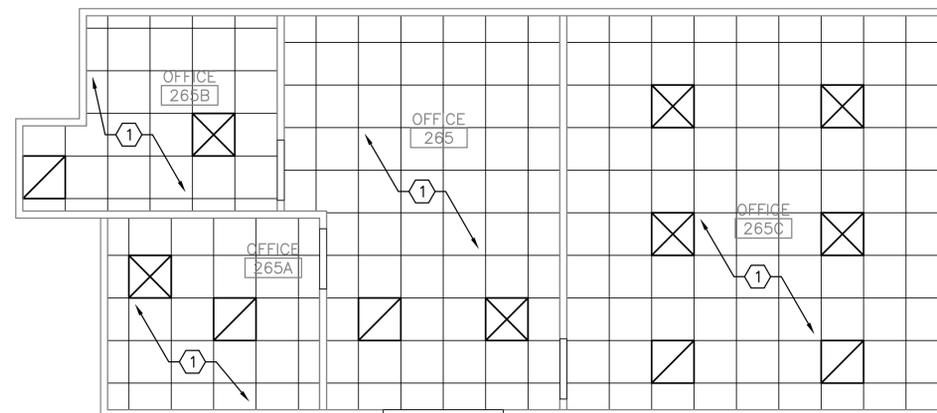
 SUPPLY DIFFUSER, REFER TO MECHANICAL DRAWINGS FOR MORE INFORMATION.

 RETURN DIFFUSER, REFER TO MECHANICAL DRAWINGS FOR MORE INFORMATION.

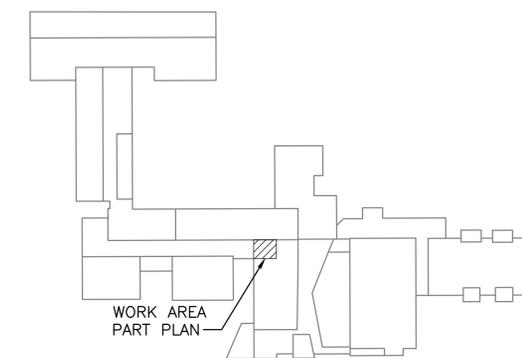
 SUSPENDED CEILING ASSEMBLY, MATCH EXISTING.



1 CURB CAPPING DETAIL @ EXISTING CURB
 SCALE: 3" = 1'-0"



2 REFLECTED CEILING PART PLAN @ AC-2
 SCALE: 1/4" = 1'-0"



KEY PLAN
 SCALE: NTS



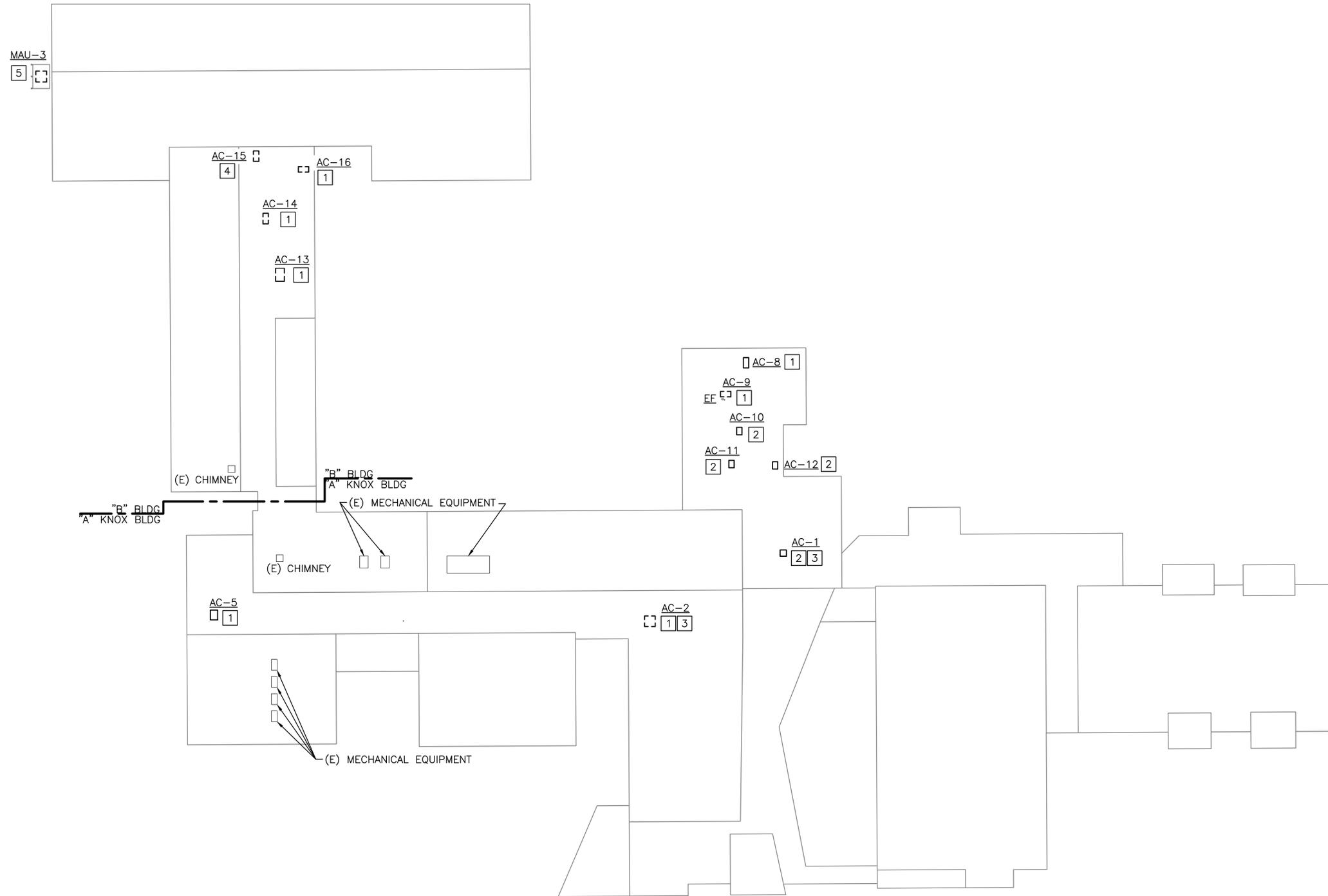
Scale: 1/4" = 1'-0"



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				MECHANICAL EQUIPMENT REPLACEMENT MCC 19-04			
				REFLECTED CEILING PLAN			
0	ISSUED FOR CONSTRUCTION	JDR	RTM	04/22/20			
REV	DESCRIPTION	DWN	APP	DATE			
				ANSI D	PROJECT NO.	DRAWING NO.	
				DATE: 04/19/2019	372.004.001	A-401	
				DES BY: JDR	SHEET	07 OF 14	
				DWN BY: JDR			
				CKD BY: RTM			



- MECHANICAL NOTES:**
- SEE DRAWING M-001 FOR MECHANICAL NOTES, ABBREVIATIONS, AND LEGEND.
 - RECOVER AND DISPOSE OF REFRIGERANT AND OIL IN ACCORDANCE WITH STATE AND FEDERAL REGULATIONS.
 - STRUCTURAL INTEGRITY OF ROOF BEYOND THE EXISTING MECHANICAL EQUIPMENT LOCATIONS HAS NOT BEEN ANALYZED. DO NOT LEAVE EQUIPMENT ON ROOF AFTER REMOVAL FROM CURB.
 - COORDINATE CRANE RENTAL WITH EQUIPMENT INSTALLATION DATES.

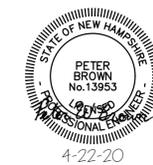
- ELECTRICAL NOTES:**
- DURING DEMOLITION OF MECHANICAL EQUIPMENT, EXISTING ELECTRICAL AND CONTROL FEEDERS ARE TO REMAIN FOR RECONNECTION TO NEW EQUIPMENT. REMOVE EXISTING DISCONNECTS.

- DEMOLITION KEYED NOTES:**
- REMOVE ROOFTOP UNIT AND ASSOCIATED CONTROLS. ROOF CURB, CONTROLS WIRING, AND DUCTWORK IN BUILDING ARE EXISTING TO REMAIN. PROTECT ROOF AND DUCT OPENINGS FROM WEATHER DURING TIME IN WHICH UNIT IS REMOVED.
 - REMOVE ROOFTOP UNIT AND ASSOCIATED CONTROLS. PREPARE ROOF CURB FOR CURB ADAPTER. CONTROLS WIRING AND DUCTWORK IN BUILDING ARE EXISTING TO REMAIN. PROTECT ROOF AND DUCT OPENINGS FROM WEATHER DURING TIME IN WHICH UNIT IS REMOVED.
 - STEEL BEAM FRAMING SUPPORTS ARE EXISTING TO REMAIN. COORDINATE CLEANING AND SURFACE PREPARATION OF BEAMS AFTER EXISTING ROOFTOP UNIT IS REMOVED, AND BEFORE NEW UNIT IS INSTALLED.
 - REMOVE ROOFTOP UNIT, DUCTWORK, AND ASSOCIATED ELECTRICAL AND CONTROLS. SEAL EXISTING CONDUIT PENETRATIONS THROUGH ROOF. MAINTAIN ANY EXISTING ROOF WARRANTY. ROOF CURB IS EXISTING TO REMAIN. SEE SHEETS M-101 & A-401 FOR CAPPING NOTES.
 - REMOVE MAU-3 ALONG WITH ASSOCIATED ELECTRICAL AND CONTROLS. CONCRETE EQUIPMENT PAD TO REMAIN.

ROOF AND EXTERIOR DEMOLITION PLAN
SCALE: 1/32" = 1'-0"



0 16' 32' 64'
Scale: 1/32" = 1'-0"



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				MANCHESTER COMMUNITY COLLEGE MANCHESTER, NH			
				MECHANICAL EQUIPMENT REPLACEMENT MCC 19-04			
				ROOF DEMOLITION PLAN			
0	ISSUED FOR CONSTRUCTION	MBD	PWB	04/22/20			
REV	DESCRIPTION	DWN	APP	DATE			
				SIZE: ANSI D	PROJECT NO:	DRAWING NO:	
				DATE: 04/19/2019	372.004.001	MD-101	
				DES BY: AMV/JLH	SHEET	09 OF 14	
				DWN BY: PML			
				CKD BY: DHB			

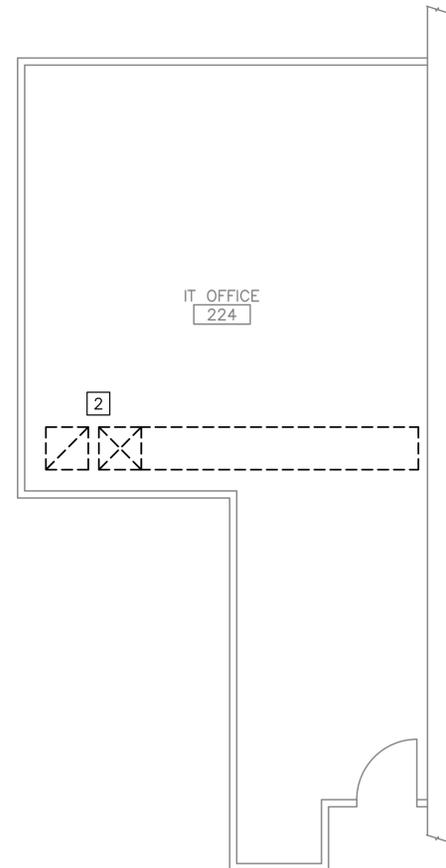
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NOTES:

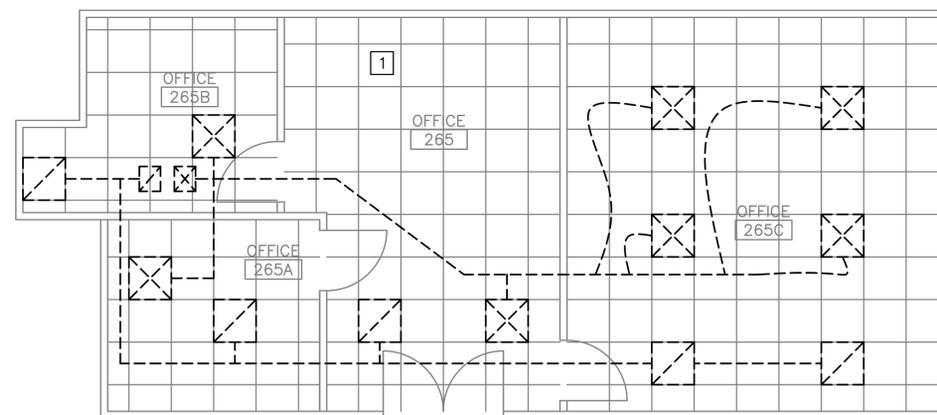
- SEE DRAWING M-001 FOR MECHANICAL NOTES, ABBREVIATIONS, AND LEGEND.

KEYED NOTES:

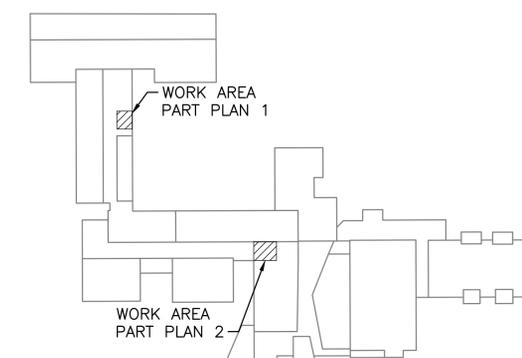
- REMOVE EXISTING 2X2 ACOUSTIC CEILING PANELS AND RETURN UNDAMAGED UNITS TO OWNER. DEMOLISH SUSPENSION GRID. COORDINATE WITH ELECTRICAL CONTRACTOR TO TEMPORARILY SUPPORT LIGHT FIXTURES. DO NOT DISTURB SPRINKLER HEADS. SUSPENSION WIRES AND WALL ANGLE MAY BE RETAINED IF NOT DAMAGED.
- REMOVE SUPPLY AND RETURN DUCTWORK WITH HANGERS UP THROUGH ROOF TO RTU.



1 AC-13 DUCTWORK PART PLAN
 MD-401 SCALE: 1/4" = 1'-0"



2 AC-2 DUCTWORK PART PLAN
 MD-401 SCALE: 1/4" = 1'-0"



KEY PLAN
 SCALE: NTS



Scale: 1/4" = 1'-0"

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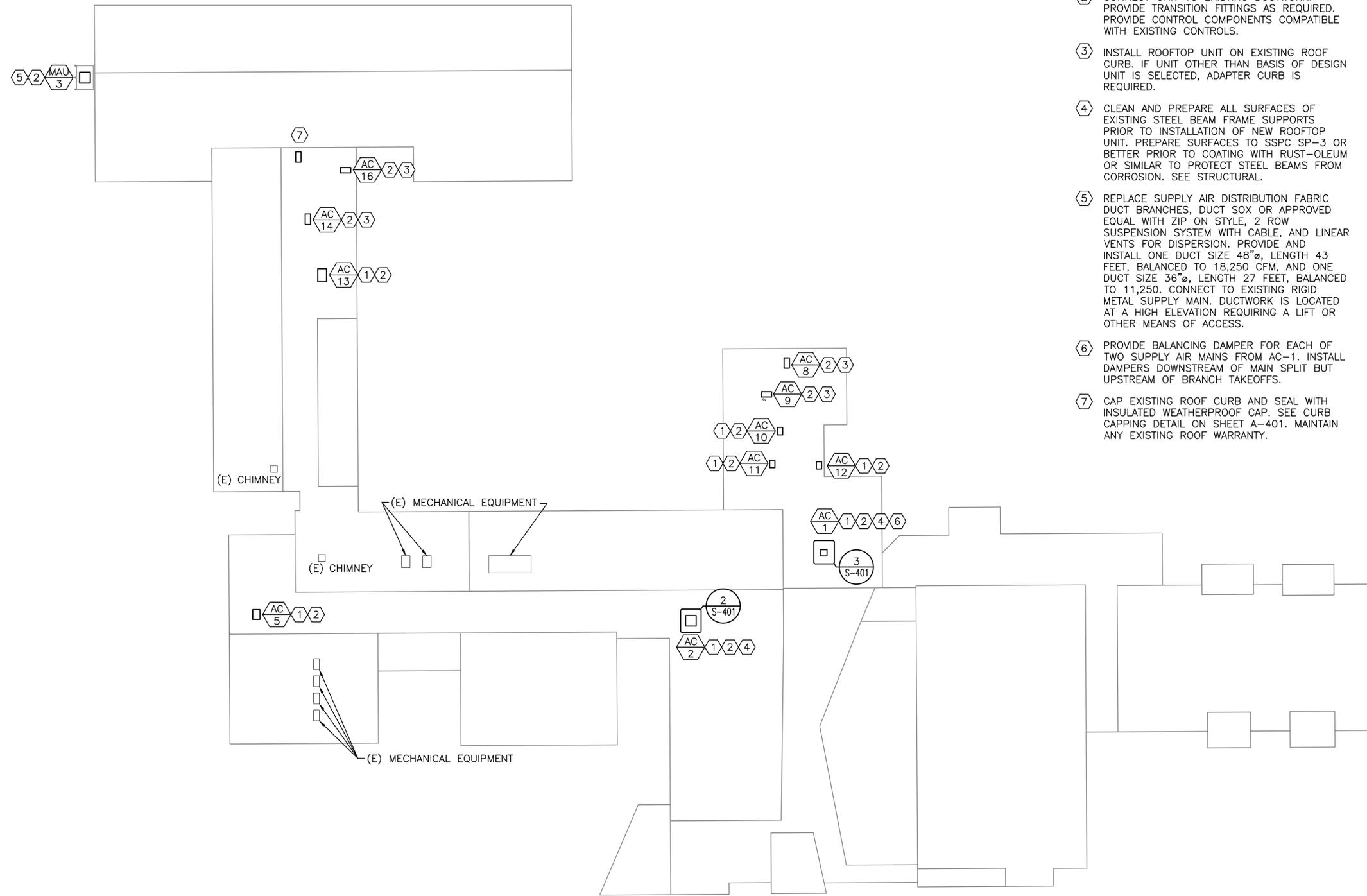
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0	ISSUED FOR CONSTRUCTION	PML	SMC	04/22/20

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SIZE: ANSI D
 DATE: 04/19/2019
 DES BY: SMC
 DWN BY: PML
 CKD BY: DHB

MANCHESTER COMMUNITY COLLEGE MANCHESTER, NH	
MECHANICAL EQUIPMENT REPLACEMENT MCC 19-04	
MECHANICAL DEMOLITION PART PLANS	
PROJECT NO. 372.004.001	DRAWING NO. MD-401
SHEET 10 OF 14	



KEYED NOTES:

- ① PROVIDE CURB ADAPTER, SEE SCHEDULE.
- ② CONNECT UNIT TO EXISTING DUCTWORK. PROVIDE TRANSITION FITTINGS AS REQUIRED. PROVIDE CONTROL COMPONENTS COMPATIBLE WITH EXISTING CONTROLS.
- ③ INSTALL ROOFTOP UNIT ON EXISTING ROOF CURB. IF UNIT OTHER THAN BASIS OF DESIGN UNIT IS SELECTED, ADAPTER CURB IS REQUIRED.
- ④ CLEAN AND PREPARE ALL SURFACES OF EXISTING STEEL BEAM FRAME SUPPORTS PRIOR TO INSTALLATION OF NEW ROOFTOP UNIT. PREPARE SURFACES TO SSPC SP-3 OR BETTER PRIOR TO COATING WITH RUST-OLEUM OR SIMILAR TO PROTECT STEEL BEAMS FROM CORROSION. SEE STRUCTURAL.
- ⑤ REPLACE SUPPLY AIR DISTRIBUTION FABRIC DUCT BRANCHES, DUCT SOX OR APPROVED EQUAL WITH ZIP ON STYLE, 2 ROW SUSPENSION SYSTEM WITH CABLE, AND LINEAR VENTS FOR DISPERSION. PROVIDE AND INSTALL ONE DUCT SIZE 48"Ø, LENGTH 43 FEET, BALANCED TO 18,250 CFM, AND ONE DUCT SIZE 36"Ø, LENGTH 27 FEET, BALANCED TO 11,250. CONNECT TO EXISTING RIGID METAL SUPPLY MAIN. DUCTWORK IS LOCATED AT A HIGH ELEVATION REQUIRING A LIFT OR OTHER MEANS OF ACCESS.
- ⑥ PROVIDE BALANCING DAMPER FOR EACH OF TWO SUPPLY AIR MAINS FROM AC-1. INSTALL DAMPERS DOWNSTREAM OF MAIN SPLIT BUT UPSTREAM OF BRANCH TAKEOFFS.
- ⑦ CAP EXISTING ROOF CURB AND SEAL WITH INSULATED WEATHERPROOF CAP. SEE CURB CAPPING DETAIL ON SHEET A-401. MAINTAIN ANY EXISTING ROOF WARRANTY.

ELECTRICAL NOTES:

- 1. CONNECT NEW MECHANICAL UNITS TO EXISTING ELECTRICAL AND CONTROL WIRE FEEDERS. CONTRACTOR RESPONSIBLE FOR SPLICING EXISTING WIRING IN THE FIELD TO EXTEND TO NEW EQUIPMENT IF REQUIRED.
- 2. CONTRACTOR TO PROVIDE NEW ELECTRICAL DISCONNECTS WITH ALL MECHANICAL UNITS.
- 3. ELECTRICAL PANELS AFFECTED BY WORK:
 - 3.1. MHP SECTIONS 1 AND 2 (208Y/120V): AC-1, AC-2, AC-5, AC-8, AC-9, AC-10, AC-11, AC-12
 - 3.2. MHP-2 (208Y/120V):LP4-2A (480/277V): AC-13, AC-14, AC-16
 - 3.3. PP-WL4 (480/277V): MAU-3
 - 3.4. ATC PANEL CB-7B (208Y/120V):

MECHANICAL NOTES:

- 1. SEE DRAWING M-001 FOR MECHANICAL NOTES, ABBREVIATIONS, AND LEGEND.
- 2. REPLACE EQUIPMENT IN THE FOLLOWING ORDER, RANKED IN THE ORDER OF IMPORTANCE: AC-1, MAU-3, AC-13, AC-14, AC-16, AC-8, AC-9, AC-10, AC-11, AC-12, AC-2, AC-5, AC-6, AC-7, AC-4, AC-22, AC-17, AC-18, AC-19, AC-20, AC-21, AC-30, AC-45, AC-46.
- 3. STRUCTURAL INTEGRITY OF ROOF BEYOND THE EXISTING MECHANICAL EQUIPMENT LOCATIONS HAS NOT BEEN ANALYZED. DO NOT LEAVE EQUIPMENT ON ROOF PRIOR TO INSTALLATION ON CURBS.
- 4. COORDINATE CRANE RENTAL WITH EQUIPMENT INSTALLATION DATES.
- 5. INSTALL GUARD RAIL AROUND ROOFTOP EQUIPMENT THAT IS LOCATED WITHIN TEN FEET OF THE ROOF EDGE.
- 6. FLASH AND SEAL PENETRATIONS THROUGH BUILDING EXTERIOR INCLUDING ROOF AND EXTERIOR WALL PENETRATIONS.
- 7. CONNECT UNIT TO EXISTING GAS SUPPLY. SEE GAS CONNECTION DETAIL ON M-501.

ELECTRICAL/MECHANICAL ROOF AND EXTERIOR PLAN

SCALE: 1/32" = 1'-0"



0 16' 32' 64'
Scale: 1/32" = 1'-0"



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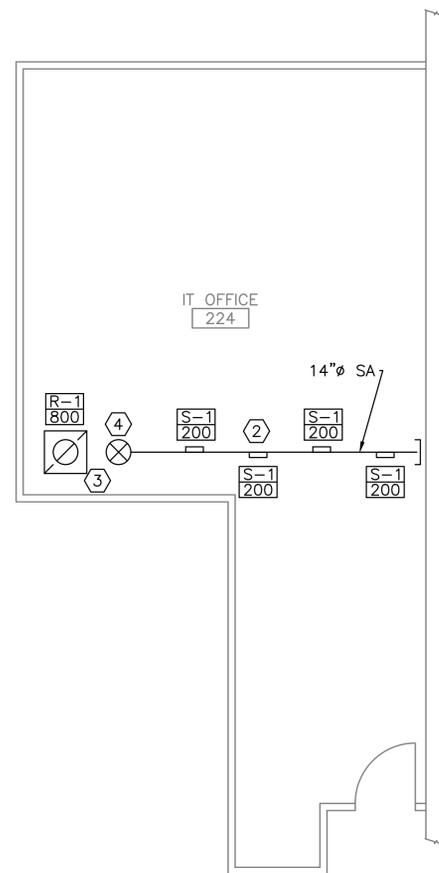
				MANCHESTER COMMUNITY COLLEGE MANCHESTER, NH			
				MECHANICAL EQUIPMENT REPLACEMENT MCC 19-04			
				ELECTRICAL / MECHANICAL ROOF PLAN			
0	ISSUED FOR CONSTRUCTION	MBD	PWB	04/22/20			
REV	DESCRIPTION	DWN	APP	DATE			
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				DATE: 04/19/2019	372.004.001	M-101	
				DES BY: AMV/JLH	SHEET	11 OF 14	
				DWN BY: PML			
				CKD BY: DHB			

NOTES:

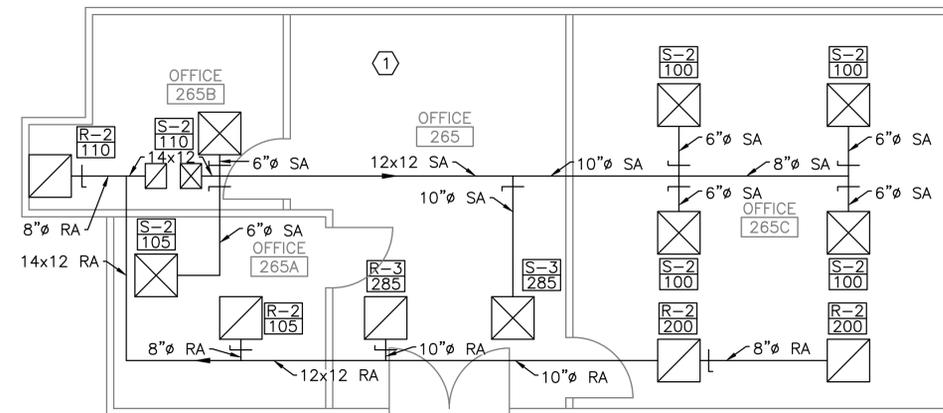
- SEE DRAWING M-001 FOR MECHANICAL NOTES, ABBREVIATIONS, AND LEGEND.

KEYED NOTES:

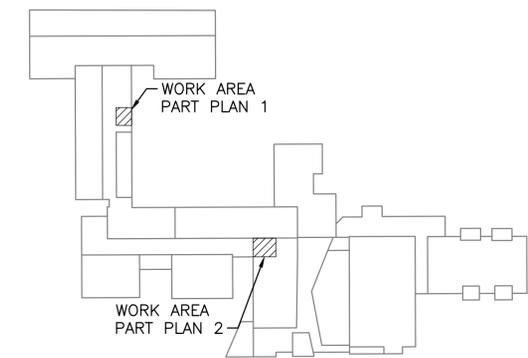
- SUPPLY AND INSTALL ALL NEW MAIN RUNNERS AND CROSS T'S AND ACCESSORIES IN ORIGINAL TYPE AND LOCATIONS AFTER ALL ABOVE-CEILING WORK HAS BEEN ACCOMPLISHED. PROCURE AND INSTALL 2X2 ACOUSTIC PANELS IN IDENTICAL PATTERN, MATERIAL, AND REGULAR EDGE AS ORIGINAL. SEE ARCHITECTURAL.
- 14"Ø SPIRAL FORMED EXPOSED ROUND DUCTWORK, PAINTED. INSTALL AS HIGH AS POSSIBLE. SUBMIT PAINT COLOR OPTIONS FOR APPROVAL BY OWNER PRIOR TO PAINTING.
- 24"x24" RETURN GRILLE UP TO 14"Ø RA DUCT TO AC-13. REUSE EXISTING ROOF PENETRATION FOR DUCTWORK.
- 14"Ø SA UP TO AC-13.



1 AC-13 DUCTWORK PART PLAN
M-401 SCALE: 1/4" = 1'-0"



2 AC-2 DUCTWORK PART PLAN
M-401 SCALE: 1/4" = 1'-0"



KEY PLAN
SCALE: NTS



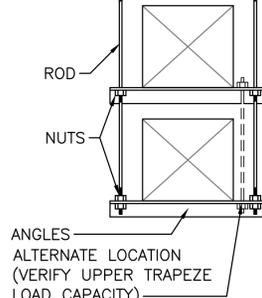
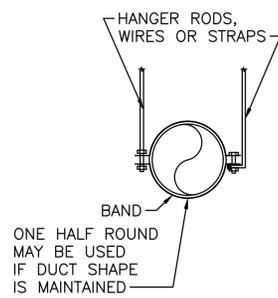
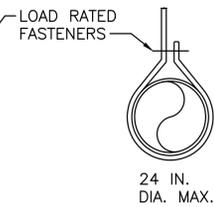
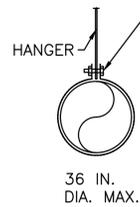
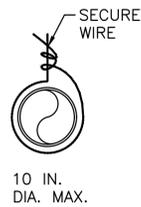
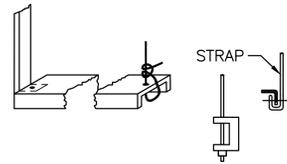
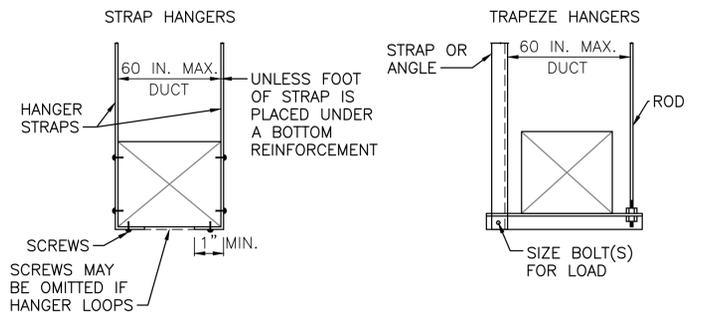
0 2' 4' 8'
Scale: 1/4" = 1'-0"



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Portland, ME
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				MANCHESTER COMMUNITY COLLEGE MANCHESTER, NH	
				MECHANICAL EQUIPMENT REPLACEMENT MCC 19-04	
				MECHANICAL PART PLANS	
0	ISSUED FOR CONSTRUCTION	PML	SMC	04/22/20	
REV	DESCRIPTION	DWN	APP	DATE	
PLEASE NOTE: THIS DOCUMENT MAY NOT ACCURATELY REPRESENT THE FINAL DOCUMENT. ONLY AN ENGINEER, ARCHITECT OR SURVEYOR SIGNED, SEALED AND DATED PAPER COPY, PROVIDED BY THIS OFFICE, MAY BE UTILIZED FOR BIDDING OR CONSTRUCTION PURPOSES.		SIZE: ANSI D	PROJECT NO. 372.004.001		DRAWING NO. M-401
		DATE: 04/19/2019	SHEET 12 OF 14		
		DES BY: SMC			
		DWN BY: PML			
		CKD BY: DHB			

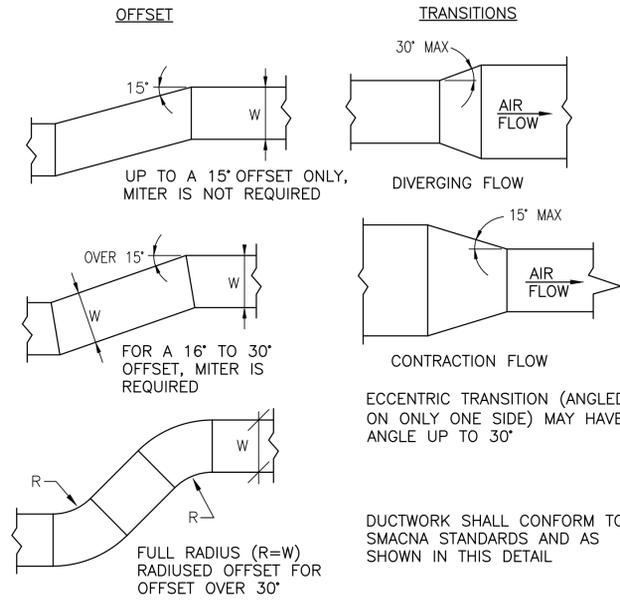


NOTE:
FOR SUPPORT SIZING AND SPACING SEE
SMACNA, HVAC DUCT CONSTRUCTION
STANDARDS, 3RD EDITION, CHAPTER 5,
TABLES: 5-1, 5-2, AND 5-3.

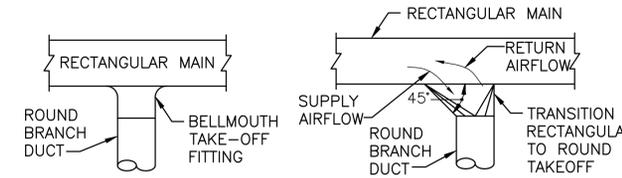
REINFORCEMENT MAY BE USED FOR
ATTACHMENT IF IT QUALIFIES FOR
BOTH DUTIES

NOTE:
DO NOT EXCEED ALLOWABLE LOAD LIMITS.
HANGERS MUST NOT DEFORM DUCT SHAPE

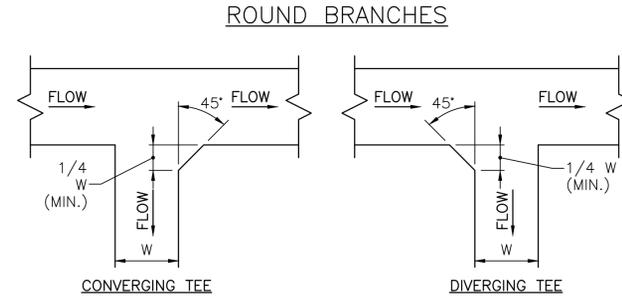
LOWER HANGER ATTACHMENTS
SCALE: NTS



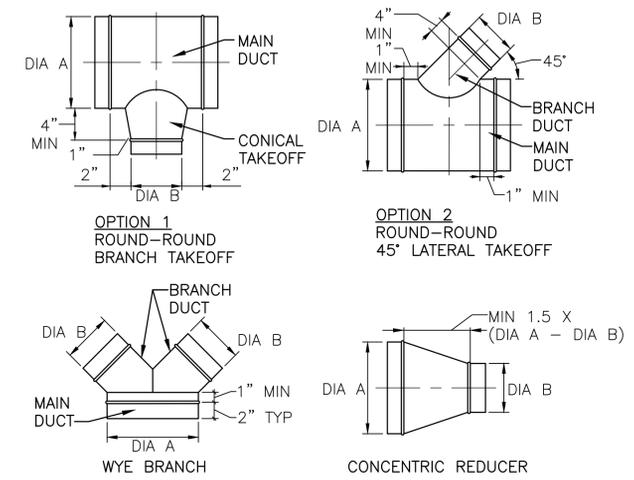
DUCTWORK TRANSITIONS DETAIL
SCALE: NTS



NOTES:
1. SPIN-IN TYPE STRAIGHT TAKE-OFF FITTINGS ARE NOT PERMITTED
2. COMPLY WITH LATEST EDITION OF SMACNA DUCT CONSTRUCTION
STANDARDS FIG. 2-6.

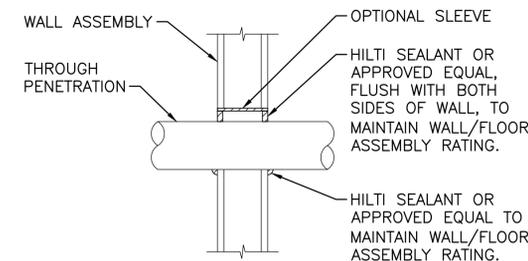


DUCT TEES TO RECTANGULAR MAINS
SCALE: NTS

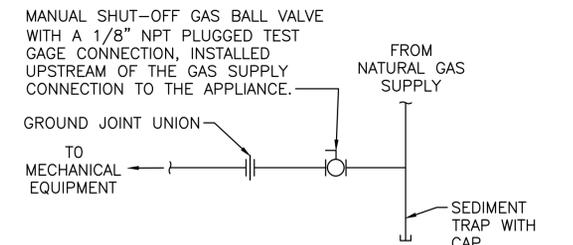


NOTE:
1. DIAMETERS A AND B MAY
VARY BASED ON DRAWINGS.

TYPICAL ROUND DUCT FITTINGS DETAIL
SCALE: NTS



DUCT/PIPE WALL PENETRATION DETAIL
SCALE: NTS



NOTES:
1. BALL VALVE AS SPECIFIED.
2. SEDIMENT TRAP AS REQUIRED BY CODE

GAS CONNECTION TO MECHANICAL EQUIPMENT
NOT TO SCALE

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REV	DESCRIPTION	DWN	APP	DATE
0	ISSUED FOR CONSTRUCTION	PML	SMC	04/22/20

MANCHESTER COMMUNITY COLLEGE MANCHESTER, NH	
MECHANICAL EQUIPMENT REPLACEMENT MCC 19-04	
MECHANICAL DETAILS	
PROJECT NO. 372.004.001	DRAWING NO. M-501
SHEET 13 OF 14	

DIRECT-FIRED MAKE UP AIR UNIT SCHEDULE

UNIT NO	LOCATION	SERVES	FAN DATA									FURNACE DATA				FILTER		ELECTRICAL		DIMENSIONS LXWXH (IN)	WEIGHT (LBS)	MANUFACTURER AND MODEL	NOTES
			MAX (CFM)	MIN (CFM)	OA	ESP (IN WG)	TSP (IN WG)	MOTOR TYPE	RPM	BHP	HP	TOTAL MBH OUT	EAT (°F)	LAT (°F)	FUEL	TYPE	THICK (IN)	V/PH/HZ	MCA (AMPS)				
MAU-3	PARKING LOT A - WEST	WELDING	30,000	30,000	NOTE 1	1.15	2.05	ODP	1750	14.6	20	3376	0	104.2	NATURAL GAS	ALUMINUM	1	460/3/60	32.4	76x76x218	3697	RAPID-AIR 4049-NP2	1,2

- NOTES:
 1. OUTSIDE AIR MODULATION 20% -100%.
 2. PROVIDE REMOTE CONTROLLER PANEL FOR USE AS CONTROLLER IN WELDING SHOP.

ROOFTOP UNIT SCHEDULE

UNIT NO.	FAN DATA			COOLING (DX)							ELECTRICAL (V/PH/HZ)	MCA (AMPS)	MOC (AMPS)	DIMENSIONS LXWXH (IN)	UNIT WEIGHT (LBS)	MANUFACTURER AND MODEL	NOTES
	CFM	ESP (IN WG)	MOTOR HP	NOM. TONS	AMBIENT (°F)	EDB (°F)	EWB (°F)	LDB (°F)	LWB (°F)	EER							
AC-1	5000	0.6	5	12.5	95	80	67	57.5	56.1	12.1	208/3/60	74.4	90	1375	YORK J12ZJC00D2B2BCA1A1	1-8,10	
AC-2	1668	0.6	1.5	5	95	80	67	57.3	55.1	12.2	208/3/60	29.3	40	865	YORK JA5ZJC00B2B2BAA1A2	1-8,10	
AC-4																11	
AC-5	2400	0.6	1.5	6	95	80	67	60.9	57.4	11.2	208/3/60	33.2	45	715	YORK JA6ZEC00B2C3BCA1A1	1-8,10	
AC-6																11	
AC-7																11	
AC-8	1600	0.6	1.5	4	95	80	67	58.8	56.9	12.0	208/3/60	23.7	30	658	YORK J04ZEC00B2C2BCA1A1	1-9	
AC-9	1600	0.6	1.5	4	95	80	67	58.8	56.9	12.0	208/3/60	23.7	30	658	YORK J04ZEC00B2C2BCA1A1	1-9	
AC-10	1200	0.6	1.5	3	95	80	67	59.1	57.3	12.0	208/1/60	28.3	35	530	YORK J03ZEC00B1C2ACA1A1	1-8,10	
AC-11	1200	0.6	1.5	3	95	80	67	59.1	57.3	12.0	208/1/60	28.3	35	530	YORK J03ZEC00B1C2ACA1A1	1-8,10	
AC-12	1200	0.6	1.5	3	95	80	67	59.1	57.3	12.0	208/1/60	28.3	35	530	YORK J03ZEC00B1C2ACA1A1	1-8,10	
AC-13	800	0.6	1.5	3	95	80	67	55.2	53.2	12.0	460/3/60	10.6	15	530	YORK J03ZEC00B4C2BCA1A1	1-8,10	
AC-14	2000	0.6	1.5	5	95	80	67	59.0	57.3	11.8	460/3/60	14.1	20	642	YORK J05ZEC00B4A2BCA1A1	1-9	
AC-16	1600	0.6	1.5	4	95	80	67	58.8	56.9	12.0	208/3/60	23.7	30	608	YORK J04ZEC00B2A2BCA1A1	1-9	
AC-17																11	
AC-18																11	
AC-19																11	
AC-20																11	
AC-21																11	
AC-22																11	

- NOTES:
 1. FACTORY MOUNTED SMOKE DETECTOR IN RETURN AIR.
 2. HAIL GUARDS.
 3. DIFFERENTIAL ENTHALPY ECONOMIZER.
 4. FACTORY MOUNTED AND POWERED CONVENIENCE OUTLET.
 5. FACTORY MOUNTED NON-FUSED DISCONNECT.
 6. HIGH-EFFICIENCY DX COOLING, UTILIZING R-410A REFRIGERANT.
 7. FILTERS WITH MINIMUM MERV-8 RATING.
 8. PIPE CONDENSATE FOR ROOFTOP UNITS TO OUTDOORS, ONTO ROOF, OR TO NEAREST DRAIN.
 9. BASIS OF DESIGN ROOFTOP UNIT IS AN EXACT REPLACEMENT FOR CURB AND DUCT FIT-UP. OTHER MANUFACTURER MAY REQUIRE CURB ADAPTER AND DUCT TRANSITIONS.
 10. PROVIDE CURB ADAPTER AND DUCT TRANSITIONS.
 11. EQUIPMENT NOT IN SCOPE OF THIS PROJECT.

DIFFUSER/REGISTER/GRILLE SCHEDULE

UNIT NO	TYPE	NOMINAL DUCT SIZE WIDTH X HEIGHT (IN X IN)	FACE SIZE (IN X IN)	PANEL SIZE (IN X IN)	INSTALL STYLE	CFM RANGE	VOLUME DAMPER	MAX PRESS DROP (IN WC)	DIRECTION OF FLOW	MAX NOISE CRITERIA	DEFLECTION (°)	THROW AT MAX CFM (FT) (50-100-150 FPM)	MANUFACTURER AND MODEL	NOTES
S-1	SUPPLY GRILLE	10x6	10x6	10x6	DUCT MOUNT	0-200	YES	0.1	1-WAY	20	22.5	27-18-12	PRICE SDG	
S-2	SUPPLY DIFFUSER	6ø	24x24	24x24	T-GRID	0-110	NO	0.1	4-WAY	20	-	5-3-2	PRICE SCD	
S-3	SUPPLY DIFFUSER	8ø	24x24	24x24	T-GRID	111-285	NO	0.1	4-WAY	20	-	9-5-3	PRICE SCD	
R-1	RETURN DIFFUSER	14ø	24x24	24x24	SURFACE MOUNT	400-800	NO	-	-	20	-	-	PRICE PDDR	
R-2	RETURN DIFFUSER	8ø	24x24	24x24	T-GRID	0-200	NO	-	-	20	-	-	PRICE PDDR	
R-3	RETURN DIFFUSER	10ø	24x24	24x24	T-GRID	201-310	NO	-	-	20	-	-	PRICE PDDR	

- NOTES:
 1.

KEYED NOTE:

① MANUFACTURER'S NAME AND MODEL NUMBER ARE THE BASIS OF DESIGN PRODUCTS AND ARE INTENDED TO INDICATE THE STANDARD OF MATERIAL OR ARTICLES REQUIRED. DESIGN IS PREDICATED AROUND LISTED MANUFACTURERS AS NOTED ON SCHEDULES; SEE SPECIFICATIONS FOR ALLOWABLE MANUFACTURERS AND PRODUCTS.

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MANCHESTER COMMUNITY COLLEGE MANCHESTER, NH			
MECHANICAL EQUIPMENT REPLACEMENT MCC 19-04			
MECHANICAL SCHEDULES			
0	ISSUED FOR CONSTRUCTION	PML	SMC 04/22/20
REV	DESCRIPTION	DWN	APP DATE
SIZE:	ANSI D	PROJECT NO.	DRAWING NO.
DATE:	04/19/2019	372.004.001	M-601
DES BY:	SMC	SHEET	
DWN BY:	PML	14 OF 14	
CKD BY:	DHB		



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COMMUNITY COLLEGE SYSTEM OF NEW HAMPSHIRE

Mechanical Equipment Replacement at Manchester Community College

Community College System of New Hampshire
26 College Drive
Concord, NH 03301-7407

Project Number MCC19-04

Technical Specifications Final Submission

April 22, 2020

Prepared for:



26 College Drive
Concord, NH 03301-7407

Division	Section Title
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TECHNICAL SPECIFICATIONS GROUP

DIVISION 5 – METALS

051200 STRUCTURAL STEEL

DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

230500 COMMON WORK RESULTS FOR HVAC
230519 METERS AND GAUGES FOR HVAC PIPING
230529 HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
230553 IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
230593 TESTING, ADJUSTING, AND BALANCING FOR HVAC
230713 DUCT INSULATION
230719 HVAC PIPING INSULATION
230923 DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC
231123 FACILITY NATURAL-GAS PIPING
232113 HYDRONIC PIPING
232118 HYDRONIC SPECIALTIES
232300 REFRIGERANT PIPING
232500 HVAC WATER TREATMENT
233113 METAL DUCTS
233700 AIR OUTLETS AND INLETS
236313 AIR-COOLED REFRIGERANT CONDENSERS
237423 PACKAGED, DIRECT-FIRED, OUTDOOR, HEATING ONLY MAKEUP AIR
 UNITS
238126 SPLIT-SYSTEM AIR CONDITIONERS

END OF TABLE OF CONTENTS

SECTION 051200 - STRUCTURAL STEEL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract.

1.2 SUMMARY

- A. Section Includes:

- 1. Structural steel.
- 2. Grout.

- B. Related Sections:

- 1. Division 1 Section "Quality Requirements" for independent testing agency procedures and administrative requirements.
- 2. Division 5 Section "Steel Deck" for field installation of shear connectors through deck.
- 3. Division 5 Section "Metal Fabrications" for miscellaneous steel fabrications and other metal items not defined as structural steel.
- 4. Division 5 Section "Metal Stairs."

1.3 DEFINITIONS

- A. Structural Steel: Elements of structural-steel frame, as classified by AISC 303, "Code of Standard Practice for Steel Buildings and Bridges."

- B. Heavy Sections: Rolled and built-up sections as follows:

- 1. Shapes included in ASTM A 6/A 6M with flanges thicker than 1-1/2 inches.
- 2. Column base plates thicker than 2 inches.

1.4 PERFORMANCE REQUIREMENTS

- A. Connections: Provide details of simple shear connections required by the Contract Documents to be selected or completed by structural-steel fabricator, including comprehensive engineering analysis by a qualified professional engineer license in the State of Maine, to withstand loads indicated and comply with other information and restrictions indicated.

- 1. Select and complete connections using schematic details indicated, AISC Manual of Steel Construction 13th Edition and AISC 360.
- 2. Use ASD; loads indicated on drawings are service-loads.

1.5 -ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Show fabrication of structural-steel components.
 - 1. Include details of cuts, connections, splices, camber, holes, and other pertinent data.
 - 2. Include embedment drawings.
 - 3. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld. Show backing bars that are to be removed and supplemental fillet welds where backing bars are to remain.
 - 4. Indicate type, size, and length of bolts, distinguishing between shop and field bolts. Identify pretensioned and slip-critical high-strength bolted connections.
 - 5. For structural-steel connections indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer licensed in the State of Maine responsible for their preparation.
- C. Welding Procedure Specifications (WPSs) and Procedure Qualification Records (PQRs): Provide according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for each welded joint whether prequalified or qualified by testing, including the following:
 - 1. Power source (constant current or constant voltage).

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer, fabricator, professional engineer and testing agency.
- B. Welding certificates.
- C. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.
- D. Mill test reports for structural steel, including physical properties.
- E. Source quality-control reports.

1.7 QUALITY ASSURANCE

- A. Fabricator Qualifications: A qualified fabricator that participates in the AISC Quality Certification Program..
- B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Comply with applicable provisions of the following specifications and documents:
 - 1. AISC 303.

2. AISC 341 and AISC 341s1.
3. AISC 360.
4. RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."

D. Preinstallation Conference: Conduct conference at Project site.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store materials to permit easy access for inspection and identification. Keep steel members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from corrosion and deterioration.

1. Do not store materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.

B. Store fasteners in a protected place in sealed containers with manufacturer's labels intact.

1. Fasteners may be repackaged provided testing and inspecting agency observes repackaging and seals containers.
2. Clean and relubricate bolts and nuts that become dry or rusty before use.
3. Comply with manufacturers' written recommendations for cleaning and lubricating ASTM F 1852 fasteners and for retesting fasteners after lubrication.

1.9 COORDINATION

A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' recommendations to ensure that shop primers and topcoats are compatible with one another.

B. Coordinate installation of anchorage items to be embedded in or attached to other construction without delaying the Work. Provide setting diagrams, sheet metal templates, instructions, and directions for installation.

PART 2 - PRODUCTS

2.1 STRUCTURAL-STEEL MATERIALS

Provide steel material with the maximum amount possible of post-consumer and pre-consumer recycled content. Provide product manufactured, fabricated and extracted within 500 miles of the project site.

A. W-Shapes: ASTM A 992/A 992M].

B. Channels, Angles, M, S-Shapes: ASTM A 36/A 36M or ASTM A 572/A 572M, Grade 50.

- C. Plate and Bar: ASTM A 36/A 36M or ASTM A 572/A 572M, Grade 50.
- D. Cold-Formed Hollow Structural Sections: ASTM A 500, Grade B, structural tubing.
- E. Corrosion-Resisting Cold-Formed Hollow Structural Sections: ASTM A 847/A 847M, structural tubing.
- F. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade B.
 - 1. Weight Class: Standard.
 - 2. Finish: Black except where indicated to be galvanized.
- G. Welding Electrodes: E70XX and comply with AWS requirements.

2.2 BOLTS, CONNECTORS, AND ANCHORS

- A. High-Strength Bolts, Nuts, and Washers: ASTM A 325, Type 1, heavy-hex steel structural bolts; ASTM A 563, Grade C, heavy-hex carbon-steel nuts; and ASTM F 436, Type 1, hardened carbon-steel washers; all with plain finish.
 - 1. Direct-Tension Indicators: ASTM F 959, Type 325, compressible-washer type with plain finish.
- B. Shear Connectors: ASTM A 108, Grades 1015 through 1020, headed-stud type, cold-finished carbon steel; AWS D1.1/D1.1M, Type B.
- C. Unheaded Anchor Rods: ASTM F 1554, Grade 36.
 - 1. Configuration: Straight unless indicated otherwise on drawings.
 - 2. Nuts: ASTM A 563 heavy-hex carbon steel.
 - 3. Plate Washers: ASTM A 36/A 36M carbon steel.
 - 4. Washers: ASTM F 436, Type 1, hardened carbon steel.
 - 5. Finish: Plain.
- D. Headed Anchor Rods: ASTM F 1554, Grade 36, straight.
 - 1. Nuts: ASTM A 563 heavy-hex carbon steel.
 - 2. Plate Washers: ASTM A 36/A 36M carbon steel.
 - 3. Washers: ASTM F 436, Type 1, hardened carbon steel.
 - 4. Finish: Plain.
- E. Threaded Rods: ASTM A 36/A 36M.
 - 1. Nuts: ASTM A 563 heavy-hex carbon steel.
 - 2. Washers: ASTM F 436, Type 1, hardened carbon steel.
 - 3. Finish: Plain.
- F. Sleeve Nuts: Made from cold-finished carbon steel bars, ASTM A 108, Grade 1018.

2.3 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive and nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.
- B. Provide grout product manufactured and extracted within 500 miles of the project site.

2.4 FABRICATION

- A. Structural Steel: Fabricate and assemble in shop to greatest extent possible. Fabricate according to AISC's "Code of Standard Practice for Steel Buildings and Bridges" and AISC 360.
 - 1. Fabricate beams with rolling camber up.
 - 2. Identify high-strength structural steel according to ASTM A 6/A 6M and maintain markings until structural steel has been erected.
 - 3. Mark and match-mark materials for field assembly.
 - 4. Complete structural-steel assemblies, including welding of units, before starting shop-priming operations.
- B. Thermal Cutting: Perform thermal cutting by machine to greatest extent possible.
 - 1. Plane thermally cut edges to be welded to comply with requirements in AWS D1.1/D1.1M.
- C. Bolt Holes: Drill or punch standard bolt holes perpendicular to metal surfaces. Gas cutting holes is not permitted.
- D. Finishing: Accurately finish ends of columns and other members transmitting bearing loads.
- E. Cleaning
 - 1. Unless otherwise approved by the coating supplier and the engineer, prepare surface to be painted according to SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."

2.5 SHOP CONNECTIONS

- A. High-Strength Bolts: Shop install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.
- B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.
 - 1. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding tolerances in AISC 303 for mill material.
 - 2. Remove backing bars or runoff tabs, back gouge, and grind steel smooth.

3. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding tolerances of AISC's "Code of Standard Practice for Steel Buildings and Bridges" for mill material.
4. Verify that weld sizes, fabrication sequence, and equipment used for architecturally exposed structural steel will limit distortions to allowable tolerances. Prevent weld show through on exposed steel surfaces.
 - a. Grind butt welds flush.
 - b. Grind or fill exposed fillet welds to smooth profile. Dress exposed welds.

2.6 SHOP PRIMING

- A. Shop prime steel all surfaces except the following:
 1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches.
 2. Surfaces to be field welded.
 3. Surfaces to be high-strength bolted with slip-critical connections. Unless coating is approved for a slip critical surface
 4. Surfaces intended to be galvanized.
- B. Steel preparation, material selection and application shall be in accordance with Section 09960 – “High-Performance Coatings”

2.7 GALVANIZING

- A. Hot-Dip Galvanized Finish: Unless noted otherwise, apply zinc coating by the hot-dip process to all structural steel in accordance with ASTM A 123/A 123M.
 1. Fill vent and drain holes that are exposed in the finished Work unless they function as weep holes, by plugging with zinc solder and filing off smooth.
 2. Galvanize lintels shelf angles welded door frames and exterior exposed steel including but not limited to the mechanical platform structure, stairs and ladders attached to structural-steel frame and located in exterior walls.
 3. Fasteners used with galvanized structural steel shall also be galvanized. Including but not limited to, bolts, anchor bolts, washers and hex nuts.

2.8 SOURCE QUALITY CONTROL

- A. Testing Agency: Contractor will engage an independent third party testing and inspecting agency to perform shop tests and inspections and prepare test reports. Inspections shall be in accordance with IBC Chapter 17.
 1. Provide testing agency with access to places where structural-steel work is being fabricated or produced to perform tests and inspections.

- B. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.
- C. Bolted Connections: Shop-bolted connections will be inspected according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."
- D. Welded Connections: In addition to visual inspection, shop-welded connections will be tested and inspected according to AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:
 - 1. Liquid Penetrant Inspection: ASTM E 165.
 - 2. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
 - 3. Ultrasonic Inspection: ASTM E 164.
 - 4. Radiographic Inspection: ASTM E 94.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify, with steel Erector present, elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments for compliance with requirements.
 - 1. Prepare a certified survey of bearing surfaces, anchor rods, bearing plates, and other embedments showing dimensions, locations, angles, and elevations.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Provide temporary shores, guys, braces, and other supports during erection to keep structural steel secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place unless otherwise indicated.
 - 1. Do not remove temporary shoring supporting composite deck construction until cast-in-place concrete has attained its design compressive strength.

3.3 ERECTION

- A. Set structural steel accurately in locations and to elevations indicated and according to AISC 303 and AISC 360.

- B. Base Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates. Clean bottom surface of plates.
 - 1. Set plates for structural members on wedges, shims, or setting nuts as required.
 - 2. Weld plate washers to top of baseplate.
 - 3. Snug-tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
 - 4. Promptly pack grout solidly between bearing surfaces and plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.
- C. Maintain erection tolerances of structural steel within AISC's "Code of Standard Practice for Steel Buildings and Bridges."
- D. Align and adjust various members that form part of complete frame or structure before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that will be in permanent contact with members. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.
 - 1. Level and plumb individual members of structure.
 - 2. Make allowances for difference between temperature at time of erection and mean temperature when structure is completed and in service.
- E. Splice members only where indicated.
- F. Do not use thermal cutting during erection unless approved by Structural Engineer.
- G. Do not enlarge unfair holes in members by burning or using drift pins. Ream holes that must be enlarged to admit bolts.
- H. Shear Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Use automatic end welding of headed-stud shear connectors according to AWS D1.1/D1.1M and manufacturer's written instructions.

3.4 FIELD CONNECTIONS

- A. High-Strength Bolts: Install high-strength bolts according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" for type of bolt and type of joint specified.
- B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.
 - 1. Comply with AISC 303 and AISC 360 for bearing, alignment, adequacy of temporary connections, and removal of paint on surfaces adjacent to field welds.
 - 2. Remove backing bars or runoff tabs where indicated, back gouge, and grind steel smooth.

3. Assemble and weld built-up sections by methods that will maintain true alignment of axes without exceeding tolerances in AISC's "Code of Standard Practice for Steel Buildings and Bridges" for mill material.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Contractor will engage a qualified independent third party testing and inspecting agency to inspect field welds and high-strength bolted connections. All testing and inspection shall be in accordance with Chapter 17 of the current edition of the International Building Code.
- B. Bolted Connections: Bolted connections will be inspected according to RCSC's "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts."
- C. Welded Connections: Field welds will be visually inspected according to AWS D1.1/D1.1M.
 1. In addition to visual inspection, field welds will be tested and inspected according to AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:
 - a. Liquid Penetrant Inspection: ASTM E 165.
 - b. Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
 - c. Ultrasonic Inspection: ASTM E 164.
 - d. Radiographic Inspection: ASTM E 94.
- D. In addition to visual inspection, test and inspect field-welded shear connectors according to requirements in AWS D1.1/D1.1M for stud welding and as follows:
 1. Perform bend tests if visual inspections reveal either a less-than-continuous 360-degree flash or welding repairs to any shear connector.
 2. Conduct tests on additional shear connectors if weld fracture occurs on shear connectors already tested, according to requirements in AWS D1.1/D1.1M.
- E. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.

END OF SECTION 05120

SECTION 230500 – COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Provide labor, materials, accessories, and other related items as required to complete operations in connection with the complete installation of the HVAC and mechanical systems as indicated on the Drawings and as specified herein.

1.2 RELATED REQUIREMENTS

- A. Conditions of the Contract apply to the work, including the work of this Division. Examine Contract Documents for requirements affecting the work.
- B. Provide cooperation with, and assistance to, the Testing and Balancing (TAB) Agent specified in Division 23 Section “Testing, Adjusting, and Balancing for Mechanical Systems.”

1.3 MECHANICAL PRE-CONSTRUCTION MEETING

- A. Conduct a mechanical conference at Project site to comply with the following:
 - 1. At least 14 days prior to beginning of mechanical work, conduct a meeting to review detailed requirements for mechanical systems installation and testing requirements. Review mechanical Drawings and Specifications, discuss project specific details and requirements, and review and discuss expectations for quality control. Establish preliminary work progress schedule and procedures for materials inspection, testing, and certifications. Require representatives of each entity directly concerned with mechanical systems installation to attend conference, including, but not limited to, the following:
 - a. General Contractor's superintendent.
 - b. Mechanical Subcontractors' project managers.
 - c. Mechanical Subcontractors' job foremen.
 - d. Sheetmetal job foreman.
 - e. Plumbing job foreman.
 - f. Controls job foreman.
 - g. Job clerk.
 - h. Contract Representative of the Owner.
 - i. Project mechanical Engineer/designer.

- j. Engineer's construction administrator.

1.4 DRAWINGS

- A. The general location of the apparatus and the details of the work are indicated on the Drawings. Exact locations not indicated shall be determined at the site as the work progresses and shall be subject to the Engineer's approval.
- B. It is not intended that the Drawings shall show every pipe, pipe rise, pipe drop, duct rise, duct drop, pipe fitting, duct fitting, or appliance, but it shall be a requirement to furnish, without additional expense, material and labor necessary to complete the systems in accordance with the design intent and with the highest possible quality available.

1.5 ALTERATIONS

- A. Execute alterations, additions, removals, relocations, new work, and other related items as indicated or required to provide a complete installation in accordance with the intent of the Contract Documents, including changes required by building alterations.
- B. Existing work disturbed or damaged by the alterations or the new work shall be repaired or replaced to the Engineer's satisfaction and at no additional cost to the Owner.
- C. Existing ductwork, piping, and other systems indicated to be removed, shall be removed from the site. Cap off existing services remaining. The Owner's Contract Representative retains the right to ownership of heating and ventilating equipment scheduled to be removed; store such equipment where requested by the Contract Representative. Material not retained by the Contract Representative shall be removed from the site.

1.6 CONTINUITY OF SERVICE

- A. Arrange to execute the work at such times and in such locations as may be required to provide uninterrupted service for the building or any of its locations. Any unavoidable conditions requiring reduced building capacity shall be arranged for by programming with the Contract Representative at the building subject to the Engineer's approval. If necessary, temporary work shall be installed to provide for the condition. Authorization for interrupting service shall be obtained in writing from the Contract Representative. Any interruption of normal service shall be performed during an overtime period to be scheduled with the Contract Representative. Costs for overtime work shall be included in the bid.

1.7 REQUIREMENTS

- A. Installation Instructions: Obtain manufacturer's printed installation instructions to aid in properly executing work on major pieces of equipment. Install equipment in accordance with manufacturer's recommendations.
- B. Objectionable Noise, Fumes and Vibration:
 - 1. Mechanical and electrical equipment shall operate without creating objectionable noise, fumes, or vibration, as determined by the Engineer.

2. If such objectionable noise, fumes, or vibration is produced and transmitted to occupied portions of building by apparatus, piping, ducts, or any other part of mechanical and electrical work, make necessary changes and additions, as approved, without extra cost to Owner.

C. Equipment Design and Installation:

1. Uniformity: Unless otherwise specified, equipment or material of same type or classification, used for same purposes, shall be product of same manufacturer.
2. Design: Equipment and accessories not specifically described or identified by manufacturer's catalog number shall be designed in conformity with ASME, IEEE, or other applicable technical standards, suitable for maximum working pressure, and with neat and finished appearance.
3. Installation: Erect equipment aligned, level and adjusted for satisfactory operation. Install so that connecting and disconnecting of piping and accessories can be made readily, and so that parts are easily accessible for inspection, operation, maintenance and repair. Minor deviations from indicated arrangements may be made, as approved.

D. Hanging of Equipment, Ductwork and Piping:

1. Support equipment, ductwork and piping from the top chord of bar joists at the "Panel Points" or from the top flange of beams. Piping 2-inch (50 mm) nominal and smaller may be supported from the bottom chord of the bar joists at the "Panel Points" or from the bottom flange of the beams.

E. Protection of Equipment and Materials: Responsibility for care and protection of materials and mechanical work rests with the Contractor until the entire project has been completed, tested and the project is accepted by the Contract Representative.

F. Foundations:

1. Ceiling Mounting: Where ceiling mounting is indicated or specified, use suspended platform or strap hangers, bracket or shelf, whichever is most suitable for equipment and its location. Construct of structural steel members, steel plates, or rods, as required; brace and fasten to building structure or to inserts as approved, or as detailed.
2. Where floor mounting is indicated, locate equipment on 4 inch (102 mm) high reinforced concrete pad of adequate size with anchors and base plates as required. The corners of pads shall be chamfered 1 inch (25 mm). Pad and steel sizes and location shall be coordinated with the approved equipment.

1.8 ELECTRIC WORK

- A. Provide motors, pilot lights, controllers, limit switches, and other related items for equipment provided under Division 23.
- B. Except as noted, required line switches, fused switches, and other related items and necessary

wiring to properly connect equipment to motors and switches shall be furnished and installed under Division 26, Electric.

- C. Provide complete wiring system for automatic temperature controls as specified under Section Division 23 Section "Instrumentation and Controls for Mechanical Systems."
- D. Wiring shall conform to the requirements of the National Electrical Code.

1.9 SUBMITTALS

- A. After award of Contract and before installation, submit for approval Shop Drawings, bulletins, Product Data, Samples, and other related items per Section 01330 "Submittal Procedures."

1.10 SUBSTITUTIONS

- A. Comply with provisions of the Instructions to Bidders and General Conditions.
 - 1. Unless otherwise specified, the following provisions shall apply: If a manufacturer's name, trade name or proprietary designation is used in the Contract Documents, the time for submission for review of proposed substitutions shall be at least 10 working days prior to the Bid date. After that time, no substitutions will be reviewed.
- B. The first item listed under "Acceptable Manufacturers", "Approved Manufacturers" or "Manufacturers" is the design basis.
 - 1. Other manufacturers listed may be used in the base bid, but conformance with details of the Specifications, as well as dimensional and electrical data, shall be verified by the Contractor.
 - 2. Engineer/Engineer has not verified that each listed manufacturer has the ability to provide an acceptable substitution for the basis-of-design product. Contractor may not assume that substitutions will be approved.
 - 3. Modifications required as a result of differences between the design basis item and the submitted and approved item must be approved by the Engineer and made at the Contractor's expense. As an example, if a rooftop HVAC unit is submitted and approved and if the unit's dimensions and weight are different from those of the unit which was used as the design basis, the Contractor shall be responsible for building structural modifications required to accommodate the submitted and approved unit, at no additional cost to the Owner.
 - 4. When, in the Engineer's opinion, engineering services are necessary for the coordination of substituted items, the Contractor shall reimburse the Owner for the cost of these services.
 - 5. For items which have no manufacturers listed, any item conforming with the Contract Documents is acceptable.

- C. Substitutions from manufacturers or providers which are not listed may be proposed within the time allowed in the General Conditions of the Specifications.
 - 1. The exception to this is products for which the list of manufacturers or providers is limited by the wording “no substitutions” or similar wording.

1.11 COORDINATION

- A. Coordinate scheduling, submittals, and Work of the various Sections of Specifications to assure efficient and orderly sequence of installation of interdependent construction elements, with provisions for accommodating items installed later.
- B. Verify that utility requirement characteristics of operating equipment are compatible with building utilities. Coordinate work of various Divisions having interdependent responsibilities for installing, connecting to, and placing in service, such equipment.
- C. Coordinate space requirements and installation of mechanical and electrical work which are indicated diagrammatically on Drawings. Follow routing shown for pipes, ducts, and conduit, as closely as practicable; place runs parallel with line of building. Utilize spaces efficiently to maximize accessibility for other installations, for maintenance, and for repairs.
- D. In finished areas, conceal pipes, ducts, and wiring within the construction. Coordinate locations of fixtures and outlets with finish elements.
- E. Coordinate completion and clean-up of work of separate Sections in preparation for Substantial Completion.
- F. After Owner occupancy of premises, coordinate access to site for correction of defective work and work not in accordance with Contract Documents, to minimize disruption of Owner's activities.

1.12 SEISMIC DESIGN

- A. This project requires special provisions for the support and restraint of natural gas piping. These provisions shall be incorporated in accordance with the following:
 - 1. The requirements of this Section are complementary to requirements listed elsewhere for the fastening and support of piping, ductwork, and equipment. Nothing indicated on the Drawings or in other Sections of these Specifications shall be interpreted as a reason to waive the requirements of this Section.
 - 2. Piping shall be adequately supported and restrained to resist seismic forces in accordance with the applicable edition of NFPA 54 for gas piping.

1.13 CLEANING

- A. Remove debris from site daily.
- B. Material and pieces of equipment shall be turned over to the Contract Representative free of

dust and dirt, both inside and out.

- C. At the completion of the Project, equipment shall have a clean, neat appearance of factory finish by cleaning or repainting as required.
- D. At the completion of the Project, surfaces exposed to view shall have a clean, neat appearance of finish free from smudges and scratches by cleaning or repainting as required.

1.14 STARTING SYSTEMS

- A. Coordinate schedule for start-up of various equipment and systems.
- B. Notify Owner 7 days prior to start-up of each item.
- C. Verify that each piece of equipment or system has been checked for proper lubrication, drive rotation, belt tension, control sequence, or other conditions which may cause damage.
- D. Verify that tests, meter readings, and specified electrical characteristics agree with those required by the equipment or system manufacturer.
- E. Verify that wiring and support components for equipment are complete and tested.
- F. Execute start-up under supervision of responsible manufacturer's representative in accordance with manufacturer's instructions.
- G. When specified in individual Specification Sections, require manufacturer to provide authorized representative to be present at site to inspect, check, and approve equipment or system installation prior to start-up, and to supervise placing equipment or system in operation.
- H. Submit a written report that equipment or system has been properly installed and is functioning correctly.

1.15 FACTORY START-UP AND START-UP REPORTS

- A. Provide factory start-up of mechanical equipment listed below. Factory start-up shall be performed by a factory authorized representative of the equipment manufacturer. When factory start-up is successfully completed for each piece of mechanical equipment listed below, submit a formal start-up report to the Engineer for approval. Start-up report shall be formatted in accordance with equipment manufacturer's recommendations. Start-up report shall be typed, not hand written, and shall be submitted in a clean and legible form.
- B. Equipment requiring factory start-up
 - 1. Boilers
 - 2. Boiler controllers
 - 3. Rooftop units
 - 4. Condensing units
 - 5. Indoor suspended air handling unit

6. Indoor wall mounted air conditioning units

1.16 ADJUSTMENTS AND OWNER'S INSTRUCTIONS

- A. After completion of the installation work called for in the Contract Documents, furnish necessary mechanics or engineers for the adjustment and operation of the systems, to the end that the systems are perfectly adjusted and turned over to the Contract Representative in perfect working order. Further instruct the Contract Representative in the care and operation of the installation, providing framed instruction charts, directions, and other related items.
- B. Instructors providing Owner training shall be experienced and familiar with the jobsite.

1.17 TESTING

- A. After the entire installation is completed and ready for operation, test the systems as outlined in Division 23 Section "Testing, Adjusting and Balancing for HVAC." These tests are supplementary to detailed tests specified herein or directed. The Contract Representative will provide water and electric current for the test. Provide necessary labor, test pump, gauges, meters, other instruments, and materials. Perform tests in the presence of the Engineer or his representative.
- B. Perform other tests specified in individual Sections of this Specification.

1.18 COMPLETION OF SYSTEMS

- A. The following mechanical systems shall not be complete until the following conditions are satisfied:
 1. Ductwork Systems:
 - a. Ductwork and related components and accessories shall be completely installed and insulated as specified.
 - b. Ductwork leakage testing shall be completed and leakage testing reports shall be submitted and approved.
 - c. Ductwork shall be balanced and a balancing report shall be submitted and approved.
 - d. Control of dampers shall be completed.
 2. Piping Systems:
 - a. Piping, valves and accessories shall be completely installed, insulated and labeled as specified.
 - b. Piping pressure testing be completed and pressure testing reports shall be submitted and approved.

- c. Piping systems shall be balanced and a balancing report shall be submitted and approved.
 - d. Control installation shall be completed.
- 3. Equipment:
 - a. Equipment, including but not limited to boilers, pumps and rooftop units shall be completely installed.
 - b. Equipment start-up reports shall be completed, submitted and approved.
 - c. Equipment balancing shall be completed and the balancing report shall be submitted and approved.
 - d. Control installation and training shall be completed.
- 4. Automatic Temperature Controls (ATC):
 - a. ATC system shall be completely installed.
 - b. Control startup and training shall be completed.
 - c. Controls shall operate in an automatic mode for a minimum of 2 months during heating system operation without substantial deficiencies.

1.19 OPERATING AND MAINTENANCE MANUALS

- A. Submit electronic copy of operating and maintenance manuals to the Engineer for review. Indicate where in the final bound copy there will be physical divider tabs.
- B. Furnish approved operating and maintenance manuals to the Contract Representative as follows: 1 bound copy in 3-ring binders, and one electronic copy on a USB 3.0 flash drive.
- C. For maintenance purposes, provide approved Submittals, parts lists, specifications, and manufacturer's maintenance bulletins for each piece of equipment. For materials used which have been submitted to the Engineer for approval but do not require regular maintenance, such as piping, ductwork, and insulation, provide one copy of approved Submittals.
- D. Provide name, address and telephone number of the manufacturer's representative and service company, for each piece of equipment or material so that service or spare parts can be readily obtained.

1.20 WARRANTY

- A. Provide guarantees and warranties for work under this Contract as indicated in the general requirements of the Contract. Warrant the work for a period of 2 years from the date of substantial completion.

- B. Provide manufacturers' standard warranties and guarantees for work by the mechanical trades. However, such warranties and guarantees shall be in addition to and not in lieu of other liabilities which the manufacturer and the Mechanical Contractor may have by law or by other provisions of the Contract Documents.
- C. Guarantee that elements of the systems provided under this Contract are of sufficient capacity to meet the specified performance requirements as set forth in these Specifications or as indicated on the Drawings.
- D. Upon receipt of notice from the Contract Representative of failure of any part of the mechanical systems or equipment during the warranty period, the Mechanical Subcontractor shall replace the affected part or parts.
- E. Furnish a written guarantee covering the above requirements before submitting the application for final payment.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 230500

SECTION 230519 – METERS AND GAUGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Pressure gauges and Pressure gauge taps.
- B. Thermometers and thermometer wells.
- C. Thermowell heat transfer paste.

1.2 RELATED SECTIONS

- A. Division 23 Section “Hydronic Piping.”
- B. Division 23 Section “Instrumentation and Controls for Mechanical Systems.”

1.3 REFERENCES

- A. ASME B40.1 - Gauges - Pressure Indicating Dial Type - Elastic Element.
- B. ASME MFC-3M - Measurement of Fluid Flow in Pipes Using Orifice, Nozzle and Venturi.
- C. ASTM D217 - Standard Test Methods for Cone Penetration of Lubricating Grease.
- D. ASTM D566 - Standard Test Method for Dropping Point of Lubricating Grease.
- E. ASTM E1 - Standard Specification for ASTM Thermometers.
- F. ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Company specializing in manufacturing the Products specified in this Section with minimum 3 years' experience.

1.5 SUBMITTALS

- A. Division 01 Section “Submittal Procedures”: Procedures for submittals.
- B. Product Data: Provide manufacturers data and list which indicates use, operating range, total range, accuracy, and location for manufactured components.

1.6 OPERATION AND MAINTENANCE DATA

- A. Include instructions for calibrating instruments.

1.7 ENVIRONMENTAL REQUIREMENTS

- A. Division 01 Section “Product Requirements”: Environmental conditions affecting products on site.
- B. Do not install instruments when areas are under construction, except for required rough-in, taps, supports and test plugs.

PART 2 - PRODUCTS

2.1 PRESSURE GAUGES

- A. Manufacturers:
 - 1. Weiss.
 - 2. Trerice.
 - 3. Marshalltown.
 - 4. Amtek.
 - 5. Dwyer.
- B. Gauges, Hot Water Heating Systems: Weiss Series 4PG-1 industrial pressure gauge, dry non-filled type, with phosphor bronze bourdon tube, silver brazed connecting joints, brass socket, bushed stainless rotary movement, 1/4-inch NPT connection, white aluminum dial with black markings, black aluminum pointer with front slotted adjustment or approved equal.
 - 1. Case: Cast aluminum or stainless steel.
 - 2. Lens: Push-in Lexan polycarbonate, or clear glass or acrylic with stainless steel ring, per manufacturer’s standard.
 - 3. Bourdon Tube: Phosphor bronze.
 - 4. Dial Size: 4 to 4-1/2 inch (101 to 114 mm).
 - 5. Connection: Lower or lower back, 1/4-inch or 1/2-inch NPT, as selected by Contractor.
 - 6. Accuracy: 1 percent of full scale range, per ANSI-ASME B40.1 Grade 1A.
 - 7. Scale: Psi.
 - 8. Range: 0-60 psig typical, select for application.]
- C. Verify suitability of range for each application. Best selection is for typical reading to be close to mid-scale.

2.2 PRESSURE GAUGE TAPPINGS

- A. Ball Valve: Provide under Division 23 Section “Hydronic Piping.”

B. Pulsation Damper:

1. Manufacturers:
 - a. Weiss.
 - b. Trerice.
 - c. Marshalltown.
 - d. Amtek.
 - e. Dwyer.
2. Pressure snubber, brass with 1/4 inch (6 mm) NPT connections.

2.3 THERMOMETERS – LIQUID-IN-GLASS TYPE

A. Manufacturers:

1. Weiss.
2. Trerice.
3. Amtek.
4. Ernst.

B. Where dial thermometers are indicated, liquid-in-glass type may be substituted.

C. Thermometer: Weiss Vari-angle industrial thermometer, ASTM E1, adjustable angle, red liquid, lens front tube, case with black textured finish, adjustable joint with positive locking device or approved equal. Case and joint may be GE Valox polyester with 40 percent glass/mineral reinforcement, or cast aluminum.

1. Size: 7-inch (178 mm) scale.
2. Window: Clear glass, secured with spring action.
3. Stem: Brass, 3/4-inch (20 mm) NPT, 3 1/2 inch (89 mm) long. Provide extended stem for socket extension in insulated pipe.
4. Accuracy: ASTM E77, 1 percent of scale range.
5. Calibration: Degrees F.
6. Scale Range: 30 to 240 degrees F for plumbing hot water, hot water heating, and supply air systems.
7. Graduations: 2 degrees F.

2.4 THERMOMETER SUPPORTS

A. Socket (Thermometer Well) for Piping: Brass separable sockets for thermometer stems, with extensions for insulated piping. Provide with Honeywell viscous heat transfer paste.

2.5 THERMOWELL HEAT TRANSFER PASTE

A. Manufacturers:

1. MG Chemicals.
2. Honeywell.
3. Trexco.

B. Description:

1. Formulation: Silicone or synthetic base, containing metal oxides.
2. Thermal Conductivity: At least 4.5 Btu-in./(hr-ft²-°F) (0.65 W/(m-K).
3. Temperature Range: To 392 degrees F (200 degrees C).
4. Flash Point: 500 degrees F (260 degrees C).
5. Dropping Point: ASTM D566, greater than 500 degrees F (260 degrees C).
6. Specific Gravity: 2.3 minimum at 77 degrees F (25 degrees C).
7. Consistency: ASTM D217, 310 to 320.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Use ball valves for water service.
- B. Division 01 - Quality Requirements: Manufacturer's instructions.
- C. Install 1 pressure gauge per pump, with taps on suction and discharge of pump; pipe to gauge.
- D. Install gauge taps in piping; refer to Division 23 Section "Hydronic Piping."
- E. Install pressure gauges with pulsation dampers. Provide valve to isolate each gauge; see "Pressure Gauge Tappings" in this Section. Extend nipples to allow clearance from insulation.
- F. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inches (64 mm) for installation of thermometer sockets. Ensure sockets allow clearance from insulation.
- G. Fill thermometer sockets with heat transfer paste.
- H. Install thermometer sockets adjacent to controls systems thermostat, transmitter, or sensor sockets.
- I. Provide instruments with scale ranges selected according to service with largest appropriate

scale.

- J. Install gauges and thermometers in locations where they are easily read from normal operating level, with thermometer in upright orientation. Install vertical to 45 degrees off vertical.
- K. Adjust gauges and thermometers to final angle, clean windows and lenses, and calibrate to zero.

END OF SECTION 230519

SECTION 230529 – HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Pipe and equipment hangers and supports.

1.2 RELATED SECTIONS

- A. Division 23 Section “Vibration and Seismic Controls for HVAC Piping and Equipment.”
- B. Division 23 Section “HVAC Piping Insulation.”
- C. Division 23 Section “Hydronic Piping.”

1.3 REFERENCES

- A. ASME B31.1 - Power Piping.
- B. ASME B31.2 - Fuel Gas Piping.
- C. ASME B31.9 - Building Services Piping.
- D. ASTM A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
- E. ASTM A653 G90 SS Gr. 33 - Specification for Steel Sheet, Zinc Coated (Galvanized) by the Hot Dipped Process.
- F. ASTM B633 - Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
- G. ASTM F708 - Design and Installation of Rigid Pipe Hangers.
- H. MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.
- I. MSS SP69 - Pipe Hangers and Supports - Selection and Application.
- J. MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices.
- K. NFPA 70 - National Electrical Code

1.4 SUBMITTALS

- A. Submit under provisions of Division 01 Section “Submittal Procedures”.
- B. Shop Drawings: Indicate system layout with location and detail of trapeze hangers.
- C. Product Data: Provide manufacturers catalog data including load capacity.

- D. Design Data: Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.
- E. Manufacturer's Installation Instructions: Indicate special procedures and assembly of components.

1.5 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum 3 years' experience.

1.6 REGULATORY REQUIREMENTS

- A. Conform to applicable Codes for support of piping.
- B. Supports for Electrical: In conformance with NFPA 70 and Division 26 of the Specifications.

PART 2 - PRODUCTS

2.1 HANGERS, SUPPORTS, & PIPE CLAMPS

- A. Approved Manufacturers (first manufacturer is basis of design):

- 1. Strut Hangers:

- a. Unistrut (division of Tyco).
- b. Anvil International.
- c. Cooper B-Line.
- d. Hydra-Zorb Company.
- e. Thomas & Betts - Superstrut line.
- f. Tolco (division of Cooper B-Line).

- 2. Adjustable Swivel Band Hangers:

- a. Carpenter & Paterson.
- b. Anvil International.
- c. Cooper B-Line.
- d. Tolco (division of Cooper B-Line).

- 3. Clevis Hangers:

- a. Cooper B-Line.
- b. Anvil International.
- c. Carpenter & Paterson.
- d. Tolco (division of Cooper B-Line).

- 4. J-Hangers:

- a. Cooper B-Line.

- b. Carpenter & Paterson.
 - c. Thomas & Betts - Superstrut line.
 - d. Tolco (division of Cooper B-Line).
 - e. Unistrut (division of Tyco).
5. Cushion Clamps:
- a. Hydra-Zorb Company.
 - b. Cooper B-Line.
 - c. Thomas & Betts - Superstrut line.
 - d. Tolco (division of Cooper B-Line).
 - e. Unistrut (division of Tyco).
6. Insulated Pipe Couplings:
- a. Cooper B-Line - Armafix line.
 - b. Klo-Shure Corporation.
7. No substitutions.
- B. Horizontal Piping Supports: Provide struts for trapeze hangers for single or multiple pipes. Where individual piping runs are hung with individual hangers, adjustable swivel band hangers, clevis hangers, or j-hangers may be used.
- C. Strut hangers shall be standard 1-5/8 inches x 1-5/8 inches (41x41 mm) size.
- D. Pipe hanger rods and nuts shall be plated to match the hangers. Nuts shall be self-locking type, or provide double nuts tightened to lock together. Rods shall be threaded one end, or continuous threaded. Provide washers at each nut.
- E. Cushion Clamps for Un-insulated Lines: Plastic cushion shall be Dupont Hytel plastic, 5555HS plastic elastomer, warranted from -40 to 275 degrees F (-40 to 135 degrees C).
- F. Copper-plated hangers are plated for identification only. Traditional thin copper plating on steel substrate does not provide adequate protection from galvanic corrosion due to contact between dissimilar metals.
- 1. Where copper-plated supports are specified for use with copper piping, either copper plating or a copper-colored finish such as Cooper B-Line's Dura-Copper epoxy coating is acceptable. This is for identification, and does not protect dissimilar metals.
 - 2. Where copper piping is used with steel hangers and supports, provide protection from galvanic corrosion such as thick plastic or vinyl factory coating, or plastic-lined cushion clamps.
- G. For Insulated Lines Clamped to Strut: Insulated pipe coupling insert with the same thickness as the insulation. Protects insulation from crushing, and provides continuous insulation and vapor barrier thru the hanger or clamp. Klo-Shure product provides plastic pipe support and rigid outer band, for field insulation into the coupling. Armafix product provides insulation with

rigid outer band, for field insulation glued to the ends of the insert.

2.2 PIPE SUPPORTS

A. Hydronic Piping:

1. Conform to ASME B31.9, ASTM F708, MSS SP58, MSS SP69 and MSS SP89.
2. Hangers for Pipe Sizes 1/2 to 1-1/2 inch (13 to 38 mm): Malleable iron, adjustable swivel, split ring.
3. Hangers for Cold Pipe Sizes 2 inches (50 mm) and Over: Carbon steel, adjustable, clevis.
4. Hangers for Hot Pipe Sizes 2 to 4 inches (50 to 100 mm): Carbon steel, adjustable, clevis.
5. Hangers for Hot Pipe Sizes 5 inches (125 mm) and Over: Adjustable steel yoke, cast iron roll, double hanger.
6. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
7. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 inches (150 mm) and Over: Steel channels with welded spacers and hanger rods, cast iron roll.
8. Wall Support for Pipe Sizes to 3 inches (76 mm): Cast iron hook.
9. Wall Support for Cold Pipe Sizes 4 inches (100 mm) and Over: Welded steel bracket and wrought steel clamp.
10. Wall Support for Hot Pipe Sizes 4 inches (100 mm) and Over: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.
11. Vertical Support: Steel riser clamp.
12. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
13. Floor Support for Hot Pipe Sizes to 4 inches (100 mm): Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
14. Floor Support for Hot Pipe Sizes 5 inches (125 mm) and Over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
15. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

2.3 INSERTS

A. Manufacturers:

1. Cooper B-Line.

2. Grinnell.

- B. Inserts: Malleable iron case of steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.

3.2 INSERTS

- A. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- B. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches (100 mm).
- C. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
- D. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut recessed into and grouted flush with slab.

3.3 PIPE HANGERS AND SUPPORTS

- A. Support horizontal piping as scheduled.
- B. Install hangers to provide minimum 1/2-inch (13 mm) space between finished covering and adjacent work.
- C. Place hangers within 12 inches (300 mm) of each horizontal elbow.
- D. Use hangers with 1-1/2 inch (38 mm) minimum vertical adjustment.
- E. Support horizontal cast iron pipe adjacent to each hub, with 5 feet (1.5 m) maximum spacing between hangers.
- F. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.
- G. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- H. Support riser piping independently of connected horizontal piping.
- I. Provide copper plated hangers and supports for copper piping.
- J. Design hangers for pipe movement without disengagement of supported pipe.

- K. Prime coat exposed steel hangers and supports with rust-resistant paint.
- L. Do not support pipes from other pipes or equipment.
- M. Size pipe hangers to accommodate continuous piping insulation.

3.4 SUPPORTING OTHER TRADES

- A. Supports furnished under Division 23 of the Specifications may also be used to support plumbing piping and electrical and control conduits, if this Subcontractor is willing to allow this. Supports shared with other trades shall be designed to accommodate the weight, expansion/contraction, vibration, and other requirements of the other trades' items without detriment to the function, accessibility, and serviceability of the HVAC items or those of the other trades. Provide flexible sections of piping and conduit as required to allow each trade's items to expand and contract along with the other trades, and to absorb vibration caused by the other trades.
- B. Electrical lighting fixtures and equipment, and items such as ceilings, may not be supported from supports furnished under this Section.
- C. Prevent contact between components of other trades, such as suspended ceiling support wires, and HVAC supports which may transmit vibration to the occupied space.

3.5 SCHEDULES

PIPE SIZE		HANGER ROD MAX. HANGER SPACING		DIAMETER	
Inches	(mm)	Feet	(m)	Inches	(mm)
Steel and Copper Piping					
1/2 to 1-1/4	12 to 32	6.5	2	3/8	9
1-1/2 to 2	38 to 50	10	3	3/8	9
2-1/2 to 3	62 to 75	10	3	1/2	13
4 to 6	100 to 150	10	3	5/8	15
8 to 12	200 to 300	14	4.25	7/8	22

END OF SECTION 230529

SECTION 230553 – IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Nameplates.
- B. Tags.
- C. Labels.
- D. Pipe Markers.

1.2 REFERENCES

- A. Division 01 Section “References”: Requirements for references and standards.
- B. ASME A13.1 - Scheme for the Identification of Piping Systems (2007 edition or newer).
- C. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

1.3 SUBMITTALS

- A. Division 01 Section “Submittal Procedures.”
- B. Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- C. Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- D. Product Data: Provide manufacturers catalog literature for each product required.
- E. Samples: Submit two tags, 1-1/2 inches (38 mm) in size.
- F. Samples: Submit two labels, 1.9 x 0.75 inches (48 x 19 mm) in size.

1.4 PROJECT RECORD DOCUMENTS

- A. Record actual locations of tagged valves; include valve tag numbers.

1.5 OPERATION AND MAINTENANCE DATA

- A. Include valve tag chart.

PART 2 - PRODUCTS

2.1 NAMEPLATES

- A. Manufacturers:
1. Seton Identification Products.
 2. E.R. Perry Signs & Engraving.
 3. Brimar Industries, Inc., PipeMarker division.
 4. No substitutions.
- B. Plastic Nameplates: Laminated 3-layer plastic with beveled edges and engraved letters on contrasting background color, 1/16 inch (1.58 mm) thick. Letters shall be black on light backgrounds, or white on dark backgrounds, as applicable. Service temperature range -40 to 175 degrees F (-40 to 79 degrees C); minimum application temperature for adhesive 50 degrees F (10 degrees C). Suitable for average outdoor lifespan of at least 2-3 years.
- C. Aluminum Nameplates: For higher temperature applications, and for outdoor applications when manufacturer does not recommend their plastic nameplates for use outdoors, provide aluminum nameplates, with integral anodized or painted surface color coating and natural aluminum engraved letters, 1/32-inch (0.78 mm) thick. Service temperature range -40 to 350 degrees F (-40 to 177 degrees C); minimum application temperature for adhesive 50 degrees F (10 degrees C). Suitable for average outdoor lifespan of at least 2-3 years.
- D. Colors: Select background color as appropriate for the application. Color for general applications shall be white (except that aluminum nameplate standard color shall be black). Color for general warnings shall be red or yellow. Colors for fluid services shall comply with ASME A13.1-2007. Comply with ASME/ANSI standards and other regulations as applicable.
- E. Provide with factory adhesive, and with side holes for fastener attachment as applicable. Mechanical fasteners are required for applications which are outdoors or otherwise exposed to weather or sunlight, or in moist areas such as kitchens and locker rooms, or on cooled surfaces subject to condensation, or on surfaces with operating temperatures above 150 degrees F (65 degrees C). Where nameplate is on an irregular surface and cannot make complete contact, provide mechanical fasteners or ties in addition to adhesive.

2.2 TAGS

- A. Plastic Tags:
1. Manufacturers:
 - a. Seton Identification Products.
 - b. E.R. Perry Signs & Engraving.
 - c. Brimar Industries, Inc., PipeMarker division.
 - d. No substitutions.
 2. Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inches (38 mm) diameter.

B. Metal Tags:

1. Manufacturers:

- a. Seton Identification Products.
- b. Brady Worldwide, Inc.
- c. Brimar Industries, Inc., PipeMarker division.
- d. No substitutions.

2. Brass with stamped letters; tag size minimum 1-1/2 inches (38 mm) diameter with smooth edges.

C. Information Tags:

1. Manufacturer: Seton Identification Products.

2. Clear plastic with printed "Danger," "Caution," or "Warning" and message; size 3-1/4 x 5-5/8 inches (83 x 143 mm) with grommet and self-locking nylon ties.

- D. Tag Chains and Hooks: Brass or stainless steel compatible with tag material for general applications. Brass where in contact with copper piping or other copper-alloy materials.

- E. Tag Chart: Typewritten letter size list in anodized aluminum frame with plexiglass cover.

2.3 LABELS

- A. Manufacturer: Seton Identification Products.

- B. Description: Polyester, size 1.9 x 0.75 inches (48 x 19 mm), adhesive backed with printed identification.

2.4 PIPE MARKERS

- A. Color and Lettering: Conform to ASME A13.1.

B. Plastic Pipe Markers:

1. Manufacturers:

- a. Seton Identification Products.
- b. Brady Worldwide, Inc.
- c. Brimar Industries, Inc., PipeMarker division.
- d. No substitutions.

2. Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering. Larger sizes may have maximum sheet size with spring fastener.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.
- B. Prepare surfaces in accordance with manufacturer's recommendations for stencil painting.

3.2 INSTALLATION

- A. Division 01 Section "Quality Requirements": Manufacturer's instructions.
- B. Install identifying devices after completion of coverings and painting.
- C. Install plastic or aluminum engraved nameplates with corrosion-resistant mechanical fasteners, or adhesive, as specified. In outdoor locations, where lifetime of nameplates is limited, fasteners shall be removable screws or bolts for ease of nameplate replacement.
- D. Install labels with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer. For unfinished canvas covering, apply paint primer before applying labels.
- E. Install tags using corrosion resistant chain. Number tags consecutively by location.
- F. Identify items of mechanical equipment such as boilers and pumps with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.
- G. Identify control panels and major control components outside panels with plastic nameplates.
- H. Identify valves in main and branch piping with metal tags.
- I. Tag automatic controls, instruments, and relays. Key to control schematic.
- J. Identify piping, concealed or exposed, with plastic pipe markers. Use tags on piping 3/4 inch (20 mm) diameter and smaller. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet (6 m) on straight runs including risers and drops, at each branch and riser take-off, adjacent to each valve and tee, at each side of penetration of structure or enclosure, and at each obstruction.
- K. Secure valve tag chart on an easily accessible wall in the mechanical room or in a location as otherwise directed by the Engineer.

3.3 COORDINATION WITH EXISTING EQUIPMENT

- A. Where an existing equipment identification system is involved, the new system shall be coordinated and compatible with the existing system.
- B. Where an existing valve tag chart is involved, the new tags shall be coordinated with the existing chart.

END OF SECTION 230553

SECTION 230593 – TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Testing, Adjustment, and Balancing of Air Systems.
- B. Testing, Adjustment, and Balancing of Hydronic Piping Systems.
- C. Measurement of Final Operating Condition of HVAC Systems.

1.2 RELATED SECTIONS

- A. Division 01 Section “Quality Requirements”: Testing laboratory services: Employment of testing agency and payment for services.
- B. Division 01 Section “General Commissioning Requirements.”

1.3 REFERENCES

- A. AABC - National Standards for Total System Balance.
- B. ADC - Test Code for Grilles, Registers, and Diffusers.
- C. ASHRAE 111 - Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-conditioning, and Refrigeration Systems.
- D. NEBB - Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.
- E. SMACNA - HVAC Systems Testing, Adjusting, and Balancing.

1.4 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. ASHRAE: American Society of Heating, Refrigerating and Air Conditioning Engineers.
- C. NEBB: National Environmental Balancing Bureau.
- D. SMACNA: Sheet Metal and Air Conditioning Contractors’ National Association.
- E. TAB: Testing, Adjusting, and Balancing.

1.5 SUBMITTALS

- A. Submit under provisions of Division 01 Section “Submittal Procedures.”
- B. Submit name of TAB Agency for approval within 14 days after award of Contract.

C. Design Review Reports:

1. Submit prior to commencement of construction under provisions of Division 01 Section "Quality Requirements."
2. Review the Contract Documents, and indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.

D. Preliminary Report Submittals:

1. Prior to commencing work of this Section, and no more than 14 days after approval of TAB Agency submittals, submit report forms or outlines indicating adjusting, balancing, and equipment data required, with columns of design data filled in. By means of plan views, equipment profiles, and similar graphical descriptions, indicate where measurements will be taken.
2. Submit the procedures to be used.

E. Field Reports: Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Engineer/Engineer and for inclusion in operating and maintenance manuals.

F. Provide reports in letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.

G. Include detailed procedures, agenda, sample report forms and copy of AABC National Project Performance Guaranty prior to commencing system balance.

H. Test Reports: Indicate data on AABC National Standards for Total System Balance forms, or forms prepared following ASHRAE 111, or NEBB forms, or forms containing information indicated in Schedules.

1.6 QUALITY ASSURANCE

A. Perform total system balance in accordance with AABC National Standards for Field Measurement and Instrumentation, Total System Balance; or ASHRAE 111; or NEBB Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.

1.7 QUALIFICATIONS

A. Agency: Company specializing in the testing, adjusting, and balancing of systems specified in this Section with minimum 3 years' experience and certified by AABC or NEBB, or equivalent experience which would qualify for membership in these testing organizations. Agency shall be one of those listed under paragraph 3.1 AGENCIES in this Section.

B. Perform Work under supervision of AABC Certified Test and Balance Engineer, NEBB Certified Testing, Balancing and Adjusting Supervisor, or registered Professional Engineer

experienced in performance of this Work and licensed at the place where the Project is located.

- C. Certification by the National Balancing Council (NBC) (an affiliate of the National Comfort Institute (NCI)) will not be allowed as a substitute for the specified qualifications.
- D. The approved Agency shall be in no way affiliated with the installing Subcontractor.

1.8 SEQUENCING

- A. Sequence work to commence after completion of systems or portions of work, and schedule completion of work before Substantial Completion of Project.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 AGENCIES

- A. Tekon Technical Consultants, Rochester, NH. Contact: Charles Corlin, (603) 335-3080.
- B. Air Solutions & Balancing, LLC, Auburn, NH. Contact: Olaf Zwickau, (603) 262-9292.
- C. Hood T.A.B. LLC, Andover, MA. Contact: Michael Hood, (978) 474-7595.
- D. Maine Air Balance, Brewer, ME. Tel. (207) 989-0533.
- E. NETB Associates LLC, East Kingston, NH. Contact: Frank Collamore, (978) 270-7547.
- F. Whitetail Air Balance LLC, Lisbon, ME. Contact: Jim Davis, (207) 577-9292.
- G. No Substitutions.

3.2 EXAMINATION

- A. Verify that systems are complete and operating correctly in accordance with sequence of operations before commencing work. Ensure the following conditions:
 - 1. Systems are started and operating in a safe and normal condition.
 - 2. Temperature control systems are installed complete and operable.
 - 3. Proper thermal overload protection is in place for electrical equipment.
 - 4. Duct systems are clean of debris.
 - 5. Access doors are closed and duct end caps are in place.
 - 6. Air outlets are installed and connected.
 - 7. Duct system leakage is minimized.

8. Hydronic systems are flushed, filled, and vented.
 9. Pumps are rotating correctly.
 10. Proper strainer baskets are clean and in place.
 11. Service and balance valves are open.
- B. Submit field reports. Report to the responsible Subcontractors, defects and deficiencies noted during performance of services which prevent system balance. Submit list of locations where the Contractor needs to provide additional balancing devices.

C. Beginning of work means acceptance of existing conditions.

3.3 PREPARATION

- A. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Engineer/Engineer to facilitate spot checks during testing.

3.4 INSTALLATION TOLERANCES

- A. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 5 percent of design for return and exhaust systems.
- B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.
- C. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

3.5 ADJUSTING

- A. Ensure recorded data represents actual measured or observed conditions.
- B. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- C. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- D. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
- E. For belt driven equipment, provide sheave and belt modifications and/or replacements as required to ensure design flow rates as specified. Variable-frequency drives shall generally be set near full speed, between 60 Hz and 55 Hz output frequency, to preserve as much frequency range as possible for controllability. Variable-frequency drives may be adjusted as specified (for example, if a motor requires a speed above 60 Hz, or if other Sections require that some speed be reserved to automatically compensate for air filter loading).

3.6 AIR SYSTEM PROCEDURE

- A. Adjust combustion air systems to provide required combustion air quantities.
- B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.
- C. Measure static air pressure conditions in combustion air ducts, and measure boiler room pressure differential to outdoors.
- D. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions. Adjust at minimum position and maximum position, and use manual dampers and actuator limit stops to minimize differences.
- E. Coordinate with Division 23 Sections “Instrumentation and Controls for Mechanical Systems” and “Condensing Boilers.”

3.7 WATER SYSTEM PROCEDURE

- A. Adjust water systems to provide required or design quantities.
- B. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.
- C. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.
- D. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing.
- E. Coordinate with Division 23 Section “Instrumentation and Controls for Mechanical Systems” for calibration of pump static pressure sensors and determination of pressure setpoints.

3.8 PROJECT CLOSEOUT

- A. Check and adjust systems approximately 6 months after final acceptance and submit report.

3.9 SCHEDULES

- A. Equipment Requiring Testing, Adjusting, and Balancing:
 - 1. Boilers
 - 2. HVAC Pumps
 - 3. Combustion Air to Boilers
 - 4. Rooftop Units

B. Report Forms:

1. Title Page:

- a. Name of Testing, Adjusting, and Balancing Agency
- b. Address of Testing, Adjusting, and Balancing Agency
- c. Telephone number of Testing, Adjusting, and Balancing Agency
- d. Project name
- e. Project location
- f. Project Engineer
- g. Project Engineer
- h. Project Contractor
- i. Project altitude
- j. Report date

2. Summary Comments:

- a. Design versus final performance
- b. Notable characteristics of system
- c. Description of systems operation sequence
- d. Summary of outdoor and exhaust flows to indicate amount of building pressurization
- e. Nomenclature used throughout report
- f. Test conditions

3. Instrument List:

- a. Instrument
- b. Manufacturer
- c. Model number
- d. Serial number
- e. Range

- f. Calibration date
4. Electric Motors:
 - a. Manufacturer
 - b. Model/Frame
 - c. HP/BHP
 - d. Phase, voltage, amperage; nameplate, actual, no load
 - e. RPM
 - f. Service factor
 - g. Starter size, rating, heater elements
 - h. Sheave Make/Size/Bore
5. Variable Frequency Drive (VFD):
 - a. Motor(s) served
 - b. Manufacturer
 - c. Model/Frame
 - d. HP/BHP ratings
 - e. Phase, voltage, amperage; nameplate, actual, no load
 - f. Input and output frequency (Hz)
 - g. Reference speed command from control system
 - h. Carrier frequency setting
 - i. Speeds programmed out for vibration
 - j. Speed adjustment for motor balancing (if allowed)
6. Pump Data:
 - a. Identification/number
 - b. Manufacturer
 - c. Size/model

- d. Impeller
 - e. Service
 - f. Design flow rate, pressure drop, BHP
 - g. Actual flow rate, pressure drop, BHP
 - h. Discharge pressure
 - i. Suction pressure
 - j. Total operating head pressure
 - k. Shut off, discharge and suction pressures
 - l. Shut off, total head pressure
7. Boiler Data:
- a. Water flow rate
 - b. Water pressure drop
 - c. Water pressure and temperature in boiler
 - d. Water inlet and outlet temperatures at full firing rate
 - e. Relief valve capacity and pressure setting
 - f. Outdoor air temperature
 - g. Reset water command temperature
 - h. Status of other boilers during testing
8. Combustion Test:
- a. Boiler manufacturer
 - b. Model number
 - c. Serial number
 - d. Fuel type
 - e. Firing rate
 - f. Overfire draft

- g. Gas pressure at meter outlet
 - h. Gas flow rate
 - i. Heat input
 - j. Burner manifold gas pressure
 - k. Percent carbon monoxide (CO₂)
 - l. Percent carbon dioxide (CO₂)
 - m. Percent oxygen (O₂)
 - n. Percent excess air
 - o. Flue gas temperature at outlet
 - p. Ambient temperature
 - q. Net stack temperature
 - r. Percent stack loss
 - s. Percent combustion efficiency
 - t. Heat output
 - u. Stack size and configuration
9. Combustion Air Data:
- a. Identification/location
 - b. Design air flow
 - c. Actual air flow to boiler by duct traverse
 - d. Actual air flow in main upstream of all boilers by duct traverse
 - e. Firing status of all boilers during test
 - f. Outside air temperature
10. Duct Traverse:
- a. Duct size
 - b. Area

- c. Design velocity
- d. Design air flow
- e. Test velocity
- f. Test air flow
- g. Duct static pressure
- h. Air temperature
- i. Air correction factor

END OF SECTION 230593

SECTION 230713 – DUCT INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Ductwork Insulation.
- B. Duct Liner.
- C. Sound Lagging Insulation.
- D. Fire Resistive Duct Wrap for Kitchen Grease Exhaust.
- E. Insulation jackets.

1.2 RELATED SECTIONS

- A. Division 23 Section “Identification for HVAC Piping and Equipment.”
- B. Division 23 Section “Metal Ducts”

1.3 REFERENCES

- A. Division 01 Section “References”: Requirements for references and standards.
- B. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- C. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus.
- D. ASTM C209 - Standard Test Methods for Cellulosic Fiber Insulating Board.
- E. ASTM C356 - Standard Test Method for Linear Shrinkage of Preformed High-Temperature Thermal Insulation Subjected to Soaking Heat.
- F. ASTM C411 - Standard Test Method for Hot Surface Performance of High Temperature Thermal Insulation.
- G. ASTM C423 - Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
- H. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
- I. ASTM C534 - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
- J. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for

Commercial and Industrial Applications.

- K. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
- L. ASTM C916 - Standard Specification for Adhesives for Duct Thermal Insulation.
- M. ASTM C1071 - Standard Specification for Thermal and Acoustical Insulation (Glass Fiber, Duct Lining Material).
- N. ASTM C1104 - Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation.
- O. ASTM C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
- P. ASTM C1482 - Standard Specification for Polyimide Flexible Cellular Thermal and Sound Absorbing Insulation.
- Q. ASTM D1056 - Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber.
- R. ASTM D1622 - Standard Test Method for Apparent Density of Rigid Cellular Plastics.
- S. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- T. ASTM E90 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
- U. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials.
- V. ASTM E119 (UL 263) - Standard Test Methods for Fire Tests of Building Construction and Materials.
- W. ASTM E136 - Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 degrees C.
- X. ASTM E162 - Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source.
- Y. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems.
- Z. ASTM E2336 - Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems.
- AA. ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
- BB. ISO 6944 - 1985 - Fire Resistance Tests - Ventilation Ducts.
- CC. NAIMA - National Insulation Standards.

- DD. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
- EE. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.
- FF. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
- GG. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.
- HH. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

1.4 SUBMITTALS

- A. Division 01 Section "Submittal Procedures".
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this Section with minimum 3 years' experience.
- B. Applicator Qualifications: Company specializing in performing the work of this Section with minimum 3 years' experience.

1.6 REGULATORY REQUIREMENTS

- A. Materials: Flame spread/smoke developed rating of 25/50 in accordance with ASTM E84, NFPA 255 and UL 723. For elastomeric foam insulation, rating shall apply for thicknesses up to 2 inches (50 mm).
- B. Insulation materials shall be asbestos free. No fibers with dimensions similar to asbestos fibers shall be released from any material.

1.7 DELIVERY, STORAGE, AND PROTECTION

- A. Division 01 Section "Product Requirements": Transport, handle, store, and protect products.
- B. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.
- C. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.8 ENVIRONMENTAL REQUIREMENTS

- A. Division 01 Section "Product Requirements": Environmental conditions affecting products on site.

- B. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- C. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Glass and Mineral Fiber Products:
 - 1. Knauf Insulation.
 - 2. Certainteed Corporation.
 - 3. Johns Manville.
 - 4. Owens Corning.
 - 5. No substitutions.
- B. Glass Fiber Insulation Sealing Tapes:
 - 1. Venture Tape Corporation.
 - 2. 3M Company.
 - 3. Ideal Tape Co., division of American Biltrite Inc.
 - 4. Nashua Tape Products, division of Berry Plastics Corp.
 - 5. No substitutions.
- C. Accessories:
 - 1. Ceel-Co division of Johns Manville (product: plastic jacket systems).
 - 2. Foster Products, division of Specialty Construction Brands, Inc., a subsidiary of H.B. Fuller (mastics, sealants, reinforcing membranes, and accessories).
 - 3. Johns Manville (products: Super-Seal acrylic polymer coatings, Zeston plastic jacket systems).
 - 4. Pabco/Childers Metals, division of ITW Insulation Systems (products: metal jacket systems, and accessories).
 - 5. Vac Systems International (product: Tough Coat acrylic polymer mechanical insulation repair coating).
 - 6. Venture Tape Corporation (product: Jacket for outdoor insulation).

2.2 GLASS FIBER, FLEXIBLE

- A. Insulation: ASTM C553; flexible, noncombustible blanket.
 - 1. 'K' ('Ksi') value: ASTM C518, 0.27 at 75 degrees F (0.039 at 24 degrees C).
 - 2. Maximum service temperature: 250 degrees F (121 degrees C) faced and 350 degrees F (176 degrees C) unfaced.
 - 3. Maximum moisture absorption: 0.20 percent by volume.
 - 4. Minimum density: 1.0 lb/cu. ft. (16 kg/m³).
- B. Vapor Barrier Jacket:
 - 1. ASTM C1136, Kraft paper reinforced with glass fiber yarn and bonded to vapor barrier film. Facing as required for the application. Integral staple flap on one edge.
 - a. Aluminum Faced: FSK (aluminum foil-scrim-kraft) construction.

- b. White Faced: PSK (polypropylene-scrim-kraft) construction.
- 2. Moisture vapor transmission: ASTM E96; 0.02 perm.
- 3. Suitable for insulation surface temperatures up to 150 degrees F (66 degrees C).
- 4. Overlap longitudinal laps and butt strips.
- 5. Secure with outward clinch expanding staples and vapor barrier mastic and pressure sensitive tape.

C. Vapor Barrier Tape: See article “Glass Fiber Insulation Sealing Tape” in this Section.

D. Outdoor Vapor Barrier Mastic: Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.

E. Tie Wire: Annealed steel, 16 ga (1.5 mm).

2.3 GLASS FIBER, RIGID

- A. Insulation: ASTM C612; rigid, noncombustible blanket. Supplied in board form.
 - 1. 'K' ('Ksi') value: ASTM C518, 0.24 at 75 degrees F (0.036 at 24 degrees C).
 - 2. Maximum service temperature: 450 degrees F (232 degrees C).
 - 3. Maximum moisture absorption: 1.0 percent by volume.
 - 4. Density: 3.0 lb/cu. ft. (48 kg/cu m).
- B. Vapor Barrier Jacket:
 - 1. ASTM C1136, kraft paper reinforced with glass fiber yarn and bonded to aluminized film. Facing as required for the application.
 - a. Aluminum Faced: FSK (foil-scrim-kraft) construction
 - b. White Faced: ASJ (all-service jacket) construction.
 - 2. Moisture vapor transmission: ASTM E96; 0.02 perm.
 - 3. Suitable for insulation surface temperatures up to 150 degrees F (66 degrees C).
 - 4. Overlap longitudinal laps and butt strips.
 - 5. Secure insulation with mechanical fasteners to substrate, and seal jacket with pressure sensitive tape.
- C. Vapor Barrier Tape: See article “Glass Fiber Insulation Sealing Tape” in this Section.
- D. Indoor Vapor Barrier Finish:
 - 1. Cloth: Untreated; 9 oz/sq yd (305 g/sq m) weight, glass fabric.
 - 2. Vinyl emulsion type acrylic, compatible with insulation, [black] [white] color.

2.4 GLASS FIBER, SEMI-RIGID

- A. Insulation: ASTM C612; semi-rigid, noncombustible blanket, with fibers oriented perpendicular to insulation surface to provide compressive strength while maintaining flexibility. Supplied in roll form, suitable for application on rounded shapes such as pipes, tanks, ducts, vessels, and other similar round and irregular shapes.
 - 1. 'K' ('Ksi') value: ASTM C518, 0.24 at 75 degrees F (0.036 at 24 degrees C).
 - 2. Maximum service temperature: 450 degrees F (232 degrees C).
 - 3. Maximum moisture absorption: 1.0 percent by volume.
 - 4. Density: 2.5 lb/cu. ft. (40 kg/cu m).

- B. Vapor Barrier Jacket:
 - 1. ASTM C1136, kraft paper with glass fiber yarn and bonded to aluminized film. Facing as required for the application.
 - a. Aluminum Faced: FSK (foil-scrim-kraft) construction
 - b. White Faced: ASJ (all-service jacket) construction.
 - 2. Moisture vapor transmission: ASTM E96; 0.02 perm.
 - 3. Suitable for insulation surface temperatures up to 150 degrees F (66 degrees C).
 - 4. Overlap longitudinal laps and butt strips.
 - 5. Secure with outward clinch expanding staples and vapor barrier mastic and pressure sensitive tape.
- C. Vapor Barrier Tape: See article "Glass Fiber Insulation Sealing Tape" in this Section.
- D. Indoor Vapor Barrier Finish:
 - 1. Cloth: Untreated; 9 oz/sq yd (305 g/sq m) weight, glass fabric.
 - 2. Vinyl emulsion type acrylic, compatible with insulation, [black] [white] color.

2.5 GLASS FIBER INSULATION SEALING TAPE

- A. Self-adhesive tape with integral vapor barrier, pressure sensitive acrylic-based or rubber-based adhesive, and release liner strip. Width 3 inch (76 mm) nominal.
- B. Manufactured by VentureTape, by the insulation manufacturer, or by one of the other tape manufacturers listed in the article "Manufacturers" in this Section.
- C. Types:
 - 1. For rigid and semi-rigid insulations, tape shall be reinforced type. For flexible "duct wrap" insulation, tape shall be either reinforced or non-reinforced.
 - 2. White or aluminum outer surface to match the insulation.
 - 3. Reinforced: Kraft paper reinforced with glass fiber yarn and bonded to vapor barrier layer.
 - a. Aluminum Finish with FSK: VentureTape 1525CW.
 - b. White Finish with ASJ: VentureTape 1540CW
 - c. White Finish with PSK: VentureTape 1531CW.
 - 4. Non-Reinforced: Foil insulation tape. Dead-soft temper 2 mil (0.05 mm) thick aluminum foil, without reinforcement. Hand-tearable.
 - a. Venture Tape 3520CW.
 - 5. Performance:
 - a. Peel Adhesion: PSTC-101 with 20 minute dwell, 45 oz/in. (12.5 N / 25 mm).
 - b. Shear Adhesion: PSTC-107, 2.2 psi (15.2 kPa) after 24 hours.
 - c. Tensile Strength: PSTC-131:
 - 1) Reinforced Types: 40 lb/in. (180.8 N / 25 mm).
 - 2) Non-reinforced Types: 21 lb/in. (94.9 N / 25 mm).
 - d. Elongation: PSTC 131, 6 percent maximum.
 - e. Service Temperature: -40 to 240 degrees F (-40 to 116 degrees C).
 - f. UL 723 listed or classified (flame/smoke rating).

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Division 01 Section “Project Management and Coordination”: Verification of existing conditions before starting work.
- B. Verify that ductwork has been tested before applying insulation materials.
- C. Verify that surfaces are clean, foreign material removed, and dry.
- D. Verify that insulation materials are clean and dry. Discard any materials that exhibit signs of moisture damage, contamination, mold, mildew, or other biological growth. Discard any materials used in the air handling airstream if they have been exposed to water.

3.2 INSTALLATION

- A. Division 01 Section “Quality Requirements”: Manufacturer's instructions.
- B. Install in accordance with NAIMA National Insulation Standards.
- C. In addition to new ductwork, provide insulation for surfaces of existing ductwork that is uninsulated. Field-verify scope of existing ductwork.
- D. Provide insulation for surfaces of ductwork, as indicated and specified. Insulation values shall meet or exceed the requirements of ASHRAE 90.1-2010, State Energy Codes, and Table I, whichever is greater. In addition, comply with the other requirements of this Section.
- E. Insulated Ductwork Conveying Air below Ambient Temperature:
 - 1. Provide insulation with vapor barrier jackets.
 - 2. Finish with tape and vapor barrier jacket.
 - 3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
 - 4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.
- F. Insulated Ductwork Conveying Air above Ambient Temperature:
 - 1. Provide with or without standard vapor barrier jacket.
 - 2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.
- G. Ductwork Exposed below 10 feet (3 meters) above finished floor in Mechanical Equipment Rooms or below 8 feet (2.4 meters) above finished floor in Finished Spaces: Provide glass fiber rigid insulation with vapor barrier jacket.
- H. It is not required to insulate ductwork which is acoustically lined, unless otherwise specified or indicated on the Drawings.
- I. Do not insulate exposed heating or cooling supply ductwork in the conditioned spaces which it serves, unless otherwise specified or indicated on the Drawings.
- J. Wherever exposed ductwork for air conditioned systems passes through non air conditioned

spaces, insulate ductwork with glass fiber rigid insulation with vapor barrier, to prevent condensation.

- K. Where rigid glass fiber insulation is scheduled, semi-rigid glass fiber insulation may be used on round and flat oval ducts and irregular shapes, and preformed pipe insulation may be used on small diameter round ducts.
- L. External Duct Insulation Application:
1. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.
 2. Secure insulation without vapor barrier with staples, tape, or wires.
 3. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift ductwork off trapeze hangers and insert spacers.
 4. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
 5. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.
- M. Outdoor and Above-Roof Applications:
1. Seal positive-pressure ductwork completely airtight to prevent air bubbles.
 2. Provide insulation with integral vapor barrier jacket.
 3. Provide watershed slope on horizontal surfaces.
 4. Fasten to duct with pins, welded to duct or adhered with field-applied adhesive (self-adhesive type not allowed). Pins shall not protrude beyond the surface of the insulation, so that finish jacket lies smooth without possibility of puncture. Space fasteners as recommended by the manufacturer, to prevent sagging, and to support weight of both insulation and jacket.
 5. Seal insulation vapor barrier with reinforced foil tape on seams, joints, and penetrations.
 6. Cover with self-adhesive cladding jacket, with seams located on bottom side of horizontal duct sections where possible. Overlap edges as recommended by the manufacturer.
 7. At required access points such as access doors and damper actuators, provide a watertight seal and removable weatherproof covers.
- N. Inspection Plates and Test Holes: Provide, where required, in ductwork or casings for balance measurements. Test holes shall be factory fabricated, airtight, and noncorrosive with screw cap and gasket. Extend cap through insulation.
- O. Install insulation after ductwork and equipment have been tested and approved.
- P. Ensure that surface is clean and dry prior to installation. Ensure that insulation is dry before and during application. Finish with system at operating conditions.
- Q. Ensure that insulation is continuous through inside walls. Pack around ducts with fireproof self-supporting insulation material, properly sealed.
- R. Finish insulation neatly at hangers, supports and other protrusions.
- S. Locate insulation or cover seams in least visible locations.

- T. Repair separation of joints or cracking of insulation due to thermal movement or poor workmanship.
- U. Standing seams, supporting angles and flanges on insulated ductwork shall be insulated with thickness equal to the duct and edges shall be finished and vapor sealed.
- V. For supply or return ductwork which is required to be insulated, insulation shall be continuous and shall include the insulating of register, grille and diffuser connection plenums/boots.
- W. Mechanical fasteners shall not be riveted or screwed to the duct and shall not penetrate the metalwork.

3.3 PAINTING AND IDENTIFICATION

- A. Paint in accordance with Division 09 Section "Painting."

3.4 FIELD INSPECTION

- A. Visually inspect to ensure that materials used conform to Specifications. Inspect installations progressively for compliance with requirements.

TABLE I
 DUCTWORK INSULATION MATERIAL AND WALL THICKNESS

DUCTWORK TYPE	INSULATION MATERIAL	VAPOR BARRIER REQUIRED	INSULATION WALL THICKNESS
Ductwork located outdoors, including above roofs	Polyisocyanurate Foam Board, Rigid, with Waterproof Jacket	Yes	2 layers of 1 inch (25.4mm) with staggered joints
Combustion air ductwork	Glass Fiber, Rigid	Yes	2 layers of 1 inch (25.4mm) with staggered joints
Outside air intake ductwork	Glass Fiber, Flexible (only if ductwork is concealed)	Yes	2 layers of 1 ½ inch (38.1 mm) with staggered joints
	Glass Fiber, Rigid	Yes	2 layers of 1 inch (25.4 mm) with staggered joints
Mixed air ductwork	Glass Fiber, Flexible (only if ductwork is concealed)	Yes	2 layers of 1 ½ inches (38.1 mm) with staggered joints
	Glass Fiber, Rigid	Yes	2 layers of 1 inch (25.4 mm) with staggered joints
Supply ductwork for heating only systems with supply air temperatures greater than or equal to 100 degrees F (37.7 degrees C)	Glass Fiber, Flexible	No	2 inch (50.8 mm)
	Glass Fiber, Rigid	No	2 inch (50.8 mm)
Supply ductwork for heating only	Glass Fiber, Flexible	No	1 ½ inches (38.1 mm)

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systems with supply air temperatures less than 100 degrees F (37.7 degrees C)	Glass Fiber, Rigid	No	1 inch (25.4 mm)
Supply Ductwork for heating and cooling systems with heating supply air temperatures greater than or equal to 100 degrees F (37.7 degrees C)	Glass Fiber, Flexible	Yes	2 inch (50.8 mm)
	Glass Fiber, Rigid	Yes	2 layers of 1 inch (25.4 mm) with staggered joints
Supply ductwork for heating and cooling systems with heating supply air temperatures less than 100 degrees F (37.7 degrees C)	Glass Fiber, Flexible	Yes	1 ½ inches (38.1 mm)
	Glass Fiber, Rigid	Yes	1 inch (25.4 mm)
Exposed supply ductwork for cooling systems that pass through non air-conditioned spaces	Glass Fiber, Rigid	Yes	1 inch (25.4 mm)
Exposed supply ductwork in mechanical or equipment rooms	Glass Fiber, Rigid	No for heating only systems, Yes for cooling systems	1 inch (25.4 mm)
Supply, return and exhaust ductwork in cold attic spaces, crawl spaces or any space outside of the building insulation envelope but within the building shell and protected from weather	Glass Fiber, Flexible	No for heating only systems, Yes for cooling systems	2 inches (50.8 mm)
	Glass Fiber, Rigid	No for heating only systems, Yes for cooling systems	2 inches (50.8 mm)

END OF SECTION 230713

SECTION 230719 – HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Piping insulation.
- B. Jackets and accessories.
- C. Shields, Inserts, and Saddles.

1.2 RELATED SECTIONS

- A. Division 23 Section “Identification for HVAC Piping and Equipment.”
- B. Division 23 Section “Hangers and Supports for HVAC Piping and Equipment”: Placement of hangers and hanger inserts.

1.3 REFERENCES

- A. Division 01 Section “References”: Requirements for references and standards.
- B. ASTM A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
- C. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)).
- D. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus.
- E. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement.
- F. ASTM C449/C449M - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
- G. ASTM C518 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
- H. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
- I. ASTM C547 - Standard Specification for Mineral Fiber Preformed Pipe Insulation.
- J. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
- K. ASTM C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for

Thermal Insulation.

- L. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
- M. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- N. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials.
- O. NAIMA National Insulation Standards.
- P. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.
- Q. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

1.4 SUBMITTALS

- A. Submit under provisions of Division 01 Section "Submittal Procedures".
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this Section with minimum 3 years' experience.
- B. Applicator Qualifications: Company specializing in performing the work of this Section with minimum 3 years' experience.

1.6 REGULATORY REQUIREMENTS

- A. Conform to maximum flame spread/smoke developed rating of 25/50 in accordance with ASTM E84, NFPA 255 and UL 723. For elastomeric foam insulation, rating shall apply for thicknesses up to 2 inches (50 mm).
- B. Insulation materials and accessories shall be asbestos-free. No fibers with dimensions similar to asbestos fibers shall be released from any material.

1.7 DELIVERY, STORAGE, AND PROTECTION

- A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

1.8 ENVIRONMENTAL REQUIREMENTS

- A. Maintain ambient conditions required by manufacturers of each product.
- B. Maintain temperature before, during, and after installation for minimum of 24 hours.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Glass and Mineral Fiber Products:

1. Knauf Insulation.
2. Certainteed Corporation.
3. Johns Manville.
4. Owens Corning.
5. No substitutions.

B. Hydrous Calcium Silicate Products:

1. IIG Industrial Insulation Group LLC, a Calsilite/Johns Manville joint venture. Thermo-12 Gold product line.
2. Johns Manville.

C. Accessories:

1. Ceel-Co division of Johns Manville (product: plastic jacket systems).
2. Foster Products, division of Specialty Construction Brands, Inc., a subsidiary of H.B. Fuller (mastics, sealants, reinforcing membranes, and accessories).
3. Johns Manville (products: Super-Seal acrylic polymer coatings, Zeston plastic jacket systems).
4. Pabco/Childers Metals, division of ITW Insulation Systems (products: metal jacket systems, and accessories).
5. Pittsburgh Corning (product: cellular glass insulation for high-density inserts).
6. Proto Corporation (product: plastic jacket systems).

2.2 GLASS FIBER AND MINERAL WOOL

A. Insulation: ASTM C547; rigid molded, noncombustible.

1. 'K' ('Ksi') value: ASTM C177, 0.24 Btu-in/(hr-sq.ft- degrees F) at 75 degrees F (0.035 W/m-K at 24 degrees C).
2. Maximum service temperature: 850 degrees F (454 degrees C).
3. Maximum moisture absorption: 0.2 percent by volume.

B. Vapor Barrier Jacket:

1. ASTM C1136, White kraft paper with glass fiber yarn, bonded to aluminized film.

2. Moisture vapor transmission: ASTM E96; 0.02 perm-inches.
- C. Tie Wire: 0.048 inch (1.22 mm) stainless steel with twisted ends on maximum 12 inch (300 mm) centers.
- D. Vapor Barrier Lap Adhesive: Compatible with insulation.
- E. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.
- F. Indoor Vapor Barrier Finish:
 1. Cloth: Untreated; 9 oz/sq yd (305 g/sq m) weight.
 2. Vinyl emulsion type acrylic, compatible with insulation, white color.
- G. Outdoor Vapor Barrier Mastic: Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
- H. Outdoor Breather Mastic: Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
- I. Insulating Cement: ASTM C449/C449M.

2.3 SHIELDS, INSERTS, AND SADDLES

- A. Shields:
 1. Carpenter and Paterson Figure 265GS, or equal.
 2. Galvanized or electro-galvanized steel, minimum 12 inch length, minimum 120-degree arc, minimum 18 ga.
 3. Provide contact adhesive to glue shields to the insulation.
- B. Snap-On Shields:
 1. Cooper B-Line "Snap-N Shield".
 2. Snap-N Shield is an acceptable substitute for metal shields when installed with strut trapeze hangers on horizontal piping.
 3. Paintable polypropylene plastic 12 inch long preformed shields, snap-on design for attachment to strut.
 4. Gluing is not required with Snap-N Shield.
 5. Provide black or white color to match the insulation in areas exposed to public view.

C. Inserts:

1. Configuration: Minimum 6 inches (150 mm) long, of same thickness and contour as adjoining insulation; may be factory fabricated.
2. Insert Material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.

D. Saddles:

1. Factory fabricated of curved carbon steel plate, of same overall thickness and contour as adjoining insulation. Sides designed for welding to pipe. Center support plate for pipe sizes 12 inches (300 mm) and larger.

2.4 MANUFACTURER'S STAMP OR LABEL

- A. Every package or standard container of insulation, jackets, cements, adhesives, and coatings delivered to the project site for use shall have the manufacturer's stamp or label attached giving name of manufacturer, brand, and description of material. Insulation packages and containers shall be asbestos-free.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that piping has been tested before applying insulation materials.
- B. Verify that surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION

- A. Install in accordance with NAIMA National Insulation Standards where applicable.
- B. Provide insulation for surfaces of piping as indicated and specified.
- C. Insulation values shall meet or exceed the requirements of ASHRAE 90.1-2010, applicable State Energy Codes, and Table I, whichever is greater. In addition, comply with the other requirements of this Section.
1. International Energy Conservation Code (IECC): The Commercial Energy Efficiency chapter of the Code allows the use of ASHRAE 90.1 insulation thicknesses instead of the Minimum Pipe Insulation table which is in that chapter of the IECC. This Specification does not reference the table in IECC.
- D. Piping systems requiring insulation, types of insulation required, and insulation thickness shall be as listed in Table I herein. For piping not listed in Table 1, insulate to meet Code requirements, using suitable specified materials, subject to Engineer's approval. Except for flexible unicellular insulation, insulation thicknesses as specified in Table I shall be one inch (25 mm) greater for insulated piping systems located outside the building and in unconditioned

spaces. Unless otherwise specified, insulate fittings, flanges, and valves, except valve stems, hand wheels, and operators. Use factory pre-molded, pre-cut, or field-fabricated insulation of the same thickness and conductivity as used on adjacent piping. Insulation exterior shall be factory cleanable, grease resistant, non-flaking, and non-peeling.

- E. Exposed Piping: Locate insulation and cover seams in least visible locations.
- F. Insulated Pipes Conveying Fluids Below Ambient Temperature: Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints.
- G. For hot piping conveying fluids over 140 degrees F (60 degrees C), insulate flanges and unions at equipment.
- H. Glass Fiber Insulated Pipes Conveying Fluids above Ambient Temperature:
 - 1. Provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples.
 - 2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.
- I. For piping which may operate at a range of temperatures (for example, heat recovery and heat exchange piping), provide insulation and vapor barriers as are suitable for the entire range of operation.
- J. Branches to Gauges, Sensors, Drains, and Vents: Insulate branches to gauges, sensors, drains, and vents as for active sections of piping. For piping with operating temperatures above ambient, insulate to at least 6 inches (150 mm) from the active main. For temperature devices, insulate to include the sensing bulb or other element. For pressure devices in hot piping with syphon loops, insulate from the active main to the syphon loop, but it is not necessary to insulate the syphon loop or the portion of the branch on the device side of the syphon loop.
- K. Shields, Inserts, and Saddles:
 - 1. Application: Provide shields at hangers. Provide inserts for piping 2 in. (50 mm) nominal size or larger. Provide saddles for piping 6 in. (150 mm) nominal size and larger and for generator exhaust piping and muffler.
 - 2. Shield location: Between insulation jacket and hanger.
 - 3. Insert location: Between support shield and piping and under the finish jacket.
 - 4. Saddle location: Between support shield and piping.
 - 5. Tack-weld saddles to the pipe or muffler. Fill air spaces within the saddle with insulation material.
 - 6. Glue shields to outside of insulation after system is filled and run at operating

temperature.

7. Align mid-length of shields, inserts, and saddles with the hanger centerline.

3.3 FIELD-APPLIED JACKETS

- A. Piping Exposed in Mechanical Equipment Rooms 8 feet (2.4 meters) or Less Above Finished Floor: Finish with PVC jacket and fitting covers.

3.4 UNIFORM INSTALLATION

- A. Systems shall use a single insulation type throughout the installation.

3.5 PREPARATION

- A. Insulate piping after system tests have been completed and surfaces to be insulated have been cleaned of dirt, rust, and scale and dried. Ensure full range of motion of equipment actuators. Modify insulation to avoid obstruction of valve handles, safety reliefs, and other components requiring movement. Allow adequate space for pipe expansion. Install insulation with jackets drawn tight and cement down on longitudinal and end laps. Do not use scrap pieces where a full length section will fit. Insulation shall be continuous through sleeves, wall and ceiling openings. Extend surface finishes to protect surfaces, ends, and raw edges of insulation. Apply coatings and adhesives at the manufacturer's recommended coverage per gallon. Individually insulate piping. Provide a moisture and vapor seal where insulation terminates against metal hangers, anchors and other projections through the insulation on surfaces for which a vapor seal is specified. Keep insulation dry during the application of any finish. Bevel and seal the edges of exposed insulation. Unless otherwise indicated, do not insulate the following:

1. Valve hand wheels.
2. Balancing valve test ports and adjustment devices.
3. Strainer blowdown valves.
4. Drain valves and air vent bodies.
5. Vibration isolating connections.
6. Adjacent insulation.
7. ASME stamps.

3.6 PIPING INSULATION

- A. Pipe Insulation: Place sections of insulation around the pipe and joints tightly butted into place. The jacket laps shall be drawn tight and smooth. Secure jacket with fire resistant adhesive, factory applied self sealing lap. Cover circumferential joints with butt strips, not less than 3-inches (76 mm) wide, of material identical to the jacket material. Overlap longitudinal laps of jacket material not less than 1-1/2 inches (38 mm). Adhesive used to secure the butt strip shall

be the same as used to secure the jacket laps. When a vapor barrier jacket is required, as indicated in Table I, or on the ends of sections of insulation that butt against flanges, unions, valves, fittings, and joints, use a vapor-barrier coating conforming to manufacturer's weatherproof coating for outside service. Apply this vapor barrier coating at longitudinal and circumferential laps. Patch damaged jacket material by wrapping a strip of jacket material around the pipe and cementing, and coating as specified for butt strips. Extend the patch not less than 1-1/2 inches (38 mm) past the break in both directions. At penetrations by pressure gauges and thermometers, fill the voids with the vapor barrier coating for outside service. Seal with a brush coat of the same coating.

- B. Seal surfaces of fibrous insulation to prevent release of fibers.

3.7 FIELD INSPECTION

- A. Visually inspect to ensure that materials used conform to specifications. Inspect installations progressively for compliance with requirements.

TABLE I
 PIPING INSULATION MATERIAL AND WALL THICKNESS

SERVICE	INSULATION MATERIAL	VAPOR BARRIER REQUIRED	INSULATION WALL THICKNESS AT THE FOLLOWING PIPE DIAMETERS					
			<1 inch	1 inch to <1.5 inches	1.5 inches to <4 inches	4 inches to <8 inches	8 inches or Greater	
Heating Systems (Hot Water Supply and Return)								
	Fluid Design Operating Temperature Range							
	201 degrees F to 250 deg. F	Glass Fiber	No	2.5 inches	2.5 inches	2.5 inches	3 inches	3 inches
	141 degrees F to 200 deg. F	Glass Fiber	No	1.5 inches	1.5 inches	2 inches	2 inches	2 inches
	105 degrees F to 140 deg. F	Glass Fiber	Yes	1 inch	1 inch	1.5 inches	1.5 inches	1.5 inches

END OF SECTION 230719

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

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. DDC system for monitoring and controlling of HVAC systems.
2. Delivery of selected control devices to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.

B. Related Requirements:

1. Section 230923.17 "Level Instruments" for liquid-level switches, sensors, and transmitters that connect to DDC systems.
2. Section 230923.22 "Position Instruments" for limit switches that connect to DDC systems.
3. Section 230923.33 "Vibration Instruments" for vibration instruments that connect to DDC systems.
4. Communications Cabling:
 - a. Section 260523 "Control-Voltage Electrical Power Cables" for balanced twisted pair communications cable.
 - b. Section 271513 "Communications Copper Horizontal Cabling" for balanced twisted pair communications cable.
 - c. Section 271523 "Communications Optical Fiber Horizontal Cabling" for optical fiber communications cable.
5. Raceways:
 - a. Section 260533 "Raceways and Boxes for Electrical Systems" for raceways for low-voltage control cable.
 - b. Section 270528 "Pathways for Communications Systems" for raceways for balanced twisted pair cabling and optical fiber cable.
6. Section 260553 "Identification for Electrical Systems" for identification requirements for electrical components.
7. Section 270553 "Identification for Communications Systems" for identification requirements for communications components.

1.3 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 over and services over a network.
 - 2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
 - 3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
 - 4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.
 - 5. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.
- 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 Controller, Programmable Application Controller, and Application-Specific Controller.
- 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 shall be capable of operating in a standalone mode using the last best available data.
- J. DOCSIS: Data-Over Cable Service Interface Specifications.
- 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. LAN: Local area network.
- O. 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.
- P. 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.
- Q. Modbus TCP/IP: An open protocol for exchange of process data.
- R. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.
- S. MTBF: Mean time between failures.
- T. 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.
- U. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.
- V. Peer to Peer: Networking architecture that treats all network stations as equal partners.
- W. POT: Portable operator's terminal.
- X. PUE: Performance usage effectiveness.
- Y. RAM: Random access memory.
- Z. RF: Radio frequency.
- AA. Router: Device connecting two or more networks at network layer.
- BB. Server: Computer used to maintain system configuration, historical and programming database.
- CC. TCP/IP: Transport control protocol/Internet protocol.
- DD. UPS: Uninterruptible power supply.
- EE. USB: Universal Serial Bus.

FF. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.

GG. VAV: Variable air volume.

HH. WLED: White light emitting diode.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 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: For each type of product include the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
 - a. Workstations.
 - b. Servers.
 - c. Printers.
 - d. Gateways.
 - e. Routers.
 - f. Protocol analyzers.
 - g. DDC controllers.

- h. Enclosures.
 - i. Electrical power devices.
 - j. UPS units.
 - k. Accessories.
 - l. Instruments.
 - m. Control dampers and actuators.
 - n. Control valves and actuators.
6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
 7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

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, 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 shall be consistently used between different drawings showing same point.
 - f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
 - g. Narrative sequence of operation.
 - 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.
 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 which initiate generation.
 3. System and product operation under each potential failure condition including, but not limited to, the following:
 - a. Loss of power.
 - b. Loss of network communication signal.
 - c. Loss of controller signals to inputs and outpoints.
 - d. Operator workstation failure.
 - e. Server failure.
 - f. Gateway failure.
 - g. Network failure
 - h. Controller failure.

- i. Instrument failure.
 - j. Control damper and valve actuator failure.
 4. Complete bibliography of documentation and media to be delivered to Owner.
 5. Description of testing plans and procedures.
 6. Description of Owner training.
- F. Samples:
 1. For each of the following exposed product, 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 Submittal: 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.

1.6 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:
 - a. Product installation location shown in relationship to room, duct, pipe and equipment.
 - b. Structural members to which products will be attached.
 - c. Wall-mounted instruments located in finished space showing relationship to light switches, fire-alarm devices and other installed devices.
 - d. Size and location of wall access panels for products installed behind walls and requiring access.
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:
 - a. Ceiling components.
 - b. Size and location of access panels for products installed above inaccessible ceiling assemblies and requiring access.
 - c. Items penetrating finished ceiling including the following:
 - 1) Lighting fixtures.
 - 2) Air outlets and inlets.
 - 3) Speakers.
 - 4) Sprinklers.
 - 5) Access panels.
 - 6) Motion sensors.
 - 7) Pressure sensors.

8) Temperature sensors and other DDC control system instruments.

B. Qualification Data:

1. Systems Provider Qualification Data:

- a. Resume of project manager assigned to Project.
- b. Resumes of application engineering staff assigned to Project.
- c. Resumes of installation and programming technicians assigned to Project.
- d. Resumes of service technicians assigned to Project.
- e. Brief description of past project including physical address, floor area, number of floors, building system cooling and heating capacity and building's primary function.
- f. Description of past project DDC system, noting similarities to Project scope and complexity indicated.
- g. Names of staff assigned to past project that will also be assigned to execute work of this Project.
- h. Owner contact information for past project including name, phone number, and e-mail address.
- i. Contractor contact information for past project including name, phone number, and e-mail address.
- j. Architect and Engineer contact information for past project including name, phone number, and e-mail address.

2. Manufacturer's qualification data.

3. Testing agency's qualifications data.

C. Welding certificates.

D. Product Certificates:

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 Bacnet.

E. Product Test Reports: For each product that requires testing to be performed by a qualified testing agency.

F. Preconstruction Test Reports: For each separate test performed.

G. Source quality-control reports.

H. Field quality-control reports.

I. Sample Warranty: For manufacturer's warranty.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.
1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
 - b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
 - c. As-built versions of submittal Product Data.
 - d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
 - e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
 - f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
 - g. Engineering, installation, and maintenance manuals that explain how to:
 - 1) Design and install new points, panels, and other hardware.
 - 2) Perform preventive maintenance and calibration.
 - 3) Debug hardware problems.
 - 4) Repair or replace hardware.
 - h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
 - i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.
 - j. List of recommended spare parts with part numbers and suppliers.
 - k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
 - l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
 - m. Licenses, guarantees, and warranty documents.
 - n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
 - o. Owner training materials.

1.8 MAINTENANCE MATERIAL SUBMITTALS

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

- B. Include product manufacturers' recommended parts lists for proper product operation over four-year period following warranty period. Parts list shall be indicated for each year.
- C. Furnish parts, as indicated by manufacturer's recommended parts list, for product operation during **[one]** **[two]** **<Insert time period>**-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]** **<Insert quantity>**.
 - 2. Programmable Application Controller: **[One]** **<Insert quantity>**.
 - 3. Application-Specific Controller: **[One]** **<Insert quantity>**.
 - 4. **[Room]**Carbon Dioxide Sensor and Transmitter: **[One]** **<Insert quantity>**.
 - 5. **[Room]**Moisture Sensor and Transmitter: **[One]** **<Insert quantity>**.
 - 6. **[Room]**Pressure Sensor and Transmitter: **[One]** **<Insert quantity>**.
 - 7. **[Room]**Temperature Sensor**[and Transmitter]:** **[One]** **<Insert quantity>**.
 - 8. General-Purpose Relay: **[One]** **<Insert quantity>**.
 - 9. Multifunction Time-Delay Relay: **[One]** **<Insert quantity>**.
 - 10. Latching Relay: **[One]** **<Insert quantity>**.
 - 11. Current-Sensing Relay: **[One]** **<Insert quantity>**.
 - 12. Combination On-Off Status Sensor and On-Off Relay: **[One]** **<Insert quantity>**.
 - 13. Transformer: **[One]** **<Insert quantity>**.
 - 14. DC Power Supply: **[One]** **<Insert quantity>**.
 - 15. Supply of **[20]** **<Insert number>** percent spare optical fiber cable splice organizer cabinets for several re-terminations.
 - 16. **<Insert product>**.

1.9 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. Demonstrated past experience with installation of DDC system products being installed for period within three consecutive years before time of bid.
3. Demonstrated past experience on five projects of similar complexity, scope and value.
4. Each person assigned to Project shall have demonstrated past experience.
5. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
6. Service and maintenance staff assigned to support Project during warranty period.
7. Product parts inventory to support on-going DDC system operation for a period of not less than 5 years after Substantial Completion.
8. DDC system manufacturer's backing to take over execution of 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 according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
3. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."
4. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

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

F. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and products and for fabrication and installation.

1. Build mockups of completed installation where products are exposed to view and are located in areas with aesthetic requirements that warrant special attention.
2. Build mockups of completed installation for areas indicated on Drawings.
3. Approval of mockups does not constitute approval of deviations from Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

1.10 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on field mockups.

1. Include test assemblies representative of proposed materials and construction.
2. Build mockup at testing agency facility using personnel, materials, and methods of construction that will be used at Project site.
3. Notify Architect seven days in advance of dates and times of tests.

- B. Preconstruction Testing: Performed by a qualified testing agency on manufacturer's standard assemblies.

1.11 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.
 - 1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
 - 2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.
 - a. Install updates only after receiving Owner's written authorization.
 - 3. Warranty service shall occur during normal business hours and commence within 24 hours of Owner's warranty service request.
 - 4. Warranty Period: Two year(s) from date of Substantial Completion.
 - a. For Gateway: Two-year parts and labor warranty for each.

PART 2 - PRODUCTS

2.1 DDC SYSTEM MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Distech Controls.
 - 2. Honeywell International Inc.
 - 3. Invensys Building Systems.
 - 4. Johnson Controls, Inc.
 - 5. Schneider Electric USA, Inc.
 - 6. Siemens Industry, Inc., Building Technologies Division.

2.2 DDC SYSTEM DESCRIPTION

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

- 1. Web-Based Access to DDC System:

- a. DDC system software shall be based on server thin-client architecture, designed around open standards of Web technology. DDC system server shall be accessed using a Web browser over DDC system network, using Owner's LAN, and remotely over Internet through Owner's LAN.
- b. Intent of thin-client architecture is to provide operators complete access to DDC system via a Web browser. No special software other than a Web browser shall be required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
- c. Web access shall be password protected.

- 2. Web-Compatible Access to DDC System:

- a. Workstation and server shall perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.
- b. DDC system shall support Web browser access to building data. Operator using a standard Web browser shall be able to access control graphics and change adjustable set points.
- c. Web access shall be password protected.

2.4 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design DDC system to satisfy requirements indicated.

- B. Delegated Design: Engage a qualified professional to design DDC system to satisfy requirements indicated.

- 1. System Performance Objectives:

- a. DDC system shall manage HVAC systems.
- b. DDC system control shall operate HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
- c. DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
- d. DDC system shall operate while unattended by an operator and through operator interaction.

- e. DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.
- C. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
1. Flame-Spread Index: 25 or less.
 2. Smoke-Developed Index: 50 or less.
- D. DDC System Speed:
1. Response Time of Connected I/O:
 - a. AI point values connected to DDC system shall be updated at least every five seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
 - b. BI point values connected to DDC system shall be updated at least every five seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
 - c. AO points connected to DDC system shall begin to respond to controller output commands within two second(s). Global commands shall also comply with this requirement.
 - d. BO point values connected to DDC system shall respond to controller output commands within two second(s). Global commands shall also comply with this requirement.
 2. Display of Connected I/O:
 - a. Analog point COV connected to DDC system shall be updated and displayed at least every five seconds for use by operator.
 - b. Binary point COV connected to DDC system shall be updated and displayed at least every five seconds for use by operator.
 - c. Alarms of analog and digital points connected to DDC system shall be displayed within 15 seconds of activation or change of state.
 - d. Graphic display refresh shall update within eight seconds.
 - e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations shall not exceed graphic refresh rate indicated.
- E. Network Bandwidth: Design each network of DDC system to include at least 30 percent available spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions.
- F. DDC System Data Storage:

1. Include capability to archive not less than 60 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) shall 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 service plan with storage adequate to store all data for term indicated. Cloud storage shall use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.
- G. DDC Data Access:
1. When logged into the system, operator shall be able to also interact with any DDC controller connected to DDC system as required for functional operation of DDC system.
 2. System(s) shall be used for application configuration; for archiving, reporting and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.
- H. Future Expandability:
1. DDC system size shall be expandable to an ultimate capacity of at least two times total I/O points indicated.
 2. Additional DDC controllers, I/O and associated wiring shall be all that is needed to achieve ultimate capacity. Initial network infrastructure shall be designed and installed to support ultimate capacity.
 3. Operator interfaces installed initially shall not require hardware and software additions and revisions for ultimate capacity.
- I. Input Point Displayed Accuracy: Input point displayed values shall meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.
1. Energy:
 - a. Thermal: Within 3 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 2 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.
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 50 ppm.
4. Moisture (Relative Humidity):
- a. Air: Within 5 percent RH.
 - b. Space: Within 5 percent RH.
 - c. Outdoor: Within 5 percent RH.
5. 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 5 percent of reading.
8. Temperature, Dew Point:
- a. Air: Within 1 deg F (0.5 deg C).
 - b. Space: Within 1 deg F (0.5 deg C).
 - c. Outdoor: Within 3 deg F (1.5 deg C).
9. Temperature, Dry Bulb:
- a. Air: Within 1 deg F (0.5 deg C).
 - b. Space: Within 1 deg F (0.5 deg C).
 - c. Outdoor: Within 2 deg F (1 deg C).
 - d. Temperature Difference: Within 0.25 deg F (0.15 deg C).
 - e. Other Temperatures Not Indicated: Within 1 deg F (0.5 deg C).
10. Temperature, Wet Bulb:
- a. Air: Within 1 deg F (0.5 deg C).
 - b. Space: Within 1 deg F (0.5 deg C).
 - c. Outdoor: Within 2 deg F (1 deg C).
11. Vibration: Within 5 percent of reading.
- J. Precision of I/O Reported Values: Values reported in database and displayed shall have following precision:

1. Current:
 - a. Milliamperes: Nearest 1/100th of a milliampere.
 - b. Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.
2. Energy:
 - a. Electric Power:
 - 1) Rate (Watts): Nearest 1/10th of a watt through 1000 W.
 - 2) Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
 - 3) Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.
 - b. Thermal, Rate:
 - 1) Heating: For Btu/h, nearest Btu/h 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 (For watts, nearest watt up to 1000 W; for kilowatts, round to nearest kilowatt up to 1000 kW; nearest 10 kW between 1000 and 10,000 kW; nearest 100 kW for above 10,000 kW).
 - 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 (For watts, nearest watt up to 1000 W; for kilowatts, round to nearest kilowatt up to 1000 kW; nearest 10 kW between 1000 and 10,000 kW; nearest 100 kW for above 10,000 kW).
 - c. Thermal, Usage:
 - 1) Heating: For Btu, nearest Btu 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 (For watt-hours, nearest watt-hour up to 1000 Wh; for kilowatt-hours, round to nearest kilowatt-hour up to 1000 kWh; nearest 10 kWh between 1000 and 10,000 kWh; nearest 100 kWh for above 10,000 kWh).
 - 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 (For watt-hours, nearest watt-hour up to 1000 Wh; for kilowatt-hours, round to nearest kilowatt-hour up to 1000 kWh; nearest 10 kWh between 1000 and 10,000 kWh; nearest 100 kWh for above 10,000 kWh).
3. Flow:

- a. Air: Nearest 1/10th of a cfm through 100 cfm; nearest cfm between 100 and 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm; nearest 100 cfm above 10,000 cfm (Nearest 1/10th of a L/s through 100 L/s; nearest L/s between 100 and 1000 L/s; nearest 10 L/s between 1000 and 10,000 L/s; nearest 100 L/s above 10,000 L/s).
 - b. Water: Nearest 1/10th gpm through 100 gpm; nearest gpm between 100 and 1000 gpm; nearest 10 gpm between 1000 and 10,000 gpm; nearest 100 gpm above 10,000 gpm (Nearest 1/10th of a L/s through 100 L/s; nearest L/s between 100 and 1000 L/s; nearest 10 L/s between 1000 and 10,000 L/s; nearest 100 L/s above 10,000 L/s).
 - c. Steam: Nearest 1/10th lb/hr through 100 lbs/hr; nearest lbs/hr between 100 and 1000 lbs/hr; nearest 10 lbs/hr above 1000 lbs/hr (Nearest 1/10th of a L/s through 100 L/s; nearest L/s between 100 and 1000 L/s; nearest 10 L/s between 1000 and 10,000 L/s; nearest 100 L/s above 10,000 L/s).
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.
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 (Nearest 1/100th of a mm through 10 mm; nearest 1/10th of a mm between 10 and 100 mm; nearest mm above 100 mm).
7. Speed:
- a. Rotation (rpm): Nearest 1 rpm.
 - b. Velocity: Nearest 1/10th fpm through 100 fpm; nearest fpm between 100 and 1000 fpm; nearest 10 fpm above 1000 fpm (Nearest 1/100th of a M/s through 10 M/s; nearest 1/10th of a M/s above 10 M/s).
8. Position, Dampers and Valves (Percentage Open): Nearest 1 percent.
9. Pressure:
- a. Air, Ducts and Equipment: Nearest 1/10th in. w.c. (Nearest Pa up to 1000 Pa; nearest 10 Pa above 1000 Pa).
 - b. Space: Nearest 1/100th in. w.c. (Nearest 1/10th Pa).
 - c. Steam: Nearest 1/10th psig through 100 psig; nearest psig above 100 psig (Nearest kPa through 1000 kPa; nearest 10 kPa above 1000 kPa).
 - d. Water: Nearest 1/10 psig through 100 psig; nearest psig above 100 psig (Nearest kPa through 1000 kPa; nearest 10 kPa above 1000 kPa).
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 in/s** (**Nearest 1/10th mm/s**).
 12. Voltage: Nearest 1/10 volt up to 100 V; nearest volt above 100 V.
- K. 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 10 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 [**span**].
 - b. Space: Within 1 percent of instrument range.
 6. Temperature, Dew Point:
 - a. Air: Within **1 deg F** (**0.5 deg C**).
 - b. Space: Within **1 deg F** (**0.5 deg C**).
 7. Temperature, Dry Bulb:
 - a. Air: Within **2 deg F** (**1 deg C**).
 - b. Space: Within **2 deg F** (**1 deg C**).
 8. Temperature, Wet Bulb:

- a. Air: Within **1 deg F** (0.5 deg C).
- b. Space: Within **1 deg F** (0.5 deg C).

L. Environmental Conditions for Controllers, Gateways, and Routers:

- 1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.
 - a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.
- 2. Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:
 - a. Outdoors, Protected: **[Type 2] [Type 3] [Type 12] <Insert type>**.
 - b. Outdoors, Unprotected: **[Type 4] [Type 4X]**.
 - c. Indoors, Heated with Filtered Ventilation: **[Type 1] [Type 2] <Insert type>**.
 - d. Indoors, Heated with Non-Filtered Ventilation: **[Type 2] [Type 12] <Insert type>**.
 - e. Indoors, Heated and Air Conditioned: **[Type 1] <Insert type>**.
 - f. Mechanical Equipment Rooms:
 - 1) Chiller and Boiler Rooms: **[Type 12] [Type 4] [Type 4X] <Insert type>**.
 - 2) Air-Moving Equipment Rooms: **[Type 1] [Type 2] [Type 12] <Insert type>**.
 - g. Localized Areas Exposed to Washdown: **[Type 4] [Type 4X] <Insert type>**.
 - h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: **[Type 2] [Type 3] [Type 12] <Insert type>**.
 - i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: **[Type 4] [Type 4X] <Insert type>**.
 - j. Hazardous Locations: Explosion-proof rating for condition.
 - k. **<Insert location and enclosure requirements>**.

M. Environmental Conditions for Instruments and Actuators:

- 1. Instruments and actuators shall 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 shall be internally insulated, electrically heated[, cooled] and ventilated as required by instrument and application.

2. Instruments, actuators and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments and actuators not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:
 - a. Outdoors, Protected: [Type 2] [Type 3] [Type 12] <Insert type>.
 - b. Outdoors, Unprotected: [Type 4] [Type 4X].
 - c. Indoors, Heated with Filtered Ventilation: [Type 1] [Type 2] <Insert type>.
 - d. Indoors, Heated with Non-Filtered Ventilation: [Type 2] [Type 12] <Insert type>.
 - e. Indoors, Heated and Air-conditioned: [Type 1] <Insert type>.
 - f. Mechanical Equipment Rooms:
 - 1) Chiller and Boiler Rooms: [Type 12] [Type 4] [Type 4X] <Insert type>.
 - 2) Air-Moving Equipment Rooms: [Type 1] [Type 2] [Type 12] <Insert type>.
 - g. Localized Areas Exposed to Washdown: [Type 4] [Type 4X] <Insert type>.
 - h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: [Type 2] [Type 3] [Type 12] <Insert type>.
 - i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: [Type 4] [Type 4X] <Insert type>.
 - j. Hazardous Locations: Explosion-proof rating for condition.
 - k. <Insert location and enclosure requirements>.

N. DDC System Reliability:

1. Design, install and configure DDC controllers, [gateways,] [routers,] [and] <Insert product> to yield a MTBF of at least [40,000] [20,000] <Insert number> hours, based on a confidence level of at least [90] <Insert number> percent. MTBF value shall include 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 that are being controlled, operational and under automatic control.
3. Critical systems and equipment that require a higher degree of DDC system redundancy than MTBF indicated shall be indicated on Drawings.

O. Electric Power Quality:

1. Power-Line Surges:
 - a. Protect DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.
 - b. Do not use fuses for surge protection.
 - c. Test protection in the normal mode and in the common mode, using the following two waveforms:
 - 1) 10-by-1000-mic.sec. waveform with a peak voltage of 1500 V and a peak current of 60 A.

- 2) 8-by-20-mic.sec. waveform with a peak voltage of 1000 V and a peak current of 500 A.
2. Power Conditioning:
 - a. Protect DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner shall be as follows:
 - 1) At 85 percent load, output voltage shall not deviate by more than plus or minus 1 percent of nominal when input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.
 - 2) During load changes from zero to full load, output voltage shall not deviate by more than plus or minus 3 percent of nominal.
 - 3) Accomplish full correction of load switching disturbances within five cycles, and 95 percent correction within two cycles of onset of disturbance.
 - 4) Total harmonic distortion shall not exceed 3-1/2 percent at full load.
 3. Ground Fault: Protect products from ground fault by providing suitable grounding. Products shall not fail due to ground fault condition.
- P. Backup Power Source:
1. HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.
- Q. UPS:
1. DDC system products powered by UPS units shall include the following:
 - a. Desktop workstations.
 - b. Printers.
 - c. Servers.
 - d. Gateways.
 - e. DDC controllers.
 2. DDC system instruments and actuators powered by UPS units shall include the following:
 - a. Instruments associated with the following systems controlled by DDC system:
 - 1) **<Insert list of systems>**.
 - b. Dampers and actuators associated with the following systems controlled by DDC system:
 - 1) **<Insert list of systems>**.

- c. Valves and actuators associated with the following systems controlled by DDC system:

- 1) <Insert list of systems>.

R. Continuity of Operation after Electric Power Interruption:

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

2.5 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 signal to control damper actuator shall be control loop output signal from DDC controller.
- 5. With switch in "Manual" position, signal to damper actuator shall be controlled at panel with either an integral or separate switch to include local control.
 - a. For Binary Control Dampers: Manual two-position switch shall have "Close" and "Open" switch positions indicated. With switch in "Close" position, damper shall close. With switch in "Open" position, damper shall open.
 - b. For Analog Control Dampers: A gradual switch shall have "Close" and "Open" switch limits indicated. Operator shall be able to rotate switch knob to adjust damper to any position from close to open.
- 6. DDC controller shall monitor and report position of each manual override selector switch. With switch placed in "manual" position, DDC controller shall 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 fan-coil units 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 a 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, signal to control-valve actuator shall be a control loop output signal from DDC controller.
5. With switch in "Manual" position, signal to valve actuator shall be controlled at panel with either an integral or a separate switch to include local control.
 - a. For Binary Control Dampers: Manual two-position switch shall have "Close" and "Open" switch positions indicated. With switch in "Close" position, damper shall close. With switch in "Open" position, damper shall open.
 - b. For Analog Control Dampers: A gradual switch shall have "Open" and "Close" switch limits indicated. Operator shall be able to rotate switch knob to adjust damper to any position from close to open.
6. DDC controller shall monitor and report position of each manual override selector switch. With switch placed in "manual" position, DDC controller shall 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 shall consist of no more than **[two] [or] [three] <Insert number>** levels of LANs.
 1. Level one LAN shall connect network controllers and operator workstations.
 2. **[Level one] [or] [Level two]** LAN shall connect programmable application controllers to other programmable application controllers, and to network controllers.
 3. **[Level two] [or] [Level three]** LAN shall connect application-specific controllers to programmable application controllers and network controllers.
 4. **[Level two] [or] [Level three]** LAN shall connect application-specific controllers to application-specific controllers.
- B. Minimum Data Transfer and Communication Speed:
 1. LAN Connecting Operator Workstations and Network Controllers: **[100] [10] [2.5] [1.25] <Insert value>** Mbps.
 2. LAN Connecting Programmable Application Controllers: **[1000] [100] <Insert value>** kbps.
 3. LAN Connecting Application-Specific Controllers: **[115,000] [76,800] [38,400] [19,200] <Insert value>** bps.
- C. DDC system shall consist of dedicated **[and separated]** LANs that are not shared with other building systems and tenant data and communication networks.
- D. System architecture shall be modular and have inherent ability to expand to not less than **[two] [three] <Insert number>** times system size indicated with no impact to performance indicated.

- E. System architecture shall perform modifications without having to remove and replace existing network equipment.
- F. Number of LANs and associated communication shall be transparent to operator. All I/O points residing on any LAN shall be capable of global sharing between all system LANs.
- G. System design shall eliminate dependence on any single device for system alarm reporting and control execution. Each controller shall operate independently by performing its' own control, alarm management and historical data collection.
- H. Special Network Architecture Requirements:
 - 1. Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and VAV terminal units, include a dedicated LAN of application-specific controllers serving VAV terminal units connected directly to controller that is controlling air-handling system air-handling unit(s). Basically, create a DDC system LAN that aligns with air-handling system being controlled.
 - 2. **<Insert additional requirements>**.

2.7 DDC SYSTEM OPERATOR INTERFACES

- A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:
 - 1. 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. Access to system, regardless of operator means used, shall be transparent to operator.
- C. Network Ports: For hardwired connection of desktop or portable workstation. Network port shall be easily accessible, properly protected, clearly labeled, and installed at the following locations:
 - 1. Each mechanical equipment room.
 - 2. Each boiler room.
 - 3. Each chiller room or outdoor chiller yard.
 - 4. Each cooling tower location.
 - 5. Each different roof level with roof-mounted air-handling units or rooftop units.
 - 6. Security system command center.
 - 7. Fire-alarm system command center.
- D. Desktop Workstations:

1. Connect to DDC system Level one 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 to DDC system Level one 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 two**] [**or**] [**Level three**] 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 one LAN.
5. Connect to system through a cellular data service.
6. Portable workstation shall be 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:

1. Connect 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 [**a dedicated application**] [**and**][**secure web access**].

H. Telephone Communications:

1. Through use of a standard modem, operator shall be able to communicate with any device connected to any system LAN.
2. Have auto-dial and auto-answer communications to allow desktop and portable workstations and DDC controllers to communicate with remote workstations and remote DDC controllers via telephone lines.
 - a. Desktop and Portable Workstations:
 - 1) Operators shall be able to perform all control functions, report functions, and database generation and modification functions as if directly connected to system LAN.
 - 2) Have routines to automatically answer calls, and either file or display information sent remotely.

- 3) Communications taking place over telephone lines shall be completely transparent to operator.
- 4) Dial-up program shall maintain a user-definable cross-reference and associated telephone numbers so it is not required to remember or manually dial telephone numbers.

b. DDC Controllers:

- 1) Not have modems unless specifically indicated for a unique controller.
- 2) Controllers with modems shall automatically place calls to report critical alarms, or to upload trend and historical information for archiving.
- 3) Analyze and prioritize alarms to minimize initiation of calls.
- 4) Buffer noncritical alarms in memory and report them as a group of alarms, or until an operator manually requests an upload.
- 5) Make provisions for handling busy signals, no-answers, and incomplete data transfers.
- 6) Call default devices when communications cannot be established with primary devices.

I. Critical Alarm Reporting:

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

J. Simultaneous Operator Use: Capable of accommodating up to **[five]** **[10]** **[20]** **<Insert number>** simultaneous operators that are accessing DDC system through any one 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. CEA-709.1-C.
3. IP.
4. IEEE 8802-3, Ethernet.
5. **<Insert type>**.

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

1. ATA 878.1, ARCNET.
2. CEA-709.1-C.

3. IP.
4. IEEE 8802-3, Ethernet.
5. **<Insert type>**.

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

1. ATA 878.1, ARCNET.
2. CEA-709.1-C.
3. EIA-485A.
4. IP.
5. IEEE 8802-3, Ethernet.
6. **<Insert type>**.

2.9 NETWORK COMMUNICATION PROTOCOL

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

B. ASHRAE 135 Protocol:

1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.
2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.
3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
4. Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.

C. Industry Standard Protocols:

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

4. Portions of DDC system networks using Modbus Application Protocol Specification V1.1b communication protocol shall be an open implementation of network devices and technology complying with Modbus Application Protocol Specification V1.1b.
5. Gateways shall be used to connect networks and network devices using different protocols.

2.10 DDC SYSTEM WIRELESS NETWORKS

- A. Use [**Zigbee**] [or] [**an open industry standard and technology used by multiple DDC system manufacturers**] <Insert wireless technology> 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. Installer shall design wireless networks to comply with DDC system performance requirements indicated. Wireless network devices shall co-exist on same network with hardwired devices.
- C. Hardwired controllers shall be capable of retrofit to wireless devices with no special software.
- D. A wireless coordinator shall provide a wireless interface between programmable application controllers, application-specific controllers, and network controllers.
- E. Wireless Coordinators:
 1. Each wireless mesh network shall use wireless coordinator(s) for initiation and formation of network.
 2. Use direct sequence spread spectrum RF technology.
 3. Operate on the 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 feet (76 m)** in line of sight.
 8. Include visual indicators to provide diagnostic information required for operator verification of operation.
- F. Wireless Routers:
 1. Each wireless mesh network shall 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 the 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 feet (76 m)** in line of sight.
8. Include indication for use in commissioning and troubleshooting.

G. Wireless Temperature Sensors:

1. Wireless temperature sensors shall 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 the 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 CFR 15, Subpart B, Class A.
6. Include set point adjustment between **55 to 85 deg F (13 to 30 deg C)**.
7. Multiple sensors shall be able to report to a router connected to a DDC controller for averaging or high and low selection.

H. One-to-One Wireless Network Receivers:

1. One-to-one wireless receivers shall 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 the 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 the sensors to confirm and synchronize data transmission.
 - f. Capable of communication up to a distance of **200 feet (61 m)**.
 - 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 shall sense and report room temperatures to one-to-one receiver.
 - a. Use direct sequence spread spectrum RF technology.
 - b. Operate on the 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 CFR 15, Subpart B, Class A.

- e. Include set point adjustment between 55 to 85 deg F (13 to 30 deg C).

2.11 DESKTOP WORKSTATIONS

- A. Description: A tower or all-in-one computer designed for normal use at a single, semipermanent location.
- B. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- C. Performance Requirements:
 1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
 2. Energy Star compliant.
- D. Personal Computer:
 1. Minimum Processor Speed: **<Insert gigahertz>**.
 2. RAM:
 - a. Capacity: **[2] [4] [8] <Insert value> [GB]**.
 - b. Speed and Type: **[1333] <Insert value> MHz, <Insert type>**.
 3. Hard Drive:
 - a. Media: **[Solid state] [Rotating disc, nominal rotational speed of 7200 rpm] [Hybrid solid-state and rotating disc]**.
 - b. Number of Hard Drives: **[One] [Two] <Insert number>**.
 - c. Capacity: **<Insert number and measurement unit>**.
 - d. Minimum Average Seek Time: **<Insert number and measurement unit>**.
 - e. Cache Buffer Size: **<Insert number and measurement unit>**.
 - f. **<Insert requirements>**.
 4. Second Hard Drive:
 - a. Media: **[Solid state] [Rotating disc, nominal rotational speed of 7200 rpm] [Hybrid solid-state and rotating disc]**.
 - b. Capacity: **<Insert number and measurement unit>**.
 - c. Minimum Average Seek Time: **<Insert number and measurement unit>**.
 - d. Cache Buffer Size: **<Insert number and measurement unit>**.
 - e. **<Insert requirements>**.
 5. Optical Drive:
 - a. Type: **<Insert type>**.
 - b. Minimum Average Access Time: **<Insert number> ms**.
 - c. Data Transfer Speed: **<Insert number> [MB] [TB]/s**.
 - d. Reading Formats: Data, audio, recordable, **<Insert other>** and rewritable.

6. Optical Read and Write Drive:
 - a. Include with at least 2 MB of data buffer.
 - b. Type: **<Insert type>**.
 - c. Minimum Data Buffer Capacity: **<Insert number and measurement unit>**.
 - d. Minimum Average Access Time: **<Insert number>** ms.
 - e. Nominal Data Transfer Rates:
 - 1) Reading: **<Insert number>** [MB] [TB]/s.
 - 2) Writing: **<Insert number>** [MB] [TB]/s.
 - f. Average access time of 150 ms or less.
 - g. MTBF of at least 100,000 power-on hours.
 7. At least four expansion slots of [32] [64] **<Insert number>** bit.
 8. Video Card:
 - a. Resolution: [1920 by 1200] **<Insert values>** pixels.
 - b. RAM: **<Insert number>** [MB] [GB] [TB].
 - c. Controller Speed: **<Insert number>** [MHz] [GHz].
 - d. On-Board Memory Speed: **<Insert number>** [MHz] [GHz].
 - e. On-Board Memory Data Width: **<Insert number>** bit.
 9. 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.
 10. Network Interface Card: Include card with connection, as applicable.
 - a. 10-100-1000 base TX Ethernet with RJ45 connector port.
 - b. 100 base FX Ethernet with SC or ST port.
- E. Wireless Ethernet, 802.11 a/b/g/n.
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.

- B. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- C. Performance Requirements:
1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
 2. Energy Star compliant.
 3. Hardware and software shall support local down-loading to DDC controllers.
 4. Data transfer rate to DDC controller shall be at network speed.
- D. Processor:
1. Minimum Processor Speed: **<Insert gigahertz>**.
 2. RAM:
 - a. Capacity: **<Insert value> [GB] [TB]**.
 - b. Speed and Type: **<Insert value> MHz, <Insert type>**.
 3. Hard Drive:
 - a. Number of Hard Drives: **[One] [Two] <Insert number>**.
 - b. Capacity: **<Insert number and measurement unit>**.
 - c. Minimum Average Seek Time: **<Insert number and measurement unit>**.
 - d. Cache Buffer Size: **<Insert number and measurement unit>**.
 - e. **<Insert requirements>**.
 4. Video Card: **<Insert number and measurement unit>** of RAM.
- E. Input and Output 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.
- F. Battery:
1. Capable of supporting operation of portable workstation for a minimum of **[8] <Insert number>** hours.
 2. Battery life of at least three years.
 3. Battery charge time of less than three hours.
 4. Spare Battery(ies). **[One] [Two]**.
- G. Keyboard:
1. 85-key **[backlit]** keyboard.
 2. Full upper- and lowercase ASCII keyset.

- H. Integral Pointing Device: Touchpad with two buttons. Gesture enabled.
- I. Display:
 - 1. **<Insert inches (mm)>** diagonal or larger high-definition WLED color display.
 - 2. Antiglare screen.
 - 3. **[1920 by 1080] <Insert value>** pixel resolution.
 - 4. Brightness: 300 nits.
- J. Network Interfaces:
 - 1. Network Interface Card: Include card with connection, as application.
 - a. 10-100-1000 base TX Ethernet with RJ45 connector port.
 - b. 100 base FX Ethernet with SC or ST port.
 - 2. Wireless:
 - a. Internal with integrated antenna, capable of supporting 802.11 a/b/g/n.
- K. Digital Video Disc Rewrite Recorder (DVD+/-RW):
 - 1. Compatible with DVD disks and data, audio, recordable and rewritable compact disks.
 - 2. Nominal Data Transfer Rates:
 - a. Reading: **<Insert number> [MB] [TB]/s.**
 - b. Writing: **<Insert number> [MB] [TB]/s.**
 - 3. 160-ms access time.
- L. Accessories:
 - 1. Nylon carrying case.
 - 2. Docking station.
 - 3. Mobile broadband card.
 - 4. Wireless optical mouse.
 - 5. **<Insert value> [GB] [TB]** portable hard drive.
 - 6. Light-sensitive web cam and noise-cancelling digital array microphone.
 - 7. Category 6a patch cable. Minimum cable length shall be **<Insert length>**.
 - 8. HDMI cable. Minimum cable length shall be **<Insert length>**.

2.13 PORTABLE OPERATOR TERMINAL

- 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 (900 mm)** 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, POT shall be accessible to DDC controllers through a wireless network connection.
- D. POT shall be powered through network connection.
- E. Connection of POT to DDC system shall 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. POT shall give operator the 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.
 - 16. **<Insert requirements>**.

2.14 SERVERS

- A. Description: x86 based permanently installed computer used for client-server computing.
- B. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- C. Mounting: [**Rack**] [**Blade**] [**Tower**] [**Tower able to be rack-mounted**].
- D. Power: [**Single**] [**Dual**] power supply, minimum 300 W.
- E. Performance Requirements:
 - 1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
 - 2. Energy Star compliant.
 - 3. Minimum Processor Speed: **<Insert gigahertz>**.
 - 4. RAM:

- a. Capacity: <Insert value> [GB] [TB].
 - b. Speed and Type: <Insert value> MGz, <Insert type>.
 - c. Expandable Capacity: <Insert value> [GB] [TB].
5. Redundant Array of Independent Disks: [Zero] [One] [Two] [Three] [Four] [Five] <Insert number> configuration.
 6. Drive Bays: Eight at 2.5 inches (65 mm) or eight at 3.5 inches (90 mm).
 7. Hard-Drive Storage: [Two] [Three] [Four] drives each with <Insert value> [GB] [TB] storage and nominal rotational speed of 7200 rpm.
 8. Network Interface: [Dual port Gigabit Ethernet] [Optical fiber].
 9. DVD +RW Drive.
 10. Color, flat-screen display with <Insert inches (mm)> diagonal viewable area.
 11. Keyboard and mouse.
 12. Next-day on-site warranty for [two] [three] <Insert number>-year period following Substantial Completion.

F. Servers shall include the following:

1. Full-feature backup server (server and backup minimum requirement).
2. Software licenses.
3. Cable installation between server(s) and network.

G. Web Server:

1. If required to be separate, include Web server hardware and software to match, except backup server is not required.
2. Firewalls between server Web and networks.
3. Password protection for access to server from Web server.
4. Cable installation between the server(s) and building Ethernet network.

H. Power each server through a [dedicated] UPS unit.

2.15 PRINTERS

A. Black and White Laser Printer:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. [1200 by 1200] <Insert value> dots per inch resolution.
3. First sheet printed within 10 seconds.
4. <Insert number> page per minute rated print speed at best quality mode.
5. Print buffer with at least <Insert value> MB of RAM, expandable to at least 288 MBs.
6. Complies with Energy Star requirements.
7. Capable of handling letter- and legal-size paper and overhead transparencies.
8. Two paper trays; one tray with <Insert number> sheet capacity, and one tray with <Insert number> sheet capacity.
9. At least <Insert number> page toner/cartridge capacity.

B. Color Laser Printer:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. [1200 by 1200] <Insert value> dots per inch resolution black and white, [1200 by 1200] <Insert value> dots per inch resolution black and white and color.
3. First sheet printed within 10 seconds.
4. <Insert number> page per minute rated print speed at best quality mode.
5. Print buffer with at least [512] <Insert value> MB of RAM, expandable to at least [one] <Insert value> GB.
6. Complies with Energy Star requirements.
7. Capable of handling letter- and legal-size paper and overhead transparencies.
8. Two paper trays; one tray with <Insert number> sheet capacity, and one tray with 500 <Insert number> sheet capacity.
9. Two-sided printing.
10. At least <Insert number> page toner/cartridge capacity.

C. Color Inkjet Printer:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Inkjet technology with true four-color printing (black, cyan, magenta, and yellow).
3. Print quality of [1200 by 600] <Insert value> dots per inch with black on inkjet paper and [4800 by 1200] <Insert value> dots per inch color printing on premium photo paper.
4. Rated speed of <Insert number> pages per minute printing black and white in normal mode and <Insert number> pages per minute printing color in normal mode.
5. Two paper trays; one tray with <Insert number> sheet capacity, and one tray with <Insert number> sheet capacity.
6. Capable of handling letter- and legal-size paper and overhead transparencies.
7. <Insert number> MB of RAM.
8. Duplex printing (printing on both sides of paper).

D. Dot Matrix Printer:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Letter-quality, wide-carriage, 24-pin dot matrix printer.
3. <Insert number> kb print buffer.
4. Minimum Print Speed:
 - a. 330 characters per second (draft).
 - b. 110 characters per second (letter quality).
5. Seven print fonts.
6. Continuous - forms feed with manual single sheet feed.
7. Capable of handling 16-inch- (400-mm-) wide continuous-feed paper.

2.16 SYSTEM SOFTWARE

A. System Software Minimum Requirements:

1. Real-time multitasking and multiuser [32-] [or] [64-]bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
2. Operating system shall be capable of operating DOS and Microsoft Windows applications.
3. Database management software shall manage all data on an integrated and non-redundant basis. Additions and deletions to database shall be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
4. Network communications software shall manage and control multiple network communications to provide exchange of global information and execution of global programs.
5. Operator interface software shall include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
6. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.

B. Operator Interface Software:

1. Minimize operator training through use of English language pronouncing and English language point identification.
2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.
3. Operator sign-off shall be a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
4. Automatic sign-off period shall be programmable from one to 60 minutes in one-minute increments on a per operator basis.
5. Operator sign-on and sign-off activity shall be recorded and sent to printer.
6. Security Access:
 - a. Operator access to DDC system shall be under password control.
 - b. An alphanumeric password shall be field assignable to each operator.
 - c. Operators shall be able to access DDC system by entry of proper password.
 - d. Operator password shall be same regardless of which computer or other interface means is used.
 - e. Additions or changes made to passwords shall be updated automatically.
 - f. Each operator shall be assigned an access level to restrict access to data and functions the operator is capable of performing.
 - g. Software shall have at least five access levels.
 - h. Each menu item shall be assigned an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
 - i. Display menu items to operator with those capable of access highlighted. Menu and operator access level assignments shall be online programmable and under password control.
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] <Insert number> segregation groups.
 - c. Segregation groups shall be selectable such as "fire points," "fire points on second floor," "space temperature points," "HVAC points," and so on.
 - d. Points shall be assignable to multiple segregation groups. Display and output of data to printer or monitor shall occur where there is a match of operator or peripheral segregation group assignment and point segregations.
 - e. Alarms shall be displayed and printed at each peripheral to which segregation allows, but only those operators assigned to peripheral and having proper authorization level will be allowed to acknowledge alarms.
 - f. Operators and peripherals shall be assignable to multiple segregation groups and all assignments are to be online programmable and under password control.
8. Operators shall be able to perform commands including, but not limited to, the following:
- a. Start or stop selected equipment.
 - b. Adjust set points.
 - c. Add, modify, and delete time programming.
 - d. Enable and disable process execution.
 - e. Lock and unlock alarm reporting for each point.
 - f. Enable and disable totalization for each point.
 - g. Enable and disable trending for each point.
 - h. Override control loop set points.
 - i. Enter temporary override schedules.
 - j. Define holiday schedules.
 - k. Change time and date.
 - l. Enter and modify analog alarm limits.
 - m. Enter and modify analog warning limits.
 - n. View limits.
 - o. Enable and disable demand limiting.
 - p. Enable and disable duty cycle.
 - q. Display logic programming for each control sequence.
 - r. <Insert requirements>.
9. Reporting:
- a. Generated automatically and manually.
 - b. Sent to displays, printers and disk files.
 - c. Types of Reporting:
 - 1) General listing of points.
 - 2) List points currently in alarm.
 - 3) List of off-line points.
 - 4) List points currently in override status.
 - 5) List of disabled points.
 - 6) List points currently locked out.
 - 7) List of items defined in a "Follow-Up" file.
 - 8) List weekly schedules.

- 9) List holiday programming.
 - 10) List of limits and deadbands.
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 shall 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. Descriptors for graphics, points, alarms and such shall be modified through operator's workstation under password control.
5. Graphic displays shall be online user definable and modifiable using the hardware and software provided.
6. Data to be displayed within a graphic shall be assignable regardless of physical hardware address, communication or point type.
7. Graphics are to be online programmable and under password control.
8. Points may be assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
9. Graphics shall also contain software points.
10. Penetration within a graphic hierarchy shall display each graphic name as graphics are selected to facilitate operator understanding.
11. Back-trace feature shall permit operator to move upward in the hierarchy using a pointing device. Back trace shall show all previous penetration levels. Include operator with option of showing each graphic full screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
12. Display operator accessed data on the monitor.
13. Operator shall select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Defined and linked graphic below that selection shall then be displayed.
14. Include operator with means to directly access graphics without going through penetration path.
15. Dynamic data shall be 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. Color shall be variable for each class of points, as chosen by operator.
18. Points shall be dynamic with operator adjustable update rates on a per point basis from [**one**] <Insert value> second to over a [**minute**] <Insert value>.
19. For operators with appropriate privilege, points shall be commanded directly from display using pointing device.

- a. For an analog command point such as set point, current conditions and limits shall be displayed and operator can position new set point using pointing device.
 - b. For a digital command point such as valve position, valve shall show its current state such as open or closed and operator could select alternative position using pointing device.
 - c. Keyboard equivalent shall be available for those operators with that preference.
20. Operator shall be able to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot and other information on other quadrants on screen. This feature shall allow real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.
21. Help Features:
- a. On-line context-sensitive help utility to facilitate operator training and understanding.
 - b. Bridge to further explanation of selected keywords. Document shall contain text and graphics to clarify system operation.
 - 1) If help feature does not have ability to bridge on keywords for more information, a complete set of user manuals shall be provided in an indexed word-processing program, which shall run concurrently with operating system software.
 - c. Available for Every Menu Item:
 - 1) Index items for each system menu item.
22. Graphic generation software shall allow operator to add, modify, or delete system graphic displays.
- a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols[**similar to those indicated**].
 - b. Graphic development package shall use a pointing device in conjunction with a drawing program to allow operator to perform the following:
 - 1) Define background screens.
 - 2) Define connecting lines and curves.
 - 3) Locate, orient and size descriptive text.
 - 4) Define and display colors for all elements.
 - 5) Establish correlation between symbols or text and associated system points or other displays.
- D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:
1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.
 2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:

- a. Room layouts with room identification and name.
 - b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
 - c. Location and identification of each hardware point being controlled or monitored by DDC system.
 - d. **<Insert requirements>**.
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. As a minimum, include the following modification capability:
 - a. Operator assignment shall include designation of operator passwords, access levels, point segregation and auto sign-off.
 - b. Peripheral assignment capability shall include 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 diagnostic capability shall include 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 capability shall include 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 capability shall include time and date set, time and occupancy schedules, exception and holiday schedules and daylight savings time schedules.
 - f. Point related change capability shall 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 shall 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. Software shall allow operator to add points, or groups of points, to DDC system and to link them to energy optimization and management programs. Additions and modifications shall be online programmable using operator workstation, downloaded to other network devices and entered into their databases. After verification of point additions and associated program operation, database shall be uploaded and recorded on hard drive and disk for archived record.
 - 5. Include high-level language programming software capability for implementation of custom DDC programs. Software shall 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, as 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 shall monitor loop response to output corrections and adjust loop response characteristics according to time constant changes imposed.
 - 2) Algorithm shall operate in a continuous self-learning manner and shall retain 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 according to alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.

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

- 1) Routine maintenance or other types of warning alarms.
 - 2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.
9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator shall be able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.
 10. To ensure that no alarm records are lost, it shall be possible to assign a backup printer to accept alarms in case of failure of primary printer.
- G. Reports and Logs:
1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
 2. Each report shall be definable as to data content, format, interval and date.
 3. Report data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on **[workstation]** **[server]** for historical reporting.
 4. Operator shall be able to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
 5. Reports and logs shall be stored on **[workstation]** **[and]** **[server]** hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
 6. Reports and logs shall be readily printed and set to be printed either on operator command or at a specific time each day.
- H. Standard Reports: Standard DDC system reports shall be provided and operator shall be able 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 shall be able to easily define any system data into a daily, weekly, monthly, or annual report. Reports shall be time and date stamped and shall contain a report title.
- J. Tenant Override Reports: Prepare Project-specific reports.
1. Weekly report showing daily total time in hours that each tenant has requested after-hours HVAC.

2. Monthly report showing daily total time in hours that each tenant has requested after-hours HVAC.
3. Annual summary report that shows after-hours HVAC usage on a monthly basis.

K. HVAC Equipment Reports: Prepare Project-specific reports.

1. Chiller Report: Daily report showing operating conditions of each chiller according to ASHRAE 147, including, but not limited to, the following:
 - a. Chilled-water entering temperature.
 - b. Chilled-water leaving temperature.
 - c. Chilled-water flow rate.
 - d. Chilled-water inlet and outlet pressures.
 - e. Evaporator refrigerant pressure and temperature.
 - f. Condenser refrigerant pressure and liquid temperature.
 - g. Condenser-water entering temperature.
 - h. Condenser-water leaving temperature.
 - i. Condenser-water flow rate.
 - j. Refrigerant levels.
 - k. Oil pressure and temperature.
 - l. Oil level.
 - m. Compressor refrigerant discharge temperature.
 - n. Compressor refrigerant suction temperature.
 - o. Addition of refrigerant.
 - p. Addition of oil.
 - q. Vibration levels or observation that vibration is not excessive.
 - r. Motor amperes per phase.
 - s. Motor volts per phase.
 - t. Refrigerant monitor level (PPM).
 - u. Purge exhaust time or discharge count.
 - v. Ambient temperature (dry bulb and wet bulb).
 - w. Date and time logged.

2. **<Insert requirements for each type of HVAC equipment requiring a report>.**

L. Utility Reports: Prepare Project-specific reports.

1. Electric Report:
 - a. Include weekly report showing daily electrical consumption and peak electrical demand with time and date stamp for each meter.
 - b. Include monthly report showing the daily electrical consumption and peak electrical demand with time and date stamp for each meter.
 - c. Include annual report showing the monthly electrical consumption and peak electrical demand with time and date stamp for each meter.
 - d. For each weekly, monthly and annual report, include sum total of submeters combined by load type, such as lighting, receptacles and HVAC equipment showing daily electrical consumption and peak electrical demand.

- e. For each weekly, monthly and annual report, include sum total of all submeters in building showing electrical consumption and peak electrical demand.
2. Natural Gas Report:
 - a. Include weekly report showing daily natural gas consumption and peak natural gas demand with time and date stamp for each meter.
 - b. Include monthly report showing the daily natural gas consumption and peak natural gas demand with time and date stamp for each meter.
 - c. Include annual report showing the monthly natural gas consumption and peak natural gas demand with time and date stamp for each meter.
 - d. For each weekly, monthly and annual report, include sum total of submeters combined by load type, such as boilers and service water heaters showing daily natural gas consumption and peak natural gas demand.
 - e. For each weekly, monthly and annual report, include sum total of all submeters in building showing natural gas consumption and peak natural gas demand.
 3. Service Water Report:
 - a. Include weekly report showing daily service water consumption and peak service water demand with time and date stamp for each meter.
 - b. Include monthly report showing the daily service water consumption and peak service water demand with time and date stamp for each meter.
 - c. Include annual report showing the monthly service water consumption and peak service water demand with time and date stamp for each meter.
 - d. For each weekly, monthly and annual report, include sum total of submeters combined by load type, such as cooling tower makeup and irrigation showing daily service water consumption and peak service water demand.
 - e. For each weekly, monthly and annual report, include sum total of all submeters in building showing service water consumption and peak service water demand.
 4. **<Insert requirements for each utility requiring a report>.**
- M. Energy Reports: Prepare Project-specific daily, weekly, monthly [**and annual**] [, **annual and since-installed**] energy reports.
1. Prepare report for each purchased energy utility, indicating the following:
 - a. Time period being reported with beginning and end date, and time indicated.
 - b. Consumption in units of measure commonly used to report specific utility consumption over time.
 - c. Gross area served by utility.
 - d. Consumption per unit area served using utility-specific unit of measure.
 - e. Cost per utility unit.
 - f. Utility cost per unit area.
 - g. Convert all utilities to a common energy consumption unit of measure and report for each utility.
 - h. Consumption per unit area using common unit of measure.

2. Prepare report for each renewable energy source, indicating the following:
 - a. Time period being reported with beginning and end date, and time indicated.
 - b. Harvested energy in units of measure commonly used to report specific harvested energy consumption over time.
 - c. Gross area served by renewable energy source.
 - d. Harvested energy per unit area served using specific unit of measure.
 - e. Cost per purchased utility unit displaced by renewable energy.
 - f. Cost savings attributed to harvested energy source.
 - g. Cost savings per unit area attributed to harvested energy.
 - h. Convert all renewable energy sources to a common energy consumption unit of measure and report for each.
 - i. Harvested energy per unit area using common unit of measure.

3. Prepare purchased energy utility report for each submetered area that indicates the following:
 - a. Time period being reported with beginning and end date, and time indicated.
 - b. Gross area served.
 - c. Energy consumption by energy utility type.
 - d. Energy consumption per unit area by energy utility type.
 - e. Total energy consumption of all utilities in common units of measure.
 - f. Total energy consumption of all utilities in common units of measure per unit area.
 - g. Unit energy cost by energy utility type.
 - h. Energy cost by energy utility type.
 - i. Energy cost per unit area by energy utility type.
 - j. Total cost of all energy utilities.
 - k. Total cost of all energy utilities per unit area.

4. Prepare Project total purchased energy utility report that combines all purchased energy utilities and all areas served. Project total energy report shall indicate the following:
 - a. Time period being reported with beginning and end date, and time indicated.
 - b. Gross area served.
 - c. Energy consumption by energy utility type.
 - d. Energy consumption per unit area by energy utility type.
 - e. Total energy consumption of all utilities in common units of measure.
 - f. Total energy consumption of all utilities in common units of measure per unit area.
 - g. Unit energy cost by energy utility type.
 - h. Energy cost by energy utility type.
 - i. Energy cost per unit area by energy utility type.
 - j. Total cost of all energy utilities.
 - k. Total cost of all energy utilities per unit area.

- N. HVAC System Efficiency Reports: Prepare Project-specific [**daily**] [**weekly**] [**monthly**] [**and annual**] [, **annual and since-installed**] HVAC system efficiency reports.
 1. Prepare report for [**each**] chilled-water system, indicating the following:

- a. Time period being reported with beginning and end date, and time indicated.
 - b. Cooling energy supplied during time period.
 - c. Power energy consumed during time period by cooling equipment used to produce cooling energy supplied. [**List power consumed for each individual piece of equipment in system and summed total of all equipment in system.**]
 - d. Energy efficiency coefficient of performance determined by dividing power energy consumed into cooling energy supplied.
 - e. Energy efficiency determined by dividing cooling energy supplied into power energy consumed.
 - f. Units of measure used in report shall be consistent with units indicated for system.
2. Prepare report for [**each**] hot-water system, indicating the following:
- a. Time period being reported with beginning and end date, and time indicated.
 - b. Cooling energy supplied during time period.
 - c. Fuel consumed during time period by boilers used to produce heating energy supplied. [**List fuel consumed for each individual piece of equipment in system and summed total of all equipment in system.**]
 - d. Energy efficiency determined by dividing heating energy supplied into fuel energy consumed.
 - e. Units of measure used in report shall be consistent with units indicated for system.
3. Prepare report for [**each**] steam system, indicating the following:
- a. Time period being reported with beginning and end date, and time indicated.
 - b. Cooling energy supplied during time period.
 - c. Fuel consumed during time period by boilers used to produce heating energy supplied. [**List fuel consumed for each individual piece of equipment in system and summed total of all equipment in system.**]
 - d. Energy efficiency determined by dividing heating energy supplied into fuel energy consumed.
 - e. Units of measure used in report shall be consistent with units indicated for system.
4. **<Insert requirements for each HVAC system requiring a report>**.
- O. PUE Reports: Prepare Project-specific [**daily**] [**weekly**] [**monthly**] [**and annual**] [, **annual and since-installed**] PUE reports.
1. Prepare separate report for each [**tenant**] **<Insert category>**.
 2. Prepare Project PUE report that combines PUE and all tenants served.
 3. Calculate PUE following guidelines in [**The Green Grid, White Paper No. 22**] **<Insert requirements>**.
- P. Weather Reports:
1. Include daily report showing the following:
 - a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
 - b. Daily minimum, maximum, and average outdoor wet-bulb temperature.

- c. Daily minimum, maximum, and average outdoor dew point temperature.
 - d. Number of heating degree-days for each day calculated from a base temperature of **[55 deg F (13 deg C)] <Insert temperature>**.
 - e. Number of cooling degree-days for each day calculated from a base temperature of **[65 deg F (18 deg C)] <Insert temperature>**.
 - f. Daily minimum, maximum, and average outdoor carbon dioxide level.
 - g. Daily minimum, maximum, and average relative humidity.
 - h. Daily minimum, maximum, and average barometric pressure.
 - i. Daily minimum, maximum, and average wind speed and direction.
2. Include weekly report showing the following:
- a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
 - b. Daily minimum, maximum, and average outdoor wet-bulb temperature.
 - c. Daily minimum, maximum, and average outdoor dew point temperature.
 - d. Number of heating degree-days for each day calculated from a base temperature of **[55 deg F (13 deg C)] <Insert temperature>**.
 - e. Number of cooling degree-days for each day calculated from a base temperature of **[65 deg F (18 deg C)] <Insert temperature>**.
 - f. Weekly minimum, maximum, and average outdoor carbon dioxide level.
 - g. Daily minimum, maximum, and average relative humidity.
 - h. Daily minimum, maximum, and average barometric pressure.
 - i. Daily minimum, maximum, and average wind speed and direction.
3. Include monthly report showing the following:
- a. Daily minimum, maximum, and average outdoor dry-bulb temperature.
 - b. Daily minimum, maximum, and average outdoor wet-bulb temperature.
 - c. Daily minimum, maximum, and average outdoor dew point temperature.
 - d. Number of heating degree-days for each day calculated from a base temperature of **[55 deg F (13 deg C)] <Insert temperature>**.
 - e. Number of cooling degree-days for each day calculated from a base temperature of **[65 deg F (18 deg C)] <Insert temperature>**.
 - f. Monthly minimum, maximum, and average outdoor carbon dioxide level.
 - g. Daily minimum, maximum, and average relative humidity.
 - h. Daily minimum, maximum, and average barometric pressure.
 - i. Daily minimum, maximum, and average wind speed and direction.
4. Include annual (12-month) report showing the following:
- a. Monthly minimum, maximum, and average outdoor dry-bulb temperature.
 - b. Monthly minimum, maximum, and average outdoor wet-bulb temperature.
 - c. Monthly minimum, maximum, and average outdoor dew point temperature.
 - d. Number of heating degree-days for each month calculated from a base temperature of **[55 deg F (13 deg C)] <Insert temperature>**.
 - e. Number of cooling degree-days for each month calculated from a base temperature of **[65 deg F (18 deg C)] <Insert temperature>**.
 - f. Annual minimum, maximum, and average outdoor carbon dioxide level.
 - g. Monthly minimum, maximum, and average relative humidity.

- h. Daily minimum, maximum, and average barometric pressure.
- i. Daily minimum, maximum, and average wind speed and direction.

Q. Standard Trends:

- 1. Trend all I/O point present values, set points, and other parameters indicated for trending.
- 2. Trends shall be associated into groups, and a trend report shall be set up for each group.
- 3. Trends shall be stored within DDC controller and uploaded to hard drives automatically on reaching [75] <Insert value> of DDC controller buffer limit, or by operator request, or by archiving time schedule.
- 4. Preset trend intervals for each I/O point after review with Owner.
- 5. Trend intervals shall be operator selectable from 10 seconds up to 60 minutes. Minimum number of consecutive trend values stored at one time shall be 100 per variable.
- 6. When drive storage memory is full, most recent data shall overwrite oldest data.
- 7. Archived and real-time trend data shall be available for viewing numerically and graphically by operators.

R. Custom Trends: Operator shall be able to define a custom trend log for any I/O point in DDC system.

- 1. Each trend shall include interval, start time, and stop time.
- 2. Data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on [workstation] [server] hard drives.
- 3. Data shall be retrievable for use in spreadsheets and standard database programs.

S. 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 shall be [as follows] [any of the following] [one of the following]:
 - a. Graphic Based: Programming shall use a library of function blocks made from preprogrammed code designed for DDC control systems.
 - 1) Function blocks shall be assembled with interconnection lines that represent to control sequence in a flowchart.
 - 2) Programming tools shall be viewable in real time to show present values and logical results of each function block.
 - b. Menu Based: Programming shall be done by entering parameters, definitions, conditions, requirements and constraints.
 - c. Line by Line and Text Based: Programming shall 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.

T. Database Management Software:

1. Where a separate SQL database is used for information storage, DDC system shall include database management software that separates database monitoring and managing functions by supporting multiple separate windows.
2. Database secure access shall be accomplished using standard SQL authentication including ability to access data for use outside of DDC system applications.
3. Database management function shall include summarized information on trend, alarm, event, and audit for the following database management actions:
 - a. Backup.
 - b. Purge.
 - c. Restore.
4. Database management software shall support the following:
 - a. Statistics: Display database server information and trend, alarm, event, and audit information on database.
 - b. Maintenance: Include method of purging records from trend, alarm, event and audit databases by supporting separate screens for creating a backup before purging, selecting database, and allowing for retention of a selected number of day's data.
 - c. Backup: Include means to create a database backup file and select a storage location.
 - d. Restore: Include a restricted means of restoring a database by requiring operator to have proper security level.
5. Database management software shall include information of current database activity, including the following:
 - a. Ready.
 - b. Purging record from a database.
 - c. Action failed.
 - d. Refreshing statistics.
 - e. Restoring database.
 - f. Shrinking a database.
 - g. Backing up a database.
 - h. Resetting Internet information services.
 - i. Starting network device manager.
 - j. Shutting down the network device manager.
 - k. Action successful.
6. Database management software monitoring functions shall continuously read database information once operator has logged on.

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

2.17 OFFICE APPLICATION SOFTWARE

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Include current version of office application software at time of Substantial Completion.
- C. Office application software package shall include multiple separate applications and use a common platform for all applications, similar to Microsoft's "Office Professional."
 1. Database.
 2. E-mail.
 3. Presentation.
 4. Publisher.
 5. Spreadsheet.
 6. Word processing.

2.18 MAINTENANCE MANAGEMENT SOFTWARE

- A. Scope:
 1. Include complete and functional software-driven maintenance management system. Software shall perform scheduling of preventive maintenance and generation of work orders, for mechanical and electrical equipment and systems.

2. Work orders shall be automatically generated from alarm conditions, run time, and calendar time. Each work order generated shall list parts, tools, craftspeople, and define task to be performed.
3. Work order generated shall be used to schedule a repair or preventive maintenance routine.
4. Work order shall be used to track completion of work, parts used and total cost of repair.
5. A database shall include an inventory tracking system. Work orders generated shall automatically update inventory database to show quantity of tools, repair parts and expendables used for a work order.
6. Work orders and preventive maintenance schedules shall be printed on a dedicated printer assigned solely to maintenance management function.

B. Additional Hardware Requirements:

1. Maintenance management software shall not require additional hardware, except for an additional printer that is dedicated to maintenance management.
2. Maintenance management software shall be integrated into DDC system.

C. Software Requirements:

1. From main menu of maintenance management system, it shall be possible through selection of icons to penetrate to individual functions described below.
2. Work Orders:
 - a. Automatically generate work orders initiated from alarm conditions, accumulated run time or calendar time. Work orders generated shall specify a particular task to be accomplished including the labor, material and tools needed to accomplish work.
 - b. Include at least two of the following types of work orders:
 - 1) Corrective and emergency maintenance work orders shall be generated for a specific job or repair for emergency, breakdown, or scheduled work.
 - 2) Preventive maintenance that are used on a periodic basis to generate preventive maintenance work orders.
 - c. Include the following functions:
 - 1) Work Order Tracking: Perform every function related to processing work orders including creating, approving and initiating work orders, checking their status history and closing or reworking them when appropriate.
 - 2) Work Requests: Report any problems that require corrective maintenance activity generated by dispatchers and those people designated to request work orders.
 - 3) Quick Reporting: Report work done on an open work order or a small job.
 - 4) Work Manager: Specify the type of labor to be applied to a specific work order at specific times. It shall include the capability to dispatch one or more laborers to top-priority jobs on as-needed basis and to interrupt work in progress to reassign labor to higher priority tasks.

- d. Reports:
 - 1) Daily Maintenance Schedule by Supervisor: List a schedule of open work orders for a specified date by supervisor.
 - 2) Equipment Cost Roll-up Report: Include a roll-up of equipment costs incurred since the date the report was last run.
 - 3) Delinquent Work Order Report: List open work orders whose target completion date is earlier than the date the report is run.
 - 4) Employee Job Assignments: List labor codes that have job assignments for the specified date.
 - 5) Daily Work Order Assignment: List work orders that have labor assignments for the specified date.
 - 6) Estimated versus Actual Work Order Costs: List a cost summary of outstanding work orders.
 - 7) Open Work Orders Report: List open work orders for locations and equipment.

3. Inventory:
 - a. Include an inventory tracking system to keep track of stocked, non-stocked and special-order items.
 - b. Link inventory tracking to database and when items are consumed, as noted on a work order issued by system, inventory of stocked items shall be automatically updated.
 - c. Include the following functions:
 - 1) Inventory Control: Enter, display, and update information on each inventory item. It shall allow viewing of master inventory records that are independent of storeroom locations or item/location records. Include a screen that lists inventory transactions that move items in or out of inventory or from one storeroom location to another. Minimum information tracked shall include the following:
 - a) Vendors supply items.
 - b) Item balances, including the bin and lot level for each storeroom location.
 - c) Alternative items.
 - 2) Issues and Transfers: Issue stock directly from inventory, with or without a work order. When transfer of stock from one location to another location occurs, provide appropriate adjustments in stock balance record. Include a trace record of stock transfers from one storeroom to another.
 - 3) Item Assembly Structures: Include modeling of equipment with inventory items and building of equipment and location hierarchies.
 - 4) Metered Material Usage:
 - a) Track usage by a piece of equipment.
 - b) Record against a standing work order for a selected piece of equipment.

- c) Material usage transaction shall be written for each item of material used and be provided as an input to calculation for per unit material consumption report for a piece of equipment.

d. Reports:

- 1) Inventory Analysis Report: List for a given storeroom location, inventory items analysis information that allows quick identification of which inventory items represent greatest monetary investment for dollar value and rate of turnover.
- 2) Inventory Cycle Count Report: List for a specified storeroom, inventory items that are due to be cycle-counted, based on cycle-count frequency and last count date.
- 3) Economic Order Quantity Report: For a given storeroom location, display optimum economic ordering quantity for items in selected results set.
- 4) Inventory Pick Report: A pick list, by work order for items needed to be pulled from a designated storeroom's inventory for work orders having a target start date of specified date.
- 5) Suggested Order Report: List inventory items in selected results set that are due to be recorded, for a specified storeroom location, based on the following calculation: Suggest a reorder if current balance minus reserve quantity plus on-order quantity is less than reorder point.
- 6) Reorder Point Report: List selected set of items and optimum minimum level to have in stock based on demand, lead delivery time and a reserve safety stock.
- 7) Inventory Valuation Report: Gives an accounting of cost of current inventory, for inventory records in a designated storeroom location.
- 8) Item Order Status: Lists items on order.
- 9) List of Expired Items: Lists expired lot items in a storeroom. Report shall include item number, description, expiration date, bin number, lot number, manufacturer lot number, and quantity of expired items in that lot and bin.
- 10) Item Availability at All Locations: Lists alternative storeroom locations for selected items.
- 11) Where Used Report: List equipment on which item is recorded as being used.

4. Equipment:

- a. Include equipment and location records; establish relationships between equipment, between locations, and between equipment and locations; track maintenance costs; and enter and review meter readings.
- b. Include the following functions:
 - 1) Equipment: Store equipment numbers and corresponding information including equipment class, location, vendor, up/down status and maintenance costs for each piece of equipment. Include building of equipment assemblies. Equipment assemblies hierarchical ordering shall be provided for arrangement of buildings, departments, equipment and sub-assemblies.

- 2) Operating Locations: Facilitate creation of records for operating locations of equipment, and track equipment that is used in multiple locations. In addition, allow hierarchical organization of equipment operating in facility by means of grouping equipment locations into areas of responsibility.
- 3) Failure Codes: Develop and display failure hierarchies to acquire an accurate history of types of failures that affect equipment and operating locations.
- 4) Condition Monitoring: Display time related or limit measurements recorded for a piece of equipment. It shall be possible to generate work orders from this screen and to take immediate action on problem conditions.

c. Reports:

- 1) Availability Statistic by Location: List equipment availability by location over a user-specified time period.
- 2) Equipment Failure Summary: List total number of failures by problem code for a piece of equipment for a specified time period.
- 3) Detailed Equipment Failure Report by Equipment: List of failure reports for the current piece of equipment for a specified time period.
- 4) Equipment Hierarchy Report: List of equipment.
- 5) Equipment History Graphs: Include a graphical report in histogram format that displays equipment breakdown history over a specified period.
- 6) Equipment Measurement Report: Tabular listing and description of each measurement point for a piece of equipment and the history of measurements taken for that point.
- 7) Maintenance Cost by Equipment: List of transactions costs for elected equipment in the specified date range.
- 8) Failure Count by Equipment: Graphically report the number of failures for each piece of equipment showing number of failures for each piece of equipment over a specified time period, occurrence of each problem code within set of failures and failures by problem code.
- 9) Failure Analysis Graphs: Graphically report number of failures for each piece of equipment over a specified time period, number of occurrences of each problem code within set of failures and failures by problem code.
- 10) Failure Code Hierarchy Report: List of failure codes in each level of the failure hierarchy.
- 11) Location Failure Summary: A summary for each selected location of failures reported and any hierarchy level locations for specified time period.
- 12) Failure Summary by Location: A summary of failures for the selected location and their subordinate locations that are part of the hierarchical system.
- 13) Detailed Failure Report by Location: List all failures for selected location and its subordinate locations that are part of a hierarchical system.
- 14) Maintenance Cost by System: List of total costs reported in a given date range for locations in selected hierarchical system.
- 15) Location Hierarchy Report: Lists member locations of a hierarchical system displayed in hierarchical fashion.

5. Purchasing:

- a. Include preparation and generation of purchase requisitions and purchase orders; to report receipt of both items and services, match invoices with purchase orders and receipts and define and convert foreign currencies.
 - b. Include the following functions:
 - 1) Purchase Requisition: Create and process purchase requisitions for items and services.
 - 2) Purchase Orders: Create and process purchase orders for items and services from scratch or from purchase requisitions. Record receipts of items and services.
 - 3) Invoices: Include functionality to match purchase orders with invoices and receipts. It shall also be possible to match a service receipt to an invoice. Project for entering of an invoice for bills that do not require purchase orders or receipts.
 - 4) Currency Management: Define currencies and specify exchange rates. Include preparation of purchase requisitions and purchase orders in currency of vendor, while tracking costs in systems base currency.
 - c. Reports:
 - 1) Invoice Approval Report: Include an approval form for entered invoices.
 - 2) Inventory Receipts Register: List purchase orders and inventory received for the user-specified time frame.
 - 3) Direct Purchase Back-Order Report: List of items ordered as a direct purchase not received by the required delivery date.
 - 4) Standard Purchase Order: A printing of primary purchase order with vendors shipping information, and items purchased.
 - 5) Purchase Order Status Report: List of purchase orders whose status has changed during a certain time period.
 - 6) Standard Purchase Requisition: A printing of primary purchase requisition, including vendor name and shipping information.
6. Job Plans:
- a. Include creation of a detailed description of work to be performed by a work order. The job plan shall contain operations, procedures and list of estimated material, labor and tools required for work.
7. Labor:
- a. Store information on employees, contractors, and crafts and include the following functions:
 - 1) Labor: Create, modify and view employee records. Employee records shall contain pay rate, overtime worked, overtime refused, special skills and certifications.
 - 2) Crafts: Create, modify and view craftspeople records.
 - 3) Labor Reporting: Report labor usage by employee or craft externally from the work orders module.

- b. Reports:
 - 1) Employee Attendance Analysis: List of planned attendance, actual attendance, vacation and sick time in hours as a percentage of planned attendance for selected employees for specified time period.
 - 2) Labor Productivity Analysis: List of actual labor hours by labor report category showing each by percentage.
 - 3) Labor Availability versus Commitments by Crafts: A graphical report that details available labor hours versus committed work order hours by craft and day.

- 8. Calendars:
 - a. Establish calendar records indicating working time for equipment, location, craft, and labor records.

- 9. Resources:
 - a. Include entry and retrieval of data associated with resources required to maintain facility and to include the following functions:
 - 1) Companies: Establish and update data on vendors and other companies.
 - 2) Tools: Create and maintain information on the tools used on jobs. The information contained within this module shall be available to job plans and work orders.
 - 3) Service Contracts: Specify information on service contracts with vendors or manufacturers.

- 10. Custom Applications:
 - a. Include creation of customized database tables and application screens that supplement functions specified.

- 11. Setup:
 - a. Include configuration of database, security and setup applications.
 - b. Perform the following functions:
 - 1) Reports and Other Applications: Register reports and other applications for use within system.
 - 2) Documents: Enter, track and link information from Drawings to equipment and inventory items.
 - 3) Chart of Accounts: Add or modify accounts; set up financial periods; enter inventory accounts, company accounts, and resource recovery accounts; and define tax codes and rates.
 - 4) Signature Security: Establish each user's access rights to modules, applications, screens and options.
 - 5) Database Configuration: Customize database, including adjusting field lengths and modifying data types.

- 6) Application Setup: Change position of icons and menu items on the main menu screen.
- 7) Application Launching: Allow for connecting of third-party applications to data fields and push buttons.

12. Utilities:

- a. Include utilities module that allows system administrator to customize system and to maintain database.
- b. Include the following functions:
 - 1) Interactive SQL: Include access to database for database management functions of import/export and backup.
 - 2) Edit Windows: Display a dialog box to customize an application.
 - 3) Archive Data: Remove records from database and store them for future reference.

D. Documentation:

1. Include complete documentation for the system consisting of a User Manual and Systems Administrator Guide.
2. User Manual shall describe how to use each application module and screen with step-by-step instructions detailing entry and retrieval of data for functions specified.
3. Include a step-by-step description of how each report is defined and retrieved.
4. Bind documentation and clearly title it indicating volume number and use.

2.19 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, <Insert equipment,> and variable-speed drives.
- B. Include gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment, only when specifically requested and approved by Owner.
- C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.
- D. Gateway Minimum Requirements:
 1. Read and view all readable object properties on non-BACnet network to BACnet network and vice versa where applicable.
 2. Write to all writeable object properties on non-BACnet network from BACnet network and vice versa where applicable.

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

2.20 ASHRAE 135 PROTOCOL ANALYZER

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

2.21 CEA-709.1-C NETWORK HARDWARE

- A. Routers:
 1. Network routers, including routers configured as repeaters, shall comply with requirements of CEA-709.1-C and include connection between two or more CEA-709.3 TP/FT-10 channels or between two or more CEA-709.3 TP/FT-10 channels and a TP/XF-1250 channel.
 2. IP Routers:
 - a. Perform layer three routing of CEA-709.1-C packets over an IP network according to CEA-852-B.
 - b. Include appropriate connection to the IP network and connections to CEA-709.3 TP/FT-10 or TP/XF-1250 network.
 - c. Support the Dynamic Host Configuration Protocol for IP configuration and use of an CEA-852-B Configuration Server (for CEA-852-B configuration), but shall 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-CEA-709.1-C protocol to CEA-709.1-C.
 2. Incorporate a network connection to a TP/FT-10 network according to CEA-709.3 and a connection for a non-CEA-709.1-C network.

2.22 WIRELESS ROUTERS FOR OPERATOR INTERFACE

A. Single-Band Wireless Routers:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description: High-speed router with integral Ethernet ports.
3. Technology: IEEE 802.11n; [2.4] <Insert number>-GHz speed band.
4. Speed: Up to [300] <Insert number> Mbps.
5. Compatibility: IEEE 802.11n/g/b/a wireless devices.
6. Ethernet Ports: Four, gigabit (1000 Mbps).
7. Wireless Security: Wi-Fi Protected Access (WPA) and WPA2 according to IEEE 802.11i.

B. Dual-Band Wireless Routers:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description: High-speed, dual-band router with integral Ethernet ports and USB port.
3. Technology: IEEE 802.11n; 2.4- and 5-GHz speed bands.
4. Speed: Up to [300] <Insert number> Mbps on 2.4-GHz band and up to [450] <Insert number> Mbps on 5-GHz band.
5. Compatibility: IEEE 802.11n/g/b/a wireless devices.
6. Ethernet Ports: Four, gigabit (1000 Mbps).
7. USB Port: One, USB 2.0 or 3.0.
8. Wireless Security: Wi-Fi Protected Access (WPA) and WPA2 according to IEEE 802.11i.

2.23 DDC CONTROLLERS

- A. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.
- B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.
- C. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.
- D. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.
- E. Environment Requirements:
 1. Controller hardware shall be suitable for the anticipated ambient conditions.
 2. Controllers located in conditioned space shall be rated for operation at [32 to 120 deg F (Zero to 50 deg C)] <Insert temperature range>.
 3. Controllers located outdoors shall be rated for operation at [40 to 150 deg F (40 to 65 deg C)] <Insert temperature range>.

- F. Power and Noise Immunity:
1. Controller shall operate at 90 to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent of nominal voltage.
 2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within **36 inches (900 mm)** of enclosure.
- G. DDC Controller Spare Processing Capacity:
1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:
 - a. Network Controllers: **[50] [60] [70] <Insert value>** percent.
 - b. Programmable Application Controllers: Not less than **[60] [70] [80] <Insert number>** percent.
 - c. Application-Specific Controllers: Not less than **[70] [80] [90] <Insert number>** percent.
 2. Memory shall support DDC controller's operating system and database and shall include the following:
 - a. Monitoring and control.
 - b. Energy management, operation and optimization applications.
 - c. Alarm management.
 - d. Historical trend data of all connected I/O points.
 - e. Maintenance applications.
 - f. Operator interfaces.
 - g. Monitoring of manual overrides.
- H. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:
1. Network Controllers:
 - a. **[10] [20] <Insert number>** percent of each AI, AO, BI, and BO point connected to controller.
 - b. Minimum Spare I/O Points per Controller:
 - 1) AIs: **[Two] [Three] <Insert number>**.
 - 2) AOs: **[Two] [Three] <Insert number>**.
 - 3) BIs: **[Three] [Five] <Insert number>**.
 - 4) BOs: **[Three] [Five] <Insert number>**.
 2. Programmable Application Controllers:
 - a. **[10] [20] <Insert number>** percent of each AI, AO, BI, and BO point connected to controller.
 - b. Minimum Spare I/O Points per Controller:

- 1) AIs: [**Two**] [**Three**] <Insert number>.
 - 2) AOs: [**Two**] [**Three**] <Insert number>.
 - 3) BIs: [**Three**] [**Five**] <Insert number>.
 - 4) BOs: [**Three**] [**Five**] <Insert number>.
3. Application-Specific Controllers:
- a. [**10**] <Insert number> percent of each AI, AO, BI, and BO point connected to controller.
 - b. Minimum Spare I/O Points per Controller:
 - 1) AIs: [**One**] [**Two**] <Insert number>.
 - 2) AOs: [**One**] [**Two**] <Insert number>.
 - 3) BIs: [**One**] [**Two**] <Insert number>.
 - 4) BOs: [**One**] [**Two**] <Insert number>.
- I. Maintenance and Support: Include the following features to facilitate maintenance and support:
1. Mount microprocessor components on circuit cards for ease of removal and replacement.
 2. Means to quickly and easily disconnect controller from network.
 3. Means to quickly and easily access connect to field test equipment.
 4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.
- J. Input and Output Point Interface:
1. Hardwired input and output points shall connect to network, programmable application and application-specific controllers.
 2. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.
 3. Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.
 4. AIs:
 - a. AIs shall include monitoring of low-voltage (zero- to 10-V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
 - b. AIs shall be compatible with, and field configurable to, sensor and transmitters installed.
 - c. Controller AIs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of [**8**] [**12**] <Insert value> bits or better to comply with accuracy requirements indicated.
 - d. Signal conditioning including transient rejection shall be provided 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 zero 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.
 5. AOs:

- a. Controller AOs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of [8] [12] <Insert value> bits or better to comply with accuracy requirements indicated.
 - b. Output signals shall have a range of [4 to 20 mA dc] [or] [zero- to 10-V dc] as required to include proper control of output device.
 - c. Capable of being individually calibrated for zero and span.
 - d. AOs shall not exhibit a drift of greater than 0.4 percent of range per year.
6. BIs:
- a. Controller BIs shall accept contact closures and shall ignore transients of less than 5-ms duration.
 - b. Isolation and protection against an applied steady-state voltage of up to 180-V ac peak.
 - c. BIs shall include a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against effects of contact bounce and noise.
 - d. BIs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.
 - e. Pulse accumulation input points shall comply with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Buffer shall be provided to totalize pulses. Pulse accumulator shall accept rates of at least 20 pulses per second. The totalized value shall be reset to zero on operator's command.
7. BOs:
- a. Controller BOs shall include relay contact closures or triac outputs for momentary and maintained operation of output devices.
 - 1) Relay contact closures shall have a minimum duration of 0.1 second. Relays shall include at least 180 V of isolation. Electromagnetic interference suppression shall be provided on all output lines to limit transients to non-damaging levels. Minimum contact rating shall be 1 A at 24-V ac.
 - 2) Triac outputs shall include at least 180 V of isolation. Minimum contact rating shall be 1 A at 24-V ac.
 - b. BOs shall include for two-state operation or a pulsed low-voltage signal for pulse-width modulation control.
 - c. BOs shall 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,] <Insert applications>. Control algorithms shall operate actuator to one end of its stroke once every [12] [24] <Insert time> hours for verification of operator tracking.

2.24 NETWORK CONTROLLERS

A. General Network Controller Requirements:

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

B. Communication:

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

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation.
2. Local Keypad and Display:
 - a. Equip controller with local keypad and digital display for interrogating and editing data.
 - b. Use of keypad and display shall require security password.

D. Serviceability:

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

2.25 PROGRAMMABLE APPLICATION CONTROLLERS

A. General Programmable Application Controller Requirements:

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

B. Communication:

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

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation.
2. Local Keypad and Display:
 - a. Equip controller with local keypad and digital display for interrogating and editing data.
 - b. Use of keypad and display shall require security password.

D. Serviceability:

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

2.26 APPLICATION-SPECIFIC CONTROLLERS

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

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

- B. Communication: Application-specific controllers shall communicate with other application-specific controller and devices on network, and to programmable application and network controllers.
- C. Operator Interface: Controller shall be equipped with a service communications port for connection to a portable operator's workstation. Connection shall extend to port on space temperature sensor that is connected to controller.
- D. Serviceability:
 - 1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
 - 2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
 - 3. Controller shall use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.27 CONTROLLER SOFTWARE

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

- d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.
2. Exception Schedules:
 - a. Include ability for operator to designate any day of the year as an exception schedule.
 - b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.
3. Holiday Schedules:
 - a. Include capability for operator to define up to 99 special or holiday schedules.
 - b. Schedules may be placed on scheduling calendar and will be repeated each year.
 - c. Operator shall be able to define length of each holiday period.
- D. System Coordination:
 1. Include standard application for proper coordination of equipment.
 2. Application shall include operator with a method of grouping together equipment based on function and location.
 3. Group may then be used for scheduling and other applications.
- E. Binary Alarms:
 1. Each binary point shall be set to alarm based on operator-specified state.
 2. Include capability to automatically and manually disable alarming.
- F. Analog Alarms:
 1. Each analog object shall have both high and low alarm limits.
 2. Alarming shall be able to be automatically and manually disabled.
- G. Alarm Reporting:
 1. Operator shall be able to determine action to be taken in event of an alarm.
 2. Alarms shall be routed to appropriate operator workstations based on time and other conditions.
 3. Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.
- H. Remote Communication:
 1. System shall have ability to dial out in the event of an alarm.
- I. Electric Power Demand Limiting:

1. Demand-limiting program shall 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. Demand-limiting program shall 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. Demand reduction shall be accomplished 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. Demand-limiting parameters, frequency of calculations, time intervals, and other relevant variables shall be based 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: System shall 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 shall calculate a time-varying analog value used to position an output or stage a series of outputs.
 - 3) Controlled variable, set point, and PID gains shall be operator-selectable.
 - e. Adaptive (automatic tuning).
- M. Staggered Start: Application shall prevent all controlled equipment from simultaneously restarting after a power outage. Order which equipment (or groups of equipment) is started, along with the time delay between starts, shall be operator-selectable.
- N. Energy Calculations:
- 1. Include software to allow instantaneous power or flow rates to be accumulated and converted to energy usage data.
 - 2. Include an algorithm that calculates a sliding-window average (rolling average). Algorithm shall be flexible to allow window intervals to be operator specified (such as 15, 30, or 60 minutes).
 - 3. Include an algorithm that calculates a fixed-window average. A digital input signal shall 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. BO points shall be protected from short cycling.
 - 2. Feature shall allow minimum on-time and off-time to be selected.
- P. On and Off Control with Differential:
- 1. Include an algorithm that allows a BO to be cycled based on a controlled variable and set point.
 - 2. Algorithm shall be direct- or reverse-acting and incorporate an adjustable differential.
- Q. Run-Time Totalization:
- 1. Include software to totalize run-times for all BI and BO points.
 - 2. A high run-time alarm shall be assigned, if required, by operator.
- 2.28 ENCLOSURES
- A. General Enclosure Requirements:
- 1. House each controller and associated control accessories in an enclosure. Enclosure shall 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 a 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. Equip doors of enclosures housing controllers and components with analog or digital displays with windows to allow visual observation of displays without opening enclosure door.
5. Individual wall-mounted single-door enclosures shall not exceed **36 inches (900 mm)** wide and **60 inches (1500 mm)** high.
6. Individual wall-mounted double-door enclosures shall not exceed **60 inches (1500 mm)** wide and **36 inches (900 mm)** high.
7. Freestanding enclosures shall not exceed **48 inches (1200 mm)** wide and **72 inches (1800 mm)** high.
8. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.
9. Supply each enclosure with a complete set of as-built schematics, tubing, and wiring diagrams and product literature located in a pocket on inside of door.

B. Internal Arrangement:

1. Internal layout of enclosure shall group and protect electric, and electronic components associated with a 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 20 percent of used terminals.
7. Include spade lugs for stranded cable and wire.
8. Install a maximum of two wires on each side of a terminal.
9. Include enclosure field power supply with a toggle-type switch located at entrance inside enclosure to disconnect power.
10. Include enclosure with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.
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). The nameplates shall have at least **1/4-inch- (6-mm-)** high lettering.
13. Route tubing cable and wire located inside enclosure within a raceway with a 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 25 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. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Enclosure shall be NRTL listed according to UL 50 or UL 50E.
3. Construct enclosure of steel, not less than:
 - a. Enclosure size less than 24 in. (600 mm): 0.053 in. (1.35 mm) or 0.067 in. (1.7 mm) thick.
 - b. Enclosure size 24 in. (600 mm) and larger: 0.067 in. (1.7 mm) or 0.093 in. (2.36 mm) thick.
4. Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Exterior color shall be manufacturer's standard.
 - b. Interior color shall be manufacturer's standard.
5. Hinged door full size of front face of enclosure and supported using:
 - a. Enclosures sizes less than 36 in. (900 mm) tall: Multiple butt hinges.
 - b. Enclosures sizes 36 in. (900 mm) tall and larger: Continuous piano hinges.
6. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Size less than 24 in. (600 mm): Solid steel, 0.053 in. (1.35 mm) thick.
 - b. Size 24 in. (600 mm) and larger: Solid aluminum, 0.10 in. (3 mm) or steel, 0.093 in. (2.36 mm) thick.
7. Internal panel mounting hardware, grounding hardware and sealing washers.
8. Grounding stud on enclosure body.
9. Thermoplastic pocket on inside of door for record Drawings and Product Data.

- E. Wall Mounted NEMA 250, Types 4 and 12:
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. Enclosure shall be NRTL listed according to UL 508A.
 3. Seam and joints are continuously welded and ground smooth.
 4. Where recessed enclosures are indicated, include enclosures with face flange for flush mounting.
 5. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
 6. Single-door enclosure sizes up to **60 inches tall by 36 inches wide** (1500 mm tall by 900 mm wide).
 7. Double-door enclosure sizes up to **36 inches tall by 60 inches wide** (900 mm tall by 1500 mm wide).
 8. Construct enclosure of steel, not less than the following:
 - a. Size Less Than **24 Inches** (600 mm): **0.053 inch** (1.35 mm) or **0.067 inch** (1.7 mm) thick.
 - b. Size **24 Inches** (600 mm) and Larger: **0.067 inch** (1.7 mm) thick.
 9. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Exterior color shall be manufacturer's standard.
 - b. Interior color shall be manufacturer's standard.
 10. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.
 - a. Sizes through **24 Inches** (600 mm) Tall: Two hinges.
 - b. Sizes between **24 Inches** (600 mm) through **48 Inches** (1200 mm) Tall: Three hinges.
 - c. Sizes Larger **48 Inches** (1200 mm) Tall: Four hinges.
 11. Double-door enclosures with overlapping door design to include unobstructed full-width access.
 - a. Single-door enclosures **48 inches** (1200 mm) and taller, and all double-door enclosures, with three-point (top, middle and bottom) latch system.
 12. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Size Less Than **24 Inches** (600 mm): Solid steel, **0.053 inch** (1.35 mm) thick.
 - b. Size **24 Inches** (600 mm) and Larger: Solid aluminum, **0.10 inch** (3 mm) or steel, **0.093 inch** (2.36 mm) thick.
 13. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
 14. Grounding stud on enclosure body.
 15. Thermoplastic pocket on inside of door for record Drawings and Product Data.

F. Wall-Mounted, NEMA 250, Type 4X SS:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Enclosure shall be NRTL listed according to UL 508A.
3. Seam and joints are continuously welded and ground smooth.
4. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
5. Construct enclosure of Type 304 stainless steel, not less than the following:
 - a. Size Less Than **24 Inches (600 mm)**: **0.053 inch (1.35 mm)** thick.
 - b. Size **24 Inches (600 mm)** and Larger: **0.067 inch (1.7 mm)** thick.
6. Outside body and door of enclosure with brushed No. 4 finish.
7. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.
 - a. Sizes through **24 Inches (600 mm)**Tall: Two hinges.
 - b. Sizes between **24 Inches (600 mm)**through **48 Inches (1200 mm)**Tall: Three hinges.
 - c. Sizes Larger **48 Inches (1200 mm)**Tall: Four hinges.
8. Corner-formed door, full size of enclosure face, supported using continuous piano hinge full length of door.
9. Doors fitted with three-point (top, middle, and bottom) latch system with single, heavy-duty, liquid-tight Type 316 stainless-steel handle with integral locking mechanism.
10. Removable internal panel shall be **0.093-inch (2.36-mm)** solid steel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
11. Internal panel mounting studs and hardware, grounding hardware, and sealing washers.
12. Install corrosion-resistant polyester vent drain in a stainless-steel sleeve at the bottom of enclosure.
13. Include enclosure with stainless-steel mounting brackets.

G. Freestanding, NEMA 250, Type 1:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Enclosure shall be NRTL listed according to UL 508A.
3. Seam and joints are continuously welded and ground smooth.
4. Externally formed body flange around perimeter of enclosure face.
5. Single-door enclosure sizes up to **84 inches tall by 36 inches wide (2100 mm tall by 900 mm wide)**.
6. Double-door enclosure sizes up to **84 inches tall by 72 inches wide (2100 mm tall by 900 mm wide)**.
7. Construct enclosure of steel, not less than **0.067 inch (1.7 mm)** thick.
8. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Exterior color shall be manufacturer's standard.
 - b. Interior color shall be manufacturer's standard.

9. Corner-formed flush door, full size of enclosure face, supported using four concealed hinges with easily removable hinge pins.
10. Double-door enclosures with overlapping door design to include unobstructed full-width access.
11. Doors with three-point (top, middle, and bottom) latch system with single heavy-duty handle and integral locking mechanism.
12. Removable back covers.
13. Removable solid steel internal panel, **0.093 inch (2.36 mm)** thick, with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
14. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
15. Grounding stud on enclosure body.
16. Thermoplastic pocket on inside of door for record Drawings and Product Data.
17. Nominal **4-inch- (100-mm-)** tall integral lifting base, not less than **0.123 inch (3.12 mm)** thick, with predrilled holes for attachment to mounting surface.
18. Each top end of enclosure fitted with lifting tabs, not less than **0.172 inch (4.37 mm)** thick.
19. Internal rack-mount shelves and angles as required by application.

H. Freestanding, NEMA 250, Types 4 and 12:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Enclosure shall be NRTL listed according to UL 508A.
3. Seam and joints are continuously welded and ground smooth.
4. Externally formed body flange around perimeter of enclosure face.
5. Type 12 Enclosure Sizes:
 - a. Single-door enclosure sizes up to **90 inches tall by 36 inches wide (2250 mm tall by 900 mm wide)**.
 - b. Double-door enclosure sizes up to **90 inches tall by 72 inches wide (2250 mm tall by 900 mm wide)**.
6. Type 4 Enclosure Sizes:
 - a. Single-door enclosure sizes up to **72 inches tall by 36 inches wide (1800 mm tall by 900 mm wide)**.
7. Construct enclosure of steel, not less than **0.093 inch (2.36 mm)** thick.
8. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 - a. Exterior color shall be manufacturer's standard.
 - b. Interior color shall be manufacturer's standard.
9. Corner-formed door with continuous perimeter oil-resistant gasket supported using continuous piano hinge full length of door.
10. Doors fitted with three-point (top, middle, and bottom) latch system with latching rod rollers and single, heavy-duty oil-tight handle with integral locking mechanism.
11. Removable solid steel internal panel, **0.093 inch (2.36 mm)** thick, with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.

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.
15. Top of enclosure fitted with no fewer than two lifting eyes.
16. Internal rack-mount shelves and angles as required by application.

2.29 RELAYS

A. General-Purpose Relays:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Relays shall be heavy duty and rated for at least 10 A at 250-V ac and 60 Hz.
3. Relays shall be either double pole double throw (DPDT) or three-pole double throw, depending on the control application.
4. Use a plug-in-style relay with an eight-pin octal plug for DPDT relays and an 11-pin octal plug for three-pole double-throw relays.
5. Construct the contacts of either silver cadmium oxide or gold.
6. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
7. Relays shall have LED indication and a manual reset and push-to-test button.
8. Performance:
 - a. Mechanical Life: At least 10 million cycles.
 - b. Electrical Life: At least 100,000 cycles at rated load.
 - c. Pickup Time: 15 ms or less.
 - d. Dropout Time: 10 ms or less.
 - e. Pull-in Voltage: 85 percent of rated voltage.
 - f. Dropout Voltage: 50 percent of nominal rated voltage.
 - g. Power Consumption: 2 VA.
 - h. Ambient Operating Temperatures: **Minus 40 to 115 deg F (Minus 40 to 46 deg C)**.
9. Equip relays with coil transient suppression to limit transients to non-damaging levels.
10. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
11. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

B. Multifunction Time-Delay Relays:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Relays shall be continuous duty and rated for at least 10 A at 240-V ac and 60 Hz.
3. Relays shall be DPDT relay with up to eight programmable functions to provide on/off delay, interval and recycle timing functions.
4. Use a plug-in-style relay with either an 8- or 11-pin octal plug.
5. Construct the contacts of either silver cadmium oxide or gold.
6. Enclose the relay in a dust-tight cover.
7. Include knob and dial scale for setting delay time.
8. 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 at 120-V ac.
 - h. Ambient Operating Temperatures: **Minus 40 to 115 deg F** (Minus 40 to 46 deg C).
9. Equip relays with coil transient suppression to limit transients to non-damaging levels.
 10. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
 11. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

C. Latching Relays:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Relays shall be continuous duty and rated for at least 10 A at 250-V ac and 60 Hz.
3. Relays shall be either DPDT or three-pole double throw, depending on the control application.
4. Use a plug-in-style relay with a multibladed plug.
5. Construct the contacts of either silver cadmium oxide or gold.
6. Enclose the 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.
 - h. Ambient Operating Temperatures: **Minus 40 to 115 deg F** (Minus 40 to 46 deg C).
8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
9. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
10. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

D. Current Sensing Relay:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Monitors ac current.
3. Independent adjustable controls for pickup and dropout current.
4. Energized when supply voltage is present and current is above pickup setting.
5. De-energizes when monitored current is below dropout current.
6. Dropout current is adjustable from 50 to 95 percent of pickup current.

7. Include a current transformer, if required for application.
8. House current sensing relay and current transformer in its own enclosure. Use NEMA 250, Type 12 enclosure for indoors and NEMA 250, Type 4 for outdoors.

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

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Description:
 - a. On-off control and status indication in a single device.
 - b. LED status indication of activated relay and current trigger.
 - c. Closed-Open-Auto override switch located on the load side of the relay.
3. Performance:
 - a. Ambient Temperature: **Minus 30 to 140 deg F (Minus 34 to 60 deg C)**.
 - b. Voltage Rating: Single-phase loads rated for 300-V ac. Three-phase loads rated for 600-V ac.
4. Status Indication:
 - a. Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.
 - b. Current Sensor Range: As required by application.
 - c. Current Set Point: **[Fixed] [Adjustable] [Fixed or adjustable as required by application]**.
 - d. Current Sensor Output:
 - 1) Solid-state, single-pole double-throw contact rated for 30-V ac and dc and for 0.4 A.
 - 2) Solid-state, single-pole double-throw contact rated for 120-V ac and 1.0 A.
 - 3) Analog, zero- to 5- or 10-V dc.
 - 4) Analog, 4 to 20 mA, loop powered.
5. Relay: Single-pole double-throw, continuous-duty coil; rated for 10-million mechanical cycles.
6. Enclosure: NEMA 250, Type 1 enclosure.

2.30 ELECTRICAL POWER DEVICES

A. Transformers:

1. Transformer shall be sized for the total connected load, plus an additional 25 percent of connected load.
2. Transformer shall be at least **[40] [100] <Insert value> VA**.
3. Transformer shall have both primary and secondary fuses.

B. Power-Line Conditioner:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. General Power-Line Conditioner Requirements:
 - a. Design to ensure maximum reliability, serviceability and performance.
 - b. Overall function of the power-line conditioner is to receive raw, polluted electrical power and purify it for use by electronic equipment. The power-line conditioner shall provide isolated, regulated, transient and noise-free sinusoidal power to loads served.
3. Standards: NRTL listed per UL 1012.
4. Performance:
 - a. Single phase, continuous, 100 percent duty rated KVA/KW capacity. Design to supply power for linear or nonlinear, high crest factor, resistive and reactive loads.
 - b. Automatically regulate output voltage to within 2 percent or better with input voltage fluctuations of plus 10 to minus 20 percent of nominal when system is loaded 100 percent. Use Variable Range Regulation to obtain improved line voltage regulation when operating under less than full load conditions.
 - 1) At 75 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 35 percent of nominal.
 - 2) At 50 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 40 percent of nominal.
 - 3) At 25 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 45 percent of nominal.
 - c. With input voltage distortion of up to 40 percent, limit the output voltage sine wave to a maximum harmonic content of 5 percent.
 - d. Automatically regulate output voltage to within 2.5 percent when load (resistive) changes from zero percent to 100 percent to zero percent.
 - e. Output voltage returns to 95 percent of nominal level within two cycles and to 100 percent within three cycles when the output is taken from no load to full resistive load or vice-versa. Recovery from partial resistive load changes is corrected in a shorter period of time.
 - f. K Factor: 30, designed to operate with nonlinear, non-sinusoidal, high crest factor loads without overheating.
 - g. Input power factor within 0.95 approaching unity with load power factor as poor as 0.6.
 - h. Attenuate load-generated odd current harmonics 23 dB at the input.
 - i. Electrically isolate the primary from the secondary. Meet isolation criteria as defined in NFPA 70, Article 250-5D.
 - j. Lighting and Surge Protection: Compares to UL 1449 rating of 330 V when subjected to Category B3 (6000 V/3000 A) combination waveform as established by IEEE C62.41.
 - k. Common-mode noise attenuation of 140 dB.
 - l. Transverse-mode noise attenuation of 120 dB.

- m. With loss of input power for up to 16.6 ms, the output sine wave remains at usable ac voltage levels.
 - n. Reliability of 200,000 hours' MTBF.
 - o. At full load, when measured at 1-m distance, audible noise is not to exceed 54 dB.
 - p. Approximately 92 percent efficient at full load.
5. Transformer Construction:
- a. Ferroresonant, dry type, convection cooled, 600V class. Transformer windings of Class H (220 deg C) insulated copper.
 - b. Use a Class H installation system throughout with operating temperatures not to exceed 150 deg C over a 40-deg C ambient temperature.
 - c. Configure transformer primary for multi-input voltage. Include input terminals for source conductors and ground.
 - d. Manufacture transformer core using M-6 grade, grain-oriented, stress-relieved transformer steel.
 - e. Configure transformer secondary in a 240/120-V split with a 208-V tap or straight 120 V, depending on power output size.
 - f. Electrically isolate the transformer secondary windings from the primary windings. Bond neutral conductor to cabinet enclosure and output neutral terminal.
 - g. Include interface terminals for output power hot, neutral and ground conductors.
 - h. Label leads, wires and terminals to correspond with circuit wiring diagram.
 - i. Vacuum impregnate transformer with epoxy resin.
6. Cabinet Construction:
- a. Design for panel or floor mounting.
 - b. NEMA 250, Type 1, general-purpose, indoor enclosure.
 - c. Manufacture the cabinet from heavy gauge steel complying with UL 50.
 - d. Include a textured baked-on paint finish.
- C. Transient Voltage Suppression and High-Frequency Noise Filter Unit:
- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - 2. The maximum continuous operating voltage shall be at least 125 percent.
 - 3. The operating frequency range shall be 47 to 63 Hz.
 - 4. Protection modes according to NEMA LS-1.
 - 5. The rated single-pulse surge current capacity, for each mode of protection, shall be no less than the following:
 - a. Line to Neutral: 45,000 A.
 - b. Neutral to Ground: 45,000 A.
 - c. Line to Ground: 45,000 A.
 - d. Per Phase: 90,000 A.
 - 6. Clamping voltages shall be in compliance with test and evaluation procedures defined in NEMA LS-1. Maximum clamping voltage shall be as follows:
 - a. Line to Neutral: 360 V.

- b. Line to Ground: 360 V.
 - c. Neutral to Ground: 360 V.
7. Electromagnetic interference and RF interference noise rejection or attenuation values shall comply with test and evaluation procedures defined in NEMA LS-1.
- a. Line to Neutral:
 - 1) 100 kHz: 42 dB.
 - 2) 1 MHz: 25 dB.
 - 3) 10 MHz: 21 dB.
 - 4) 100 MHz: 36 dB.
 - b. Line to Ground:
 - 1) 100 kHz: 16 dB.
 - 2) 1 MHz: 55 dB.
 - 3) 10 MHz: 81 dB.
 - 4) 100 MHz: 80 dB.
8. Unit shall have LED status indicator that extinguishes to indicate a failure.
9. Unit shall be listed by an NRTL as a transient voltage surge suppressor per UL 1449, and as an electromagnetic interference filter per UL 1283.
10. Unit shall not generate any appreciable magnetic field.
11. Unit shall not generate an audible noise.

D. DC Power Supply:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- 2. Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.
- 3. Enclose circuitry in a housing.
- 4. Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.
- 5. Performance:
 - a. Output voltage nominally 25-V dc within 5 percent.
 - b. Output current up to 100 mA.
 - c. Input voltage nominally 120-V ac, 60 Hz.
 - d. Load regulation within 0.5 percent from zero- to 100-mA load.
 - e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
 - f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

2.31 UNINTERRUPTABLE POWER SUPPLY (UPS) UNITS FOR WORKSTATIONS

A. 250 through 1000 VA:

- 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)

2. UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.
 3. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.
 - a. Larger-capacity units shall be provided for systems with larger connected loads.
 - b. UPS shall provide **[five]** <Insert number> minutes of battery power.
 4. Performance:
 - a. Input Voltage: Single phase, 120- or 230-V ac, compatible with field power source.
 - b. Load Power Factor Range (Crest Factor): 0.65 to 1.0.
 - c. Output Voltage: 101- to 132-V ac, while input voltage varies between 89 and 152-V ac.
 - d. On Battery Output Voltage: Sine wave.
 - e. Inverter overload capacity shall be minimum 150 percent for 30 seconds.
 - f. Recharge time shall be a maximum of six hours to 90 percent capacity after full discharge to cutoff.
 - g. Transfer Time: 6 ms.
 - h. Surge Voltage Withstand Capacity: IEEE C62.41, Categories A and B; 6 kV/200 and 500 A; 100-kHz ringwave.
 5. UPS shall be automatic during fault or overload conditions.
 6. Unit with integral line-interactive, power condition topology to eliminate all power contaminants.
 7. Include front panel with power switch and visual indication of power, battery, fault and temperature.
 8. Unit shall include an audible alarm of faults and front panel silence feature.
 9. Unit with four NEMA WD 1, NEMA WD 6 Configuration 5-15R receptacles.
 10. UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure) **[and connect the points to the DDC system]**.
 11. Batteries shall be sealed lead-acid type and be maintenance free. Battery replacement shall be front accessible by user without dropping load.
 12. Include tower models installed in ventilated cabinets to the particular installation location.
- B. 1000 through 3000 VA:
1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 2. UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.
 3. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.
 - a. Larger-capacity units, or multiple units, shall be provided for systems with larger connected loads.
 - b. UPS shall provide **[five]** **[10]** <Insert number> minutes of battery power.

4. Performance:
 - a. Input Voltage: Single phase, 120-V ac, plus 20 to minus 30 percent.
 - b. Power Factor: Minimum 0.97 at full load.
 - c. Output Voltage: Single phase, 120-V ac, within 3 percent, steady state with rated output current of 10.0 A, 30.0-A peak.
 - d. Inverter overload capacity shall be minimum 150 percent for 30 seconds.
 - e. Recharge time shall be a maximum of eight hours to 90 percent capacity.
5. UPS bypass shall be automatic during fault or overload conditions.
6. UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure) [**and connect the points to the DDC system**].
7. Batteries shall be sealed lead-acid type and be maintenance free.
8. Include tower models installed in ventilated cabinets or rack models installed on matching racks, as applicable to the particular installation location and space availability/configuration.

2.32 PIPING AND TUBING

1. Copper Tubing:
 - a. Seamless phosphor deoxidized copper, soft annealed or drawn tempered, with chemical and physical properties according to ASTM B75.
 - b. Performance, dimensions, weight and tolerance according to ASTM B280.
 - c. Diameter, as required by application, not less than nominal **0.25 inch (6 mm)**.
 - d. Wall thickness, as required by the application, but not less than **0.030 inch (0.8 mm)**.
2. Copper Tubing Connectors and Fittings:
 - a. Brass, compression type.
 - 1) [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - b. Brass, solder-joint type.
 - 1) [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
3. Galvanized-Steel Piping:
 - a. Galvanized pipe shall be ASTM A53/A53M, Schedule 40.
 - b. Fittings, galvanized malleable iron, ASME B16.3, Class 150.
4. Polyethylene Tubing:

- a. Fire-resistant black virgin polyethylene according to ASTM D1248, Type 1, Class C and Grade 5.
 - b. Tubing shall comply with stress crack test according to ASTM D1693.
 - c. Diameter, as required by application, of not less than nominal **0.25 inch (6 mm)**.
5. Polyethylene Tubing Connectors and Fittings:
- a. Brass, barbed fittings.
 - 1) [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - b. Brass, compression type.
 - 1) [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Process Tubing:
1. Products in this paragraph are intended for signals to instruments connected to liquid and steam systems.
 2. Copper Tubing:
 - a. Seamless phosphor deoxidized copper, soft annealed or drawn tempered with chemical and physical properties according to ASTM B75.
 - b. Performance, dimensions, weight and tolerance according to ASTM B280.
 - c. Diameter, as required by application, of not less than nominal **0.25 inch (6 mm)**.
 - d. Wall thickness, as required by application, but not less than **0.030 inch (0.8 mm)**.
 3. Copper Tubing Connectors and Fittings:
 - a. Brass, compression type.
 - 1) [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - b. Brass, solder-joint type.
 - 1) [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 4. Stainless-Steel Tubing:
 - a. Seamless Type 316 stainless steel, Grade TP, cold drawn, annealed and pickled, free from scale.
 - b. Chemical and physical properties according to ASTM A269.
 - c. Diameter, as required by application, of not less than nominal **0.25 inch (6 mm)**.
 - d. Wall thickness, as required by application, but not less than **0.035 inch (0.9 mm)**.
 - e. Furnish stainless-steel tubing in **20-foot (6-mm)** straight random lengths.

5. Stainless-Steel Tubing Connectors and Fittings:
 - a. Connectors and fittings shall be stainless steel, with stainless-steel collets, flareless type.
 - 1) [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - b. Connect instruments to tubing with connectors having compression connector on one end and IPS or NPT thread on other end.

2.33 CONTROL WIRE AND CABLE

- A. Wire: Single conductor control wiring above 24 V.
 1. Wire size shall be at least [No. 18] [No. 16] [No. 14] <Insert value> AWG.
 2. Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inch (50- to 65-mm) lay.
 3. Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C according to UL 83.
 4. Conductor colors shall be black (hot), white (neutral), and green (ground).
 5. Furnish wire on spools.
- B. Single Twisted Shielded Instrumentation Cable above 24 V:
 1. Wire size shall be a minimum [No. 18] [No. 20] [No. 22] <Insert value> AWG.
 2. Conductors shall be a twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch (50- to 65-mm) lay.
 3. Conductor insulation shall have a Type THHN/THWN or Type TFN rating.
 4. Shielding shall be 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
 5. Outer jacket insulation shall have a 600-V, 90-deg C rating and shall be Type TC cable.
 6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
 7. Furnish wire on spools.
- C. Single Twisted Shielded Instrumentation Cable 24 V and Less:
 1. Wire size shall be a minimum [No. 18] [No. 20] [No. 22] <Insert value> AWG.
 2. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch (50- to 65-mm) lay.
 3. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
 4. Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
 5. Outer jacket insulation shall have a 300-V, 105-deg C rating and shall be Type PLTC cable.

6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

1. Cable shall be balanced twisted pair.
2. Comply with the following requirements and for balanced twisted pair cable described in [Section 260523 "Control-Voltage Electrical Power Cables."] [Section 271513 "Communications Copper Horizontal Cabling."]
 - a. Cable shall be plenum rated.
 - b. Cable shall have a unique color that is different from other cables used on Project.

2.34 RACEWAYS

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

2.35 OPTICAL FIBER CABLE AND CONNECTORS

- A. Comply with requirements in Section 271323 "Communications Optical Fiber Backbone Cabling" for optical fiber backbone cabling and connectors.
- B. Comply with requirements in Section 271523 "Communications Optical Fiber Horizontal Cabling" for optical fiber horizontal cabling and connectors.

2.36 ACCESSORIES

A. Pressure Electric Switches:

1. Diaphragm-operated snap acting switch.
2. Set point adjustable from 3 to 20 psig (21 to 138 kPa).
3. Differential adjustable from 2 to 6 psig (14 to 41 kPa).
4. Rated for resistance loads at 120-V ac.
5. Body and switch housing shall be metal.

B. Damper Blade Limit Switches:

1. Sense positive open and/or closed position of the damper blades.
2. NEMA 250, Type 13, oil-tight construction.
3. Arrange for the mounting application.

4. Additional waterproof enclosure when required by its environment.
5. Arrange to prevent "over-center" operation.

C. Instrument Enclosures:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Include instrument enclosure for secondary protection to comply with requirements indicated in "Performance Requirements" Article.
3. NRTL listed and labeled to UL 50.
4. Sized to include at least 25 percent spare area on subpanel.
5. Instrument(s) mounted within enclosure on internal subpanel(s).
6. Enclosure face with engraved, laminated phenolic nameplate for each instrument within enclosure.
7. Enclosures housing multiple instruments shall route tubing and wiring within enclosure in a raceway having a continuous removable cover.
8. Enclosures larger than **12 inches (300 mm)** **<Insert dimension>** shall have a hinged full-size face cover.
9. Equip enclosure with lock and common key.

D. Manual Valves:

1. Needle Type:
 - a. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - b. PTFE packing.
 - c. Construct of brass for use with copper and polyethylene tubing and of stainless steel for use with stainless-steel tubing.
 - d. Aluminum T-bar handle.
 - e. Include tubing connections.
2. Ball Type:
 - a. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
 - b. Body: Bronze ASTM B62 or ASTM B61.
 - c. Ball: Type 316 stainless steel.
 - d. Stem: Type 316 stainless steel.
 - e. Seats: Reinforced PTFE.
 - f. Packing Ring: Reinforced PTFE.
 - g. Lever: Stainless steel with a vinyl grip.
 - h. 600 WOG.
 - i. Threaded end connections.

E. Wall-Mounted Portable Workstation Cabinet:

1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
2. Surface-mounted wall cabinet for tilt-out operation of laptop computers and large-format mobile devices.

3. Cabinet shall have a load limit of 50 lb (23 kg).
4. Cabinet shall include the following:
 - a. Oil-filled dampers for controlled lowering of equipment to operational position.
 - b. 3RU EIA mounting rails.
 - c. Removable laptop shelf.
 - d. Separate top compartment with mounting area, hinged rail and security lock.
 - e. Front ventilation slots.
 - f. Knockouts for conduit connections on top and bottom of cabinet.
5. Cabinet shall be constructed of steel and painted with a powder-coat epoxy.
6. Inside center of backbox shall have provision to mount a field-furnished and -installed, single gang electrical outlet box.

2.37 IDENTIFICATION

A. Instrument Air Pipe and Tubing:

1. Engraved tag shall bear the following information:
 - a. Service (Example): "Instrument Air."
 - b. Pressure Range (Example): 0 to 30 psig (0 to 200 kPa).
2. Letter size shall be a minimum of 0.25 inch (6 mm) high.
3. Tag shall consist of white lettering on blue background.
4. Tag shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded blue with contrasting white center exposed by engraving through outer layer.
5. Include tag with a brass grommet, chain and S-hook.

B. Control Equipment, Instruments, and Control Devices:

1. 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 shall be as follows:
 - a. Operator Workstations: Minimum of 0.5 inch (13 mm) high.
 - b. Servers: Minimum of 0.5 inch (13 mm) high.
 - c. Printers: Minimum of 0.5 inch (13 mm) high.
 - d. DDC Controllers: Minimum of 0.5 inch (13 mm) high.
 - e. Gateways: Minimum of 0.5 inch (13 mm) high.
 - f. Repeaters: Minimum of 0.5 inch (13 mm) high.
 - g. Enclosures: Minimum of 0.5 inch (13 mm) high.
 - h. Electrical Power Devices: Minimum of 0.25 inch (6 mm) high.
 - i. UPS units: Minimum of 0.5 inch (13 mm) high.

- j. Accessories: Minimum of **0.25 inch (6 mm)** high.
 - k. Instruments: Minimum of **0.25 inch (6 mm)** high.
 - l. Control Damper and Valve Actuators: Minimum of **0.25 inch (6 mm)** high.
3. Legend shall consist of white lettering on black background.
 4. Laminated acrylic or melamine plastic sign shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded black with contrasting white center exposed by engraving through outer layer and shall be fastened with drive pins.
 5. Instruments, control devices and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require additional identification.
- C. Valve Tags:
1. Brass tags and brass chains attached to valve.
 2. Tags shall be at least **1.5 inches (38 mm)** 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 the tape banding for conduits. After painting, label cover plate "HVAC Controls," using an engraved phenolic tag.
 3. For raceways housing air signal tubing, add a 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 shall be at least 14-point type with white lettering on red background.
 3. Warning label shall read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
 4. Lettering shall be enclosed in a white line border. Edge of label shall extend at least **0.25 inch (6 mm)** beyond white border.

2.38 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate the following according to industry standards for each product, and to verify DDC system reliability specified in performance requirements:
 - 1. DDC controllers.
 - 2. Gateways.
 - 3. Routers.
 - 4. Operator workstations.
- 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 products to verify actual locations of connections before installation.
 - 1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
 - 2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

- A. Communication Interface to Equipment with Integral Controls:
 - 1. DDC system shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.
 - 2. Equipment to Be Connected:

- a. Domestic water booster pumps specified in Section 221123.13 "Domestic-Water Packaged Booster Pumps."
- b. Air-terminal units specified in Section 233600 "Air Terminal Units."
- c. Kitchen hoods specified in Section 233813 "Commercial-Kitchen Hoods."
- d. Boilers specified in Section 235213 "Electric Boilers."
- e. Boilers specified in Section 235216 "Condensing Boilers."
- f. Boilers specified in Section 235223 "Cast-Iron Boilers."
- g. Boilers specified in Section 235233 "Water-Tube Boilers."
- h. Boilers specified in Section 235239 "Fire-Tube Boilers."
- i. Feedwater equipment specified in Section 235313 "Boiler Feedwater Pumps."
- j. Deaerators specified in Section 235316 "Deaerators."
- k. Chillers specified in Section 236413.13 "Direct-Fired Absorption Water Chillers."
- l. Chillers specified in Section 236413.16 "Indirect-Fired Absorption Water Chillers."
- m. Chillers specified in Section 236416 "Centrifugal Water Chillers."
- n. Chillers specified in Section 236423.13 "Air-Cooled, Scroll Water Chillers."
- o. Chillers specified in Section 236423.16 "Water-Cooled, Scroll Water Chillers."
- p. Chillers specified in Section 236426.13 "Air-Cooled, Rotary-Screw Water Chillers."
- q. Chillers specified in Section 236426.16 "Water-Cooled, Rotary-Screw Water Chillers."
- r. Cooling towers specified in Section 236513.13 "Open-Circuit, Forced-Draft Cooling Towers."
- s. Cooling towers specified in Section 236513.16 "Closed-Circuit, Forced-Draft Cooling Towers."
- t. Cooling towers specified in Section 236514.13 "Open-Circuit, Induced-Draft, Counterflow Cooling Towers."
- u. Cooling towers specified in Section 236514.14 "Open-Circuit, Induced-Draft, Crossflow Cooling Towers."
- v. Cooling towers specified in Section 236514.16 "Closed-Circuit, Induced-Draft, Counterflow Cooling Towers."
- w. Cooling towers specified in Section 236514.17 "Closed-Circuit, Induced-Draft, Combined-Flow Cooling Towers."
- x. Heat wheels and heat exchangers specified in Section 237223 "Air-to-Air Energy Recovery Equipment."
- y. Air-handling units specified in Section 237313 "Modular Indoor Central-Station Air-Handling Units."
- z. Roof-top units specified in Section 237413 "Packaged, Outdoor, Central-Station Air-Handling Units."
- aa. Dedicated outdoor-air units specified in Section 237433 "Dedicated Outdoor-Air Units."
- bb. Packaged terminal air-conditioners specified in Section 238113.11 "Packaged Terminal Air-Conditioners, Through-Wall Units."
- cc. Packaged terminal air-conditioners specified in Section 238113.12 "Packaged Terminal Air-Conditioners, Freestanding Units."
- dd. Packaged terminal air-conditioners specified in Section 238113.13 "Packaged Terminal Air-Conditioners, Outdoor, Wall-Mounted Units."

- ee. Computer-room air-conditioning units specified in Section 238123.11 "Small-Capacity (6 Tons (21 kW) and Smaller), Computer-Room Air-Conditioners, Floor Mounted Units."
- ff. Computer-room air-conditioning units specified in Section 238123.12 "Large-Capacity (7 Tons (25 kW) and Larger), Computer-Room Air-Conditioners, Floor Mounted Units."
- gg. Computer-room air-conditioning units specified in Section 238123.13 "Computer-Room Air Conditioners, Ceiling-Mounted Units."
- hh. Computer-room air-conditioning units specified in Section 238123.14 "Computer-Room Air Conditioners, Console Units."
- ii. Computer-room, rack-mounted cooling equipment specified in Section 238123.18 "Computer-Room, Rack-Cooling Equipment."
- jj. Fan-coil units specified in Section 238219 "Fan Coil Units."
- kk. Unit ventilators specified in Section 238223 "Unit Ventilators."
- ll. Wetted-element humidifiers specified in Section 238413.16 "Wetted-Element Humidifiers."
- mm. Atomizing humidifiers specified in Section 238413.19 "Atomizing Humidifiers."
- nn. Direct-steam-injection humidifiers specified in Section 238413.23 "Direct-Steam-Injection Humidifiers."
- oo. Self-contained steam humidifiers specified in Section 238413.29 "Self-Contained Steam Humidifiers."
- pp. Heat exchanger humidifiers specified in Section 238413.36 "Heat Exchanger Humidifiers."
- qq. Dehumidification units specified in Section 238416 "Mechanical Dehumidification Units."
- rr. Switchboards specified in Section 262300 "Low-Voltage Switchgear."
- ss. Motor-control centers specified in Section 262419 "Motor-Control Centers."
- tt. Variable-frequency controllers specified in Section 262923 "Variable-Frequency Motor Controllers."
- uu. Diesel emergency engine generators specified in Section 263213.13 "Diesel Emergency Engine Generators."
- vv. Diesel engine generators specified in Section 263213.14 "Diesel Engine Generators."
- ww. Gaseous emergency engine generators specified in Section 263213.16 "Gaseous Emergency Engine Generators."
- xx. Gaseous engine generators specified in Section 263213.17 "Gaseous Engine Generators."
- yy. Bi-fuel emergency engine generators specified in Section 263213.19 "Bi-Fuel Emergency Engine Generators."
- zz. Bi-fuel engine generators specified in Section 263213.20 "Bi-Fuel Engine Generators."
- aaa. UPS specified in Section 263353 "Static Uninterruptible Power Supply."
- bbb. Refrigerant monitoring.

B. Communication Interface to Other Building Systems:

1. DDC system shall have a communication interface with systems having a communication interface.
2. Systems to Be Connected:

- a. Elevators specified in Section 142100 "Electric Traction Elevators."
- b. Elevators specified in Section 142113 "Electric Traction Freight Elevators."
- c. Elevators specified in Section 142400 "Hydraulic Elevators."
- d. Elevators specified in Section 142413 "Hydraulic Freight Elevators."
- e. Escalators specified in Section 143100 "Escalators."
- f. Automated water treatment systems specified in Section 232500 "HVAC Water Treatment."
- g. Automated water treatment systems specified in Section 232516 "Water Treatment for Open-Loop Hydronic Systems."
- h. Automated water treatment systems specified in Section 232519 "Water Treatment for Steam System Feedwater."
- i. Power monitoring specified in Section 260913 "Electrical Power Monitoring and Control."
- j. Lighting controls specified in Section 260926 "Lighting Control Panelboards."
- k. Lighting controls specified in Section 260943.16 "Addressable-Luminaire Lighting Controls."
- l. Lighting controls specified in Section 260943.23 "Relay-Based Lighting Controls."
- m. Fire-alarm system specified in Section 284621.11 "Addressable Fire-Alarm Systems."
- n. Fire-alarm system specified in Section 284621.13 "Conventional Fire-Alarm Systems."
- o. Access controls specified in Section 281300 "Access Control System Software and Database Management."
- p. Intrusion detection specified in Section 283100 "Intrusion Detection."
- q. Perimeter security specified in Section 283121 "Area and Perimeter Intrusion Detection."

3.3 DDC SYSTEM INTERFACE WITH EXISTING SYSTEMS

A. Interface with Existing Systems:

1. DDC systems shall interface existing systems to achieve integration.
2. Monitoring and Control of DDC System by Existing Control System:
 - a. DDC system performance requirements shall be satisfied when monitoring and controlling DDC system by existing control system.
 - b. Operator of existing system shall be able to upload, download, monitor, trend, control and program every input and output point in DDC system from existing control system using existing control system software and operator workstations.
 - c. Remote monitoring and control from existing control system shall not require operators of existing control system to learn new software.
 - d. Interface of DDC system into existing control system shall be transparent to operators of existing control system and allow operators to program, monitor, and control DDC system from any operator workstation connected to existing control system.
3. Integration of Existing Control System into DDC System:

- a. Existing control system performance requirements shall be satisfied when monitoring and controlling existing control system through DDC system.
 - b. Operator shall be able to upload, download, monitor, alarm, report, trend, control and program every input and output point in existing system from DDC system using operator workstations and software provided. The combined systems shall share one database.
 - c. Interface of existing control system I/O points into DDC system shall be transparent to operators. All operational capabilities shall be identical regardless of whether I/O already exists or I/O is being installed.
- B. Integration with Existing Enterprise System:
1. DDC system shall interface with an existing enterprise system to adhere to Owner standards already in-place and to achieve integration.
 2. Owner's control system integrator will provide the following services:
 - a. Enterprise system expansion and development of graphics, logs, reports, trends and other operational capabilities of enterprise system for I/O being added to DDC control system for use by enterprise system operators.
 - b. Limited assistance during commissioning to extent of DDC system integration with existing enterprise system.
 - c. Prepare on-site demonstration mockup of integration of DDC system to be installed with existing system before installing DDC system.
 3. Engage Owner's control system integrator to provide the following services:
 - a. Enterprise system expansion and development of graphics, logs, reports, trends and other operational capabilities of enterprise system for I/O being added to DDC control system for use by enterprise system operators.
 - b. Limited assistance during commissioning to extent of DDC system integration with existing enterprise system.
 - c. Prepare on-site demonstration mockup of integration of DDC system to be installed with existing system before installing DDC system.
 4. Control System Integrator Contact Information:
 - a. Company: **<Insert name>**.
 - b. Company Street Address: **<Insert address>**.
 - c. Company Contact: **<Insert name>**.
 - d. Phone Number: **<Insert phone number>**.
 - e. E-mail Address: **<Insert e-mail address>**.
 5. Attend meetings with control system integrator to integrate DDC system.

3.4 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

- A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.
- B. Deliver the following to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.
 - 1. DDC control dampers, which are specified in Section 230923.12 "DDC Control Dampers."
 - 2. Airflow sensors and switches, which are specified in Section 230923.14 "Flow Instruments."
 - 3. Pressure sensors, which are specified in Section 230923.23 "Pressure Instruments."
- C. Deliver the following to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.
 - 1. DDC control valves, which are specified in Section 230923.11 "Control Valves."
 - 2. Pipe-mounted flow meters, which are specified in Section 230923.14 "Flow Instruments."
 - 3. Pipe-mounted sensors, switches and transmitters. Flow meters are specified in Section 230923.14 "Flow Instruments." Liquid temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
 - 4. Tank-mounted sensors, switches and transmitters. Pressure sensors, switches, and transmitters are specified in Section 230923.23 "Pressure Instruments." Liquid temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
 - 5. Pipe- and tank-mounted thermowells. Liquid thermowells are specified in Section 230923.27 "Temperature Instruments."

3.5 CONTROL DEVICES FOR EQUIPMENT MANUFACTURER FACTORY INSTALLATION

- A. Deliver the following to air-handling unit manufacturer for factory installation. Include installation instructions to air-handling unit manufacturer and supervise installation for compliance with requirements.
 - 1. Programmable application or application-specific controller.
 - 2. Unit-mounted DDC control dampers and actuators, which are specified in Section 230923.12 "Control Dampers."
 - 3. Unit-mounted airflow sensors, switches and transmitters, which are specified in Section 230923.14 "Flow Instruments."
 - 4. Unit-mounted gas sensors and transmitters, which are specified in Section 230923.16 "Gas Instruments."
 - 5. Unit-mounted leak-detection switches, which are specified in Section 230923.18 "Leak-Detection Instruments."
 - 6. Unit-mounted speed sensors, switches and transmitters, which are specified in Section 230923.24 "DDC Speed Instruments."

7. Unit-mounted pressure sensors, switches and transmitters, which are specified in Section 230923.23 "Pressure Instruments."
 8. Unit-mounted temperature sensors, switches and transmitters. Air-temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
 9. Relays.
- B. Deliver the following to terminal unit manufacturer for factory installation. Include installation instructions to terminal unit manufacturer.
1. Programmable application or application-specific controller.
 2. Electric damper actuator. Dampers actuators are specified in Section 230923.12 "Control Dampers."
 3. Unit-mounted flow and pressure sensors, transmitters and transducers. Flow sensors, transmitters, and transducers are specified in Section 230923.14 "Flow Instruments." Pressure sensors, switches, and transmitters are specified in Section 230923.23 "Pressure Instruments."
 4. Unit-mounted temperature sensors. Air-temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
 5. Relays.
- C. Deliver the following to fan-coil unit manufacturer for factory installation. Include installation instructions to fan-coil unit manufacturer.
1. Programmable application or application-specific controller.
 2. Unit-mounted temperature sensors. Air-temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
 3. Flow and pressure switches. Air and liquid flow sensors, transmitters, and transducers are specified in Section 230923.14 "Flow Instruments." Pressure sensors, switches, and transmitters are specified in Section 230923.23 "Pressure Instruments."
 4. Leak-detection switches, which are specified in Section 230923.18 "Leak-Detection Instruments."
 5. Relays.
- 3.6 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 when subjected to a force.
 - D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.
 - E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

- F. Firestop Penetrations Made in Fire-Rated Assemblies: Comply with requirements in Section 078413 "Penetration Firestopping."
- G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 079200 "Joint Sealants."
- H. Welding Requirements:
 - 1. Restrict welding and burning to supports and bracing.
 - 2. No equipment shall be 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, shall be by inert-gas electric arc process and shall be performed by qualified welders according to applicable welding codes.
 - 4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.
- I. Fastening Hardware:
 - 1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 - 3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.
- J. 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.
- K. 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 "Raceways and Boxes for Electrical Systems."
 - 3. Where instruments are located in a corrosive airstream and are not corrosive resistant from manufacturer, field install products in NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.7 WORKSTATION INSTALLATION

- A. Desktop Workstations Installation:

1. Install workstation(s) at location(s) directed by Owner.
2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single duplex electrical power receptacle.
3. Install software on workstation(s) and verify software functions properly.
4. Develop Project-specific graphics, trends, reports, logs and historical database.
5. Power each workstation through a dedicated UPS unit. Locate UPS adjacent to workstation.

B. Portable Workstations Installation:

1. Turn over portable workstations to Owner at Substantial Completion.
2. Install software on workstation(s) and verify software functions properly.

C. Color Graphics Application:

1. Use system schematics indicated 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. Final editing shall be done 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 hard copy for inclusion in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

D. Wall-Mounted Portable Operator's Workstation Cabinet Installation:

1. Install wall-mounted portable operator's workstation cabinet(s) at location(s) indicated on Drawings.
2. Install wall-mounted portable operator's workstation cabinet(s) at following location(s) and at locations directed by Owner:
 - a. Each mechanical room.
 - b. Chiller room.
 - c. Boiler room.
3. Connect each cabinet to [120-V, single-phase, 60Hz] <Insert power requirements> field power source, and install single gang electrical box with [NEMA WD 6, Type 20R duplex] <Insert receptacle type> receptacle and metal cover plate in cabinet. Comply with requirements in Section 262726 "Wiring Devices."
4. Connect each cabinet to Ethernet network and install an Ethernet network port for connection to portable operator workstation Ethernet cable. Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."

3.8 POT INSTALLATION

- A. Install **[one]** **[two]** **<Insert quantity>** portable operator terminal(s).
- B. Turn over POTs to Owner at Substantial Completion.
- C. Install software on each POT and verify that software functions properly.

3.9 SERVER INSTALLATION

- A. Install **[one]** **[two]** **<Insert quantity>** server(s) at location(s) directed by Owner.
- B. Install number of servers required to suit requirements indicated. Review Project requirements and indicate layout of proposed 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 **[dedicated]** UPS unit. Locate UPS adjacent to server.

3.10 PRINTER INSTALLATION

- A. Provide the following printer(s) at location(s) directed by Owner:
 - 1. Black and White Laser: Quantity, **[one]** **[one per desktop workstation]** **<Insert quantity>**.
 - 2. Color Laser: Quantity, **[one]** **[one per desktop workstation]** **<Insert quantity>**.
 - 3. Color Inkjet: Quantity, **[one]** **[one per desktop workstation]** **<Insert quantity>**.
 - 4. Dot Matrix: Quantity, **[one]** **[one per desktop workstation]** **<Insert quantity>**.
- B. Install printer software on workstations and verify that software functions properly.

3.11 GATEWAY INSTALLATION

- A. Install gateways if required for DDC system communication interface requirements indicated.
 - 1. Install gateway(s) required to suit indicated requirements.
 - a. **<Insert requirements>**.
- B. Test gateway to verify that communication interface functions properly.

3.12 ROUTER INSTALLATION

- A. Install routers if required for DDC system communication interface requirements indicated.

1. Install router(s) required to suit indicated requirements.

a. <Insert requirements>.

B. Test router to verify that communication interface functions properly.

3.13 CONTROLLER INSTALLATION

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 controller with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation of Network Controllers:

1. Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Top of controller shall be within [72 inches (1800 mm)] [84 inches (2100 mm)] <Insert dimension> of finished floor.

F. Installation of Programmable Application Controllers:

1. Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Top of controller shall be within [72 inches (1800 mm)] [84 inches (2100 mm)] <Insert dimension> of finished floor.

G. Application-Specific Controllers:

1. Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.14 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 (1500 mm) 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 WPA2 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 portable workstation and other wireless devices intended for use by operators.

3.15 ENCLOSURES INSTALLATION

- A. Install the following items in enclosures, to comply with indicated requirements:
 - 1. Gateways.
 - 2. Routers.
 - 3. Controllers.
 - 4. Electrical power devices.
 - 5. UPS units.
 - 6. Relays.
 - 7. Accessories.
 - 8. Instruments.
 - 9. Actuators
- B. Attach wall-mounted enclosures to wall using the following types of steel struts:
 - 1. For NEMA 250, [**Type 1**] <Insert type> Enclosures: Use [**painted steel**] [**galvanized-steel**] [**corrosion-resistant-coated steel**] strut and hardware.
 - 2. For NEMA 250, [**Type 4**] [**Type 4X**] <Insert type> 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-**] [**or**] [**stainless-**] steel anchors.
- E. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireway used for application shall have protection equal to NEMA 250 rating of connected enclosures.

3.16 ELECTRIC POWER CONNECTIONS

- A. Connect electrical power to DDC system products requiring electrical power connections.

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

3.17 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification products and installation.
- B. Install laminated acrylic or melamine plastic signs with unique identification on face for each of the following:
 - 1. Operator workstation.
 - 2. Server.
 - 3. Printer.
 - 4. Gateway.
 - 5. Router.
 - 6. Protocol analyzer.
 - 7. DDC controller.
 - 8. Enclosure.
 - 9. Electrical power device.
 - 10. UPS unit.
 - 11. Accessory.
- C. Install unique instrument identification on face of each instrument connected to a DDC controller.
- D. Install unique identification on face of each control damper and valve actuator connected to a 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. Shall be permanently attached to equipment that can be automatically started by DDC control system.
2. Shall be located in highly visible location near power service entry points.

3.18 NETWORK INSTALLATION

- A. Install optical fiber cable when connecting between the following network devices and when located in different buildings on campus, or when distance between devices exceeds **<Insert distance>**:
 1. Operator workstations.
 2. Operator workstations and network controllers.
 3. Network controllers.
- B. Install balanced twisted pair or optical fiber cable when connecting between the following network devices:
 1. Operator workstations.
 2. Operator workstations and network controllers.
 3. Network controllers.
- C. 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.
- D. Install cable in continuous raceway.
 1. Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit.

3.19 NETWORK NAMING AND NUMBERING

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

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

3.20 PIPING AND TUBING INSTALLATION

A. Identify piping and tubing as follows:

1. Every 50 feet (15 m) of straight run.
2. At least once for each branch within 36 inches (900 mm) of main tee.
3. At each change in direction.
4. Within 36 inches (900 mm) 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 shall have same unique number at instrument connection and termination at opposite end of tube.

B. Isolation Valves Installation:

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. Valves shall be located to be readily accessible from floor.

C. Process Tubing Installation:

1. Install process tubing for signal to instruments in liquid and steam systems. Instruments include, but are not limited to, the following:
 - a. Meters.
 - b. Sensors.
 - c. Switches.
 - d. Transmitters.
2. Support tubing according to MSS SP-69, Table 3, but at intervals no less than 60 inches (1500 mm).
3. Install NPS 1/2 (DN 15) process tubing for industrial-grade sensors, transmitters, and switches. Install stainless-steel bushings where required.
4. Make tubing bends with a bending tool. Flattened or wrinkled bends are unacceptable.
5. Support tubing independent of other trades.
6. Route tubing parallel to and at right angles to building construction.
7. Install tubing concealed in areas with ceilings.
8. Install a dirt leg with an isolation valve and threaded plug in drain valve at each connection to a transmitter and switch.

9. Insulate process piping connected to hot water and steam systems for personnel protection if the surface temperature exceeds **120 deg F (49 deg C)**. Only insulate piping within maintenance personnel reach from floor, platform, or catwalk.
10. Wrap pipe threads of fitting in process tubing with service temperatures below **350 deg F (177 deg C)** with a single wrap of PTFE tape.
11. Coat pipe threads of fittings on process tubing in services with temperatures exceeding **350 deg F (177 deg C)** with pipe compound before being made up to reduce the possibility of galling.
12. Do not make tubing connections to a fitting before completing makeup of the connection.
13. Check tubing for correct diameter and wall thickness. Cut the tube ends square and deburred. Exercise care during cutting to keep tubing round.
14. Do not install fittings close to a bend. A length of straight tubing, not deformed by bending, is required for a proper connection.
15. Align tubing with fitting when installed. Avoid springing tube into position.
16. Install tubing with extreme care exercised to keep foreign matter out of system. Open tubing ends shall be kept plugged to keep out dust, dirt and moisture.
17. Do not attach tubing to equipment that may be removed frequently for maintenance or may impart vibration and expansion from temperature change.
18. Protect exposed tubing in mechanical equipment rooms from inadvertent mechanical damage within **76 inches (1800 mm)** above floor. Use aluminum channel reversed and secured over tubing to protect tubing from damage.

D. 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, gages, and other control devices.
3. Locate valves to be readily accessible from floor.

3.21 CONTROL WIRE, CABLE AND RACEWAYS INSTALLATION

A. Comply with NECA 1.

B. Wire and Cable Installation:

1. Comply with installation requirements in Section 260523 "Control-Voltage Electrical Power Cables."
2. Comply with installation requirements in Section 271313 "Communications Copper Backbone Cabling."
3. Comply with installation requirements in Section 271513 "Communications Copper Horizontal Cabling."
4. 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.
5. Terminate wiring in a junction box.
 - a. Clamp cable over jacket in junction box.
 - b. Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.
6. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
7. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.
8. Use shielded cable to transmitters.
9. Use shielded cable to temperature sensors.
10. Perform continuity and meager testing on wire and cable after installation.

C. Conduit Installation:

1. Comply with Section "260533 "Raceways and Boxes for Electrical Systems" for control-voltage conductors.
2. Comply with Section 270528 "Pathways for Communications Systems" for balanced twisted pair cabling and optical fiber installation.

3.22 OPTICAL FIBER CABLE SYSTEM INSTALLATION

- A. Comply with installation requirements in Section 271323 "Communications Optical Fiber Backbone Cabling."
- B. Comply with installation requirements in Section 271523 "Communications Optical Fiber Horizontal Cabling."

3.23 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 Acceptance Testing Specification. Certify compliance with test parameters.
 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Testing:

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

3.24 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. Control Damper Checkout:
 1. Verify that control dampers are installed correctly for flow direction.
 2. Verify that proper blade alignment, either parallel or opposed, has been provided.
 3. Verify that damper frame attachment is properly secured and sealed.
 4. Verify that damper actuator and linkage attachment is secure.
 5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
 6. Verify that damper blade travel is unobstructed.
- F. Control Valve Checkout:
 1. Verify that control valves are installed correctly for flow direction.
 2. Verify that valve body attachment is properly secured and sealed.
 3. Verify that valve actuator and linkage attachment is secure.

4. Verify that actuator wiring is complete, enclosed and connected to correct power source.
5. Verify that valve ball, disc or plug travel is unobstructed.
6. 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.

G. Instrument Checkout:

1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.
4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8. For temperature instruments:
 - a. Verify sensing element type and proper material.
 - b. Verify length and insertion.

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

- A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
- B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
- C. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
- D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.
- E. Provide diagnostic and test equipment for calibration and adjustment.
- F. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
- G. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
- H. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

- I. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.
- J. Analog Signals:
 - 1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
 - 2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
 - 3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.
- K. Digital Signals:
 - 1. Check digital signals using a jumper wire.
 - 2. Check digital signals using an ohmmeter to test for contact making or breaking.
- L. Control Dampers:
 - 1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
 - 2. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.
 - 3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
 - 4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.
- M. 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 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 a 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.
- N. Meters: Check sensors at zero, 50, and 100 percent of Project design values.
- O. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.
- P. Switches: Calibrate switches to make or break contact at set points indicated.
- Q. 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.

3.26 DDC SYSTEM CONTROLLER CHECKOUT

- A. Verify power supply.
 1. Verify voltage, phase and hertz.
 2. Verify that protection from power surges is installed and functioning.
 3. Verify that ground fault protection is installed.
 4. If applicable, verify if connected to UPS unit.
 5. If applicable, verify if connected to a backup power source.
 6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.
- B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.
- C. Verify that spare I/O capacity is provided.

3.27 DDC CONTROLLER I/O CONTROL LOOP TESTS

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

10. Prepare and submit a report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desired results.

3.28 DDC SYSTEM VALIDATION TESTS

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

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

F. Validation Test:

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

G. DDC System Response Time Test:

1. Simulate HLC.

- a. Heavy load shall be an occurrence of 50 percent of total connected binary COV, one-half of which represent an "alarm" condition, and 50 percent of total connected analog COV, one-half of which represent an "alarm" condition, that are initiated simultaneously on a one-time basis.
2. Initiate 10 successive occurrences of HLC and measure response time to typical alarms and status changes.
3. Measure with a timer having at least 0.1-second resolution and 0.01 percent accuracy.
4. Purpose of test is to demonstrate DDC system, as follows:
 - a. Reaction to COV and alarm conditions during HLC.
 - b. Ability to update DDC system database during HLC.
5. Passing test is contingent on the following:
 - a. Alarm reporting at printer beginning no more than two seconds after the initiation (time zero) of HLC.
 - b. All alarms, both binary and analog, are reported and printed; none are lost.
 - c. Compliance with response times specified.
6. Prepare and submit a report documenting HLC tested and results of test including time stamp and print out of all alarms.

H. DDC System Network Bandwidth Test:

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

3.29 DDC SYSTEM WIRELESS NETWORK VERIFICATION

- A. DDC system Installer shall design wireless DDC system networks to comply with performance requirements indicated.
- B. Installer shall verify wireless network performance through field testing and shall document results in a field test report.
- C. Testing and verification of all wireless devices shall include, but not be limited to, the following:
 1. Speed.
 2. Online status.
 3. Signal strength.

3.30 FINAL REVIEW

- A. Submit written request to Architect and Construction Manager when DDC system is ready for final review. Written request shall state the following:
 1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
 2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
 3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
 4. DDC system is complete and ready for final review.
- B. Review by Architect and Construction Manager shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.
- C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.
- D. Should more than two reviews be required, DDC system manufacturer and Installer shall compensate entity performing review for total costs, labor and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review.
- E. Prepare and submit closeout submittals when no deficiencies are reported.
- F. A part of DDC system final review shall include a demonstration to parties participating in final review.
 1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
 2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
 3. Demonstration shall include, but not be limited to, the following:
 - a. Accuracy and calibration of 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 shall be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.
 - c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.

- d. Operation of randomly selected dampers and valves in normal-on, normal-off and failed positions.
- e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.
- f. Trends, summaries, logs and reports set-up for Project.
- g. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.
- h. Software's ability to communicate with controllers, operator workstations, uploading and downloading of control programs.
- i. Software's ability to edit control programs off-line.
- 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 is not lost during power failure.
 - 2) Operator Interface: Ability to connect directly to each type of digital controller with a portable workstation and mobile device. Show that maintenance personnel interface tools perform as indicated in manufacturer's technical literature.
 - 3) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.
 - 4) Electric Power: Ability to disconnect any controller safely from its power source.
 - 5) Wiring Labels: Match control drawings.
 - 6) Network Communication: Ability to locate a controller's location on network and communication architecture matches Shop Drawings.
 - 7) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators and devices.
- 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 an operator using workstation graphics, or by completing a field in a 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.

3.31 EXTENDED OPERATION TEST

- A. Extended operation test is intended to simulate normal operation of DDC system by Owner.
- B. Operate DDC system for an operating period of 14 consecutive calendar days following Substantial Completion. Coordinate exact start date of testing with Owner.

- C. Provide an operator familiar with DDC system installed to man an operator workstation while on-site during eight hours of each normal business day occurring during operating period.
- D. During operating period, DDC system shall demonstrate correct operation and accuracy of monitored and controlled points as well as operation capabilities of sequences, logs, trends, reports, specialized control algorithms, diagnostics, and other software indicated.
 - 1. Correct defects of hardware and software when it occurs.
- E. Definition of Failures and Downtime during Operating Period:
 - 1. Failed I/O point constituting downtime is an I/O point failing to perform its intended function consistently and a point physically failed due to hardware and software.
 - 2. Downtime is when any I/O point in DDC system is unable to fulfill its' required function.
 - 3. Downtime shall be calculated as elapsed time between a detected point failure as confirmed by an operator and time point is restored to service.
 - 4. Maximum time interval allowed between DDC system detection of failure occurrence and operator confirmation shall be 0.5 hours.
 - 5. Downtime shall be logged in hours to nearest 0.1 hour.
 - 6. Power outages shall not count as downtime, but shall suspend test hours unless systems are provided with UPS and served through a backup power source.
 - 7. Hardware or software failures caused by power outages shall count as downtime.
- F. During operating period, log downtime and operational problems are encountered.
 - 1. Identify source of problem.
 - 2. Provide written description of corrective action taken.
 - 3. Record duration of downtime.
 - 4. Maintain log showing the following:
 - a. Time of occurrence.
 - b. Description of each occurrence and pertinent written comments for reviewer to understand scope and extent of occurrence.
 - c. Downtime for each failed I/O point.
 - d. Running total of downtime and total time of I/O point after each problem has been restored.
 - 5. Log shall be available to Owner for review at any time.
- G. For DDC system to pass extended operation test, total downtime shall not exceed 1 percent of total point-hours during operating period.
 - 1. Failure to comply with minimum requirements of passing at end of operating period indicated shall require that operating period be extended one consecutive day at a time until DDC system passes requirement.
- H. Evaluation of DDC system passing test shall be based on the following calculation:

1. Downtime shall be counted on a point-hour basis where total number of DDC system point-hours is equal to total number of I/O points in DDC system multiplied by total number of hours during operating period.
2. One point-hour of downtime is one I/O point down for one hour. Three points down for five hours is a total of 15 point-hours of downtime. Four points down for one-half hour is 2 point-hours of downtime.
3. Example Calculation: Maximum allowable downtime for 30-day test when DDC system has 1000 total I/O points (combined analog and binary) and has passing score of 1 percent downtime is computed by 30 days x 24 h/day x 1000 points x 1 percent equals 7200 point-hours of maximum allowable downtime.

- I. Prepare test and inspection reports.

3.32 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.

3.33 MAINTENANCE SERVICE

- A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by DDC system manufacturer's authorized service representative. Include monthly preventive maintenance, repair or replacement of worn or defective components, cleaning, calibration and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.34 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, service agreement shall include 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. Upgrading software shall include operating system and new or revised licenses for using software.
 1. Upgrade Notice: At least 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

3.35 DEMONSTRATION

- A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.

B. Extent of Training:

1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
3. Minimum Training Requirements:
 - a. Provide not less than five days of training total.
 - b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.
 - c. Total days of training shall be broken into not more than two separate training classes.
 - d. Each training class shall be not less than one consecutive day(s).

C. Training Schedule:

1. Schedule training with Owner 20 business days before expected Substantial Completion.
2. Schedule training to provide Owner with at least 15 business days of notice in advance of training.
3. Training shall occur within normal business hours at a mutually agreed on time. Unless otherwise agreed to, training shall occur Monday through Friday, except on U.S. Federal holidays, with two morning sessions and two afternoon sessions. Each morning session and afternoon session shall be split in half with 30-minute break between sessions. Morning and afternoon sessions shall be separated by 60-minute lunch period. Training, including breaks and excluding lunch period, shall not exceed eight hours per day.
4. Provide staggered training schedule as requested by Owner.

D. Training Attendee List and Sign-in Sheet:

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

E. Training Attendee Headcount:

1. Plan in advance of training for two attendees.
2. Make allowance for Owner to add up to one 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 and technical school education and degree.
 2. Intermediate user knowledge of computers and office applications.
 3. Intermediate knowledge of HVAC systems.
 4. Intermediate knowledge of DDC systems.
 5. Intermediate knowledge of DDC system and products installed.
- G. Attendee Training Manuals:
1. Provide each attendee with a color hard copy of all training materials and visual presentations.
 2. Hard-copy materials shall be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
 3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of all hard-copy materials.
- H. Instructor Requirements:
1. One or multiple qualified instructors, as required, to provide training.
 2. Instructors shall have not less than five years of providing instructional training on not less than five past projects with similar DDC system scope and complexity to DDC system installed.
- I. Organization of Training Sessions:
1. Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate the following three levels of operators:
 - a. Daily operators.
 - b. Advanced operators.
 - c. System managers and administrators.
 2. Plan and organize training sessions to group training content to protect DDC system security. Some attendees may be restricted to some training sessions that cover restricted content for purposes of maintaining DDC system security.
- J. Training Outline:
1. Submit training outline for Owner review at least 10 business day before scheduling training.

2. Outline shall include a detailed agenda for each training day that is broken down into each of four training sessions that day, training objectives for each training session and synopses for each lesson planned.

K. On-Site Training:

1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power and data connectivity for instructor and each attendee.
2. Instructor shall provide training materials, projector and other audiovisual equipment used in training.
3. Provide as much of training located on-site as deemed feasible and practical by Owner.
4. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration and service requirements.
5. Operator workstation provided with DDC system shall be used in training. If operator workstation is not indicated, provide a temporary workstation to convey training content.

L. 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 a workstation for use by each attendee.

M. Training Content for Daily Operators:

1. Basic operation of system.
2. Understanding DDC system architecture and configuration.
3. Understanding each unique product type installed including performance and service requirements for each.
4. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm and each unique optimization routine.
5. Operating operator workstations, printers and other peripherals.
6. Logging on and off system.
7. Accessing graphics, reports and alarms.
8. Adjusting and changing set points and time schedules.
9. Recognizing DDC system malfunctions.
10. Understanding content of operation and maintenance manuals including control drawings.
11. Understanding physical location and placement of DDC controllers and I/O hardware.
12. Accessing data from DDC controllers.
13. 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, -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:

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 off-line.
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:

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

END OF SECTION 230923

SECTION 231123 - FACILITY NATURAL-GAS 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. Pipes, tubes, and fittings.
 - 2. Piping specialties.
 - 3. Piping and tubing joining materials.
 - 4. Pressure regulators.
 - 5. Dielectric fittings.

1.3 DEFINITIONS

- A. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Piping specialties.
 - 2. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
 - 3. Pressure regulators. Indicate pressure ratings and capacities.
 - 4. Dielectric fittings.

1.5 INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For pressure regulators to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Steel Support 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.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.
- B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

1.9 PROJECT CONDITIONS

- A. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:
 - 1. Notify Contract Representative no fewer than two days in advance of proposed interruption of natural-gas service.
 - 2. Do not proceed with interruption of natural-gas service without Contract Representative's written permission.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Minimum Operating-Pressure Ratings:
 - 1. Piping and Valves: 100 psig minimum unless otherwise indicated.
 - 2. Service Regulators: 65 psig minimum unless otherwise indicated.
- B. Natural-Gas System Pressure within Buildings: More than 0.5 psig but not more than 2 psig.

2.2 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A234/A234M for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - a. Material Group: 1.1.
 - b. End Connections: Threaded or butt welding to match pipe.
 - c. Lapped Face: Not permitted underground.
 - d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
 - e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.

2.3 PIPING SPECIALTIES

- A. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.4 JOINING MATERIALS

- A. Joint Compound and Tape: Suitable for natural gas.
- B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.5 MANUAL GAS SHUTOFF VALVES

- A. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
 1. CWP Rating: 125 psig.
 2. Threaded Ends: Comply with ASME B1.20.1.
 3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
 4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.

5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
 6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.
- B. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.
1. CWP Rating: 125 psig.
 2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
 3. Service Mark: Initials "WOG" shall be permanently marked on valve body.
- C. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Apollo Flow Controls; Conbraco Industries, Inc.
 2. Body: Bronze, complying with ASTM B584.
 3. Ball: Chrome-plated bronze.
 4. Stem: Bronze; blowout proof.
 5. Seats: Reinforced TFE; blowout proof.
 6. Packing: Threaded-body packnut design with adjustable-stem packing.
 7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 8. CWP Rating: 600 psig.
 9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- D. Two-Piece, Regular-Port Bronze Ball Valves with Bronze Trim: MSS SP-110.
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Apollo Flow Controls; Conbraco Industries, Inc.
 2. Body: Bronze, complying with ASTM B584.

3. Ball: Chrome-plated bronze.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE.
6. Packing: Threaded-body packnut design with adjustable-stem packing.
7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
8. CWP Rating: 600 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.6 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Appliance Pressure Regulators: Comply with ANSI Z21.18.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Maxitrol Company.
2. Body and Diaphragm Case: Die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.

8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
9. Maximum Inlet Pressure: 1 psig.

2.7 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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Capitol Manufacturing Company.
 - c. Matco-Norca.
 - d. WATTS.
 2. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric Flanges:
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Capitol Manufacturing Company.
 - b. Matco-Norca.
 2. Description:
 - a. Standard: ASSE 1079.
 - b. Factory-fabricated, bolted, companion-flange assembly.
 - c. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
 - d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Close equipment shutoff valves before turning off natural gas to premises or piping section.
- B. Inspect natural-gas piping according to NFPA 54 to determine that natural-gas utilization devices are turned off in piping section affected.
- C. Comply with NFPA 54 requirements for prevention of accidental ignition.

3.3 INDOOR PIPING INSTALLATION

- A. Comply with NFPA 54 for installation and purging of natural-gas piping.
- B. 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.
- C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. 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.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Locate valves for easy access.
- H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.
- I. Install piping free of sags and bends.
- J. Install fittings for changes in direction and branch connections.
- K. Verify final equipment locations for roughing-in.

- L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
- M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
 - 1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
- P. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- Q. Connect branch piping from top or side of horizontal piping.
- R. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
- S. Do not use natural-gas piping as grounding electrode.
- T. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
- U. Install pressure gage downstream from each line regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

3.4 VALVE INSTALLATION

- A. Install manual gas shutoff valve for each gas appliance ahead of equipment connector.
- B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

3.5 PIPING JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. 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:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

F. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

G. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.6 HANGER AND SUPPORT INSTALLATION

A. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

C. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.

3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.

3.7 CONNECTIONS

- A. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.
- B. Install piping adjacent to appliances to allow service and maintenance of appliances.
- C. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
- D. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.8 LABELING AND IDENTIFYING

- A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.

3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 1. Test, inspect, and purge natural gas according to NFPA 54 and authorities having jurisdiction.
- C. Natural-gas piping will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 231123

SECTION 232113 – HYDRONIC PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Pipe and Pipe Fittings For:
 - 1. Heating water piping system.
 - 2. Equipment drains and overflows.
- B. Valves:
 - 1. Ball valves.
 - 2. Butterfly valves.
 - 3. Check valves.

1.2 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Access Doors.

1.3 RELATED SECTIONS

- A. Division 23 Section “Hangers and Supports for HVAC Piping and Equipment.”
- B. Division 23 Section “Identification for HVAC Piping and Equipment.”
- C. Division 23 Section “HVAC Piping Insulation.”
- D. Division 23 Section “Hydronic Specialties.”
- E. Division 23 Section “HVAC Water Treatment”: Pipe cleaning.

1.4 REFERENCES

- A. ASME - Boiler and Pressure Vessel Codes, SEC 9 - Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.
- B. ASME B16.3 - Malleable Iron Threaded Fittings Class 50 and 300.
- C. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
- D. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
- E. ASME B31.9 - Building Services Piping.

- F. ASME B36.10M - Welded and Seamless Wrought Steel Pipe.
 - G. ASTM A53 - Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless.
 - H. ASTM A234 - Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.
 - I. ASTM A240 - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
 - J. ASTM A312 - Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
 - K. ASTM A403 - Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
 - L. ASTM B32 - Solder Metal.
 - M. ASTM B88 - Seamless Copper Water Tube.
 - N. AWS D1.1 - Structural Welding Code.
 - O. AWWA C110 - Ductile - Iron and Grey -Iron Fittings 3 in. through 48 in. (75 mm through 1200 mm), for Water and Other Liquids.
 - P. AWWA C111 - Rubber-Gasket Joints for Ductile Iron and Grey-Iron Pressure Pipe and Fittings.
 - Q. AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids.
 - R. MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices.
- 1.5 SUBMITTALS
- A. Submit under provisions of Division 01 Section “Submittal Procedures.”
 - B. Product Data: Include data on pipe materials, pipe fittings, valves, and accessories. Provide Manufacturers catalogue information. Indicate valve data and ratings.
 - C. Welders Certificate: Include welder’s certification of compliance with ASME SEC 9 and AWS D1.1.
 - D. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
- 1.6 PROJECT RECORD DOCUMENTS
- A. Submit under provisions of Division 01 Section “Closeout Procedures.”
 - B. Record actual locations of valves.

1.7 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Division 01 Section “Operation and Maintenance Data.”
- B. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.8 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum 3 years’ experience.
- B. Installer: Company specializing in performing the work of this Section with minimum 3 years’ experience.
- C. Welders: Certify in accordance with ASME SEC 9 and AWS D1.1.
- D. Pressed Pipe Fittings: Submit documentation of fitting-manufacturer training of installers or their on-site supervisors, with names of individuals.

1.9 REGULATORY REQUIREMENTS

- A. Conform to ASME B31.9 code for installation of piping system.
- B. Welding Materials and Procedures: Conform to ASME SEC 9 and applicable state labor regulations.
- C. Provide certificate of compliance from authority having jurisdiction indicating approval of welders.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Division 01 Section “Product Requirements.”
- B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- C. Provide temporary protective coating on cast iron and steel valves.
- D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 - PRODUCTS

2.1 HEATING WATER PIPING, ABOVE GROUND

- A. Steel Pipe: ASTM A53, Schedule 40 for sizes less than 12 inch, 0.375 inch wall for sizes 12 inch and over, black.
 - 1. Fittings: ASTM B16.3, malleable iron or ASTM A234, forged steel welding type fittings.
 - 2. Joints: Schedule 40 threaded for pipe sizes 2 inch and smaller, and AWS D1.1, welded for pipe sizes over 2 inch.
 - 3. Grooved and Shouldered Pipe End Couplings: As specified in this Section, with grooved steel pipe, is an acceptable alternate to the above for water service operating at temperatures from -30 to 230 degrees F, utilizing grade E, EPDM gasket compound.
- B. Copper Tubing: ASTM B88, Type L hard drawn.
 - 1. Allowed only for pipe sizes 2 inch and smaller.
 - 2. Fittings: ASME B16.18, cast brass, or ASME B16.22, solder wrought copper.
 - 3. Joints: Solder fittings.

2.2 EQUIPMENT DRAINS AND OVERFLOWS

- A. Steel Pipe: ASTM A53, Schedule 40 galvanized.
 - 1. Fittings: Galvanized cast iron, or ASTM B16.3 malleable iron.
 - 2. Joints: Threaded, or grooved mechanical couplings.
- B. Copper Tubing: ASTM B88, Type L, hard drawn.
 - 1. Fittings: ASME B16.18, cast brass, or ASME B16.22 solder wrought copper.
 - 2. Joints: Solder fittings.

2.3 SOLDER MATERIALS:

- A. Manufacturers:
 - 1. Harris (Product: Stay-Brite).
 - 2. Lucas-Milhaupt (Product: Silvabrite).
 - 3. No substitutions.
- B. Nominal Composition: Alloy of silver and tin (3-6 percent Ag, remainder Sn). Antimony-free.

C. Physical Properties:

1. Color: Bright Silver
2. Solidus: 430 degrees F
3. Liquidus: 430 degrees F
4. Electrical Conductivity: 16.4 percent IACS
5. Shear Strength: 10,600 psi
6. Tensile Strength: 14,000 psi
7. Elongation: 48 percent

D. Specification Compliance:

1. NSF 51
2. ASTM B32-89, Alloy Grade Sn96
3. Federal Spec. QQ-S-571E, Class Sn 96 with exception to QPL paragraph 3.1
4. J-STD-006, Sn96Ag04A

E. Flux:

1. Harris (Product: Stay Clean Paste Flux, Stay Clean Liquid Flux (used with 4 inch or larger copper tubing also stainless steels), or Bridgit Water Soluble Paste Flux).
2. Canfield (Product: Aqua-Brite or AB Cream Flux). Glycerin-based, water soluble.

2.4 UNIONS, FLANGES, AND COUPLINGS

A. Unions for Pipe 2 inch and Under:

1. Ferrous Piping: 150 psig malleable iron, threaded.
2. Copper Pipe: Bronze, soldered joints.

B. Flanges for Pipe Over 2 Inch:

1. Ferrous Piping: 150 psig forged steel, slip-on.
2. Copper Piping: Bronze.
3. Gaskets: 1/16 inch thick preformed neoprene or EPDM, reinforced as required for the system operating pressure, up to relief valve setting.

- C. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

2.5 PIPE HANGERS AND SUPPORTS

- A. See Division 23 Section “Hangers and Supports for HVAC Piping and Equipment.”

2.6 VALVES

- A. Manufacturers:

1. Nibco.
2. Apollo.
3. Center Line – butterfly valves.
4. Crane.
5. Hammond.
6. Jenkins.
7. Milwaukee.
8. Watts.

- B. Ball Valves:

1. Up To and Including 2 inch:
 - a. Bronze two piece body, chrome plated brass ball, teflon seats and stuffing box ring, lever handle, solder or threaded ends.
 - b. 150 lb S.W.P., 600 lb W.O.G.
2. Over 2 Inch:
 - a. Cast steel body, chrome plated steel ball, teflon seat and stuffing box seals, lever handle, flanged.
 - b. 150 lb S.W.P., 285 lb W.O.G.
3. Stem Extensions: Provide ball valves in insulated piping with stem extensions to allow for continuous thickness of field-installed insulation.

- C. Butterfly Valves:

1. Body: Cast or ductile iron with resilient replaceable EPDM seat, wafer or lug ends, extended neck.
2. Disc: Aluminum bronze or chrome plated ductile iron.
3. Operator: 10 position lever handle for shut-off service, infinite position lever handle with memory stop for throttling service, handwheel and gear drive for sizes 8" (203 mm) and larger.

4. Pressure rating shall be 150 psi at 225 degrees F.

D. Swing Check Valves:

1. Up To and Including 2 inch: Bronze body, bronze trim, bronze rotating swing disc, with composition disc, solder or threaded ends.
2. Over 2 inch: Iron body, bronze trim, bronze or bronze faced rotating swing disc, renewable disc and seat, flanged ends.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Ream pipe and tube ends. Remove burrs.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.
- D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.
- E. After completion, fill, clean, and treat systems. Refer to Division 23 Section "HVAC Water Treatment."

3.2 INSTALLATION

- A. Install in accordance with Manufacturer's instructions.
- B. Install components furnished under other Section and Divisions of the Specifications. Such items may include but are not limited to: Sensors furnished under Division 23 Section "Instrumentation and Control for Mechanical Systems."
- C. Pipe used shall be new material, and threads on piping shall be full length and clean cut with inside edges reamed smooth to full inside bore.
- D. Minimum pipe size allowed for hydronic piping shall be 3/4 inch. Piping less than 3/4 inch shall not be allowed for these piping systems.
- E. Route piping in orderly manner, parallel to building structure, and maintain gradient.
- F. Install piping to conserve building space, and not interfere with use of space.
- G. Group piping whenever practical at common elevations.
- H. Erect piping to provide for the easy passage and noiseless circulation of water under working conditions.
- I. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top

of pipe level. Slope water piping 1 inch in 40 feet and arrange to drain at low points. Slope piping up in direction of water flow.

- J. On closed systems, equip low points with 3/4 inch drain valves and hose nipples. Provide, at high points of mains, collecting chambers and high capacity float operated automatic air vents, with ball valves on their inlets to valve off after initial system startup. Provide, at high points of branches, manual air vents with air chambers.
- K. Use main sized saddle type branch connections for directly connecting branch lines to mains in steel piping if main is at least 1 pipe size larger than the branch for up to 6 inch mains and if main is at least 2 pipe sizes larger than branch for 8 inch and larger mains. Do not project branch pipes inside the main pipe.
- L. Caulking of threads will not be allowed on any piping.
- M. Pipe joint compound shall be put on male threads only.
- N. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
- O. Dissimilar Metals: Use non-conducting dielectric connections whenever jointing dissimilar metals. Cast red-brass (not yellow brass) or bronze-bodied fittings such as valves and couplings may be used when joining steel to copper, steel to stainless steel, or copper to stainless steel. Steel and stainless steel may connect directly to iron, but copper may not connect directly to iron.
- P. Where welded joints are required, steel piping shall be installed by the use of the oxyacetylene or electric welding process, except immediate connections to accessible equipment may be threaded. Piping shall have butt welds with welding fittings, standard factory fabricated tees, elbows, reducers, caps, and accessories. Branch outlets 2 inch (50.8 mm) and smaller shall be made by the use of approved welding type half-couplings, "Weldolet" or "Threadolet" fittings.
 - 1. Piping smaller than 2 inch may be installed at the Contractor's option with welding type, or threaded type fittings, except that piping regardless of size concealed in trenches or inaccessible building construction (for example, concealed behind sheetrock walls or concealed above sheetrock ceilings) shall be welded.
 - 2. Offsets shall be installed with long radius welding elbows.
 - 3. Welding shall be executed only by certified welding mechanics in accordance with the best practice of the trade.
- Q. In the erection of mains, use special care in the support, working into place without springing or forcing, and proper allowance made for expansion.
- R. Pipes shall be anchored, guided, and otherwise supported, where necessary, to prevent vibration or to control expansion.

- S. Make such offsets as are shown and required to place the pipes and risers in proper position to avoid other work.
- T. Take branch lines off bottom of mains or at 45 degree bottom angle, as space permits.
- U. Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.
- V. Install a sufficient number of unions or flanged fittings to facilitate making possible future alterations or repairs.
- W. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.

3.3 VALVES

A. Valve Type Selection:

1. Use Butterfly Valves or Ball Valves with lever handles at boiler supply and return connections to provide easy viewing of valve position in accordance with applicable State boiler rules and regulations.
2. Use ball or butterfly valves for shut-off and to isolate equipment, part of systems, or vertical risers.
3. Use Bronze Ball Valves for general shut-off service in heating system piping 3 inch and smaller.
4. Use Bronze Ball Valves for drain valves with hose connections. Provide valve of size indicated; if size isn't indicated, provide at least 3/4 inch valve size. Provide outlet fitting for standard "garden hose" with 3/4 inch hose threads. Provide brass cap with retainer chain. Compression-type "boiler drain valves" are not allowed.
5. Use Check Valves at pump discharges.

B. With the exception of valves which must be properly sized to ensure design flow rates (such as balancing valves), valves shall be line sized.

C. Install valves with stems upright or horizontal, not inverted.

3.4 CLEANING

- A. After satisfactory completion of pressure tests, before permanently connecting equipment, strainers, and the like, clean equipment thoroughly, blow and flush piping for a sufficient length of time as directed, so that interiors will be free of foreign matter. Perform cleaning in the presence of an authorized representative of the Engineer. Provide a minimum of 10 days notification to the Engineer prior to system cleaning.

- B. Fill, vent and circulate the system with approved solution in accordance with equipment (boiler, piping, coils, and others) manufacturer's recommendation, allowing it to reach design or operating temperatures. After circulating for 6 hours, drain the system completely and remove and clean strainer screens. Perform cleaning in the presence of an authorized representative of the Engineer. Provide a minimum of 10 days notification to the Engineer prior to system cleaning.
- C. Fill and vent system as required.
- D. Manually vent heat transfer units and high points of the system.
- E. Adjust the pressure reducing valve to provide minimum of 5 psig pressure at the highest point of the system.
- F. After system has been completely filled, start zone pumps and circulate cold water for a short time to dislodge small air bubbles, and return them to air extraction device.
- G. Raise water temperature to 200 degrees F (93 degrees C) while operating pumps.
- H. Stop pump and vent radiation and high points of the system. Normal operation may now be started at any time.

3.5 TESTING

- A. No joint or section of piping shall be left untested.
- B. Before testing piping systems, remove, or otherwise protect from damage, control devices, air vents, and other parts which are not designed to stand test pressures.
- C. Test piping for leaks under 100 psig air pressure with soap suds prior to hydrostatic testing.
- D. Test piping hydrostatically to 1-1/2 times the maximum systems operating pressure, but in no case to less than 75 psig, for at least 4 consecutive hours, during which time pressure shall remain constant without pumping.
- E. Test and obtain Engineer's approval before painting, covering, or concealing piping, including swing joints.

END OF SECTION 232113

SECTION 232118 – HYDRONIC SPECIALTIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Air vents.
- B. Strainers.
- C. Balancing Valves

1.2 RELATED SECTIONS

- A. Division 23 Section “Meters and Gauges for HVAC Piping”: Test Ports.
- B. Division 23 Section “Hydronic Piping.”
- C. Division 23 Section “HVAC Water Treatment”: Pipe cleaning.

1.3 REFERENCES

- A. ASME - Boilers and Pressure Vessel Codes, SEC 8-D-Rules for Construction of Pressure Vessels.
- B. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

1.4 SUBMITTALS

- A. Submit under provisions of Division 01 Section “Submittal Procedures.”
- B. Product Data: Provide product data for manufactured products and assemblies required for this project. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description, model and dimensions.
- C. Submit inspection certificates for pressure vessels from authority having jurisdiction.
- D. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.

1.5 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Division 01 Section “Closeout Procedures.”

1.6 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Division 01 Section “Operation and Maintenance Data.”
- B. Maintenance Data: Include installation instructions, assembly views, lubrication instructions,

and replacement parts list.

1.7 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this Section with minimum 3 years' experience.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Division 01 Section "Product Requirements."
- B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- C. Provide temporary protective coating on cast iron and steel valves.
- D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.9 MAINTENANCE SERVICE

- A. Furnish service and maintenance of glycol system for 1 year from date of substantial completion.
- B. Monthly visit to make glycol fluid concentration analysis on site with refractive index measurement instrument. Detail findings with maintenance personnel in writing of corrective actions needed including analysis and amounts of glycol or water added.

PART 2 - PRODUCTS

2.1 AIR VENTS

- A. Manual Type: Short vertical sections of 2 inch (50 mm) diameter pipe to form air chamber, with 1/8 inch (3 mm) brass needle valve at top of chamber.
- B. Float Type:
 - 1. Manufacturers:
 - a. Bell & Gossett.
 - b. Caleffi.
 - c. Taco.
 - d. Thrush.
 - e. Wheatley.
 - 2. Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless

steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.

C. Washer Type:

1. Manufacturers:

- a. Bell & Gossett.
- b. Caleffi.
- c. Taco.

2. Brass with hydrosopic fiber discs, vent ports, adjustable cap for manual shut-off, and integral spring loaded ball check valve.

2.2 STRAINERS

A. Manufacturers:

1. Sarco.
2. Armstrong.
3. Bell & Gossett.
4. Flo-Fab.
5. Wheatley.

- B. Size 2 inch and Under: Screwed brass or iron body for 175 psig working pressure, Y pattern with 1/32 inch stainless steel perforated screen.

- C. Size 2-1/2 inch to 4 inch: Flanged iron body for 175 psig working pressure, Y pattern with 3/64 inch stainless steel perforated screen.

- D. Size 5 inch and Larger: Flanged iron body for 175 psig working pressure, basket pattern with 1/8 inch stainless steel perforated screen.

2.3 BALANCING VALVES AND COMBINATION BALANCING/SHUT-OFF VALVES.

A. Manufacturers:

1. Bell & Gossett.
2. Armstrong.
3. Griswold Controls.
4. Nexus Valve.
5. Taco.
6. Watts.
7. Wheatley.

B. Valves shall conform to one of the following:

1. Fixed-Orifice Manual Balancing Valve: Calibrated, ball type balance valve with precision machined orifice, readout valves equipped with integral check valves and

gasketed caps, calibrated nameplate and indicating pointer with memory stop. Readout valves measure the pressure differential across the fixed orifice plate or venturi. Valve shall be designed for positive shut-off.

2. Variable-Orifice Manual Balancing Valve: Cast iron or bronze, globe style, balance valve with handwheel with vernier type ring setting and memory stop, readout valves equipped with integral check valves and gasketed caps. Readout valves measure the pressure differential across the variable opening between valve plug and valve seat. Valve shall be designed for positive shut-off. Drain valve, if furnished with this valve, may be positioned properly to substitute for the separate drain valve indicated.
- C. Cast iron, wafer type, orifice insert flow meter for 250 psig working pressure, with read-out valves equipped with integral check valves with gasketed caps.
- D. Size balancing valves to allow a reading of 2 to 5 ft wg pressure drop at design flow rates. Submittals shall include a chart of valve selections, indicating room number, terminal heating device tag, flow rate, pressure drop, and differential pressure reading.
- E. Insulation: Valves may be furnished with prefabricated thermal insulation. Flame spread reading shall be 25 or less per ASTM E84. R-value shall be 4 hr-sq.ft- F/Btu or greater. Install in accordance with Division 23 Section "HVAC Piping Insulation."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install specialties in accordance with manufacturer's instructions.
- B. Where large air quantities can accumulate, provide enlarged air collection standpipes.
- C. Provide manual air vents at system high points and as indicated.
- D. Provide valved drain and hose connection on strainer blow down connection.
- E. Provide separate check, balancing, and shutoff valves (or relocated existing combination pump discharge valve if so indicated) on discharge side of centrifugal pumps.
- F. Support pump fittings with floor mounted pipe and flange supports.
- G. Ensure that balancing valves are installed with minimum upstream length of straight pipe as recommended by the manufacturer.
- H. Ensure that balancing valves are installed with the readout valves fully accessible, including space required for insertion of metering probes.
- I. Relief Valves: Provide on boilers. Pipe relief valve outlet to nearest floor drain or as indicated.

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APRIL 22, 2020

END OF SECTION 232118

SECTION 232300 – REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Piping.
- B. Refrigerant.
- C. Moisture and Liquid Indicators.
- D. Valves.
- E. Strainers.
- F. Check Valves.
- G. Pressure Relief Valves.
- H. Filter-Driers.
- I. Solenoid Valves.
- J. Expansion Valves.
- K. Receivers.
- L. Flexible Connections.

1.2 RELATED SECTIONS

- A. Division 08 Section “Access Doors and Frames.”
- B. Division 09 Section “Painting.”
- C. Division 23 Section “Hangers and Supports for HVAC Piping and Equipment.”
- D. Division 23 Section “HVAC Piping Insulation.”
- E. Division 23 Section “Split System Air Conditioners.”
- F. Division 23 Section “Instrumentation and Controls for Mechanical Systems.”
- G. Division 26 “Electrical.”

1.3 REFERENCES

- A. ARI 495 - Refrigerant Liquid Receivers.

- B. ARI 710 - Liquid Line Dryers.
- C. ARI 730 - Flow-Capacity Rating and Application of Suction-Line Filters and Filter-Driers
- D. ARI 750 - Thermostatic Refrigerant Expansion Valves.
- E. ARI 760 - Solenoid Valves for Use With Volatile Refrigerants.
- F. ASHRAE 15 - Safety Code for Mechanical Refrigeration.
- G. ASHRAE 34 - Number Designation of Refrigerants.
- H. ASME - Boiler and Pressure Vessel Codes, SEC 9 - Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.
- I. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
- J. ASME B16.26 - Cast Copper Alloy Fittings For Flared Copper Tubes.
- K. ASME B31.5 - Refrigeration Piping.
- L. ASME B31.9 - Building Services Piping.
- M. ASME SEC 8D - Boilers and Pressure Vessels Code, Rules for Construction of Pressure Vessels.
- N. ASTM A53 - Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
- O. ASTM A234 - Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.
- P. ASTM B88 - Seamless Copper Water Tube.
- Q. ASTM B280 - Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
- R. ASTM F405 - Standard Specification for Corrugated Polyethylene (PE) Pipe and Fittings.
- S. ASTM F667 - Standard Specification for 3 through 24 in. Corrugated Polyethylene Pipe and Fittings.
- T. AWS A5.8 - Brazing Filler Metal.
- U. AWS D1.1 - Structural Welding Code, Steel.
- V. UL 429 - Electrically Operated Valves.

1.4 SYSTEM DESCRIPTION

- A. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide

necessary joining fittings. Ensure flanges, unions, and couplings for servicing are consistently provided.

B. Liquid Indicators:

1. Use line size liquid indicators in main liquid line leaving condenser.
2. If receiver is provided, install in liquid line leaving receiver.
3. Use line size on leaving side of liquid solenoid valves.

C. Valves:

1. Use service valves on suction and discharge of compressors.
2. Use gauge taps at compressor inlet and outlet.
3. Use gauge taps at hot gas bypass regulators and at filters and filter driers, inlet and outlet.
4. Use check valves on compressor discharge.
5. Use check valves on condenser liquid lines on multiple condenser systems.

D. Refrigerant Charging (Packed Angle) Valve: Use in liquid line between receiver shut-off valve and expansion valve.

E. Strainers:

1. Use line size strainer upstream of each automatic valve.
2. Where multiple expansion valves with integral strainers are used, use single main liquid line strainer.
3. On steel piping systems, use strainer in suction line.
4. Use shut-off valve on each side of strainer.

F. Pressure Relief Valves: Use on ASME receivers and on compressors converted to higher pressure refrigerant. Pipe field-installed valves and valves furnished with equipment to outdoors as required by ASHRAE Standard 15 and where directed.

G. Permanent Filter-Driers:

1. Use in low temperature systems.
2. Use in systems utilizing hermetic compressors.
3. Use filter-driers for each solenoid valve.

H. Replaceable Cartridge Filter-Driers:

1. Use vertically in liquid line adjacent to receivers.
2. Use with filter elements in suction line. Provide temporary wax removal filter-drier core in low temperature systems and systems where motor failure has occurred.
3. Use filter-driers for each solenoid valve.

I. Solenoid Valves:

1. Use in liquid line of systems operating with single pump-out or pump-down compressor control.
2. Use in liquid line of single or multiple evaporator systems.
3. Use in oil bleeder lines from flooded evaporators to stop flow of oil and refrigerant into the suction line when system shuts down.

J. Receivers:

1. Use on systems 5 tons (18 kW) and larger, sized to accommodate pump down charge.

2. Use on systems with long piping runs.

K. Flexible Connectors: Utilize at or near compressors where piping configuration does not absorb vibration.

1.5 SUBMITTALS

A. Submit under provisions of Division 01 Section "Submittal Procedures."

B. Shop Drawings: Indicate schematic layout of system, including equipment, critical dimensions, and sizes.

C. Product Data: Provide general assembly of specialties, including manufacturer's catalog information. Provide manufacturer's catalog data including load capacity.

D. Pipe Sizing Recommendations of Equipment Manufacturers:

1. Verify indicated pipe sizes with the manufacturers of the associated equipment. If manufacturer's recommendations differ from the sizes indicated on the Drawings, submit recommendations to the Architect. The Architect will make the final determination of pipe sizes. Provide sizes per final determination at no additional cost to the Owner. In sizing piping, include modifications as required to affected items including but not limited to piping, valves, filters, other pipeline accessories, insulation, supports, sleeves, conduits, building openings, and building enclosures.
2. Submission of manufacturer's recommendations, and equipment performance related to pipe sizing, is the Contractor's responsibility.
3. Verify sizing prior to any preparation for piping installation.

E. Design Data: Submit design data indicating pipe sizing. Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.

F. Test Reports: Indicate results of leak test, acid test.

G. Manufacturer's Installation Instructions: Indicate support, connection requirements, and isolation for servicing.

H. Submit welders' certifications of compliance with AWS D1.1., and their assigned identification letters, numbers or symbols.

1.6 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Division 01 Section "Closeout Procedures."

B. Record exact locations of equipment and refrigeration accessories on record drawings.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Division 01 Section "Operation and Maintenance Data."

B. Maintenance Data: Include instructions for changing cartridges, assembly views, spare parts

lists.

1.8 QUALIFICATIONS

- A. Installer: Company specializing in performing the work of this Section with minimum 3 years' experience.
- B. Design piping system under direct supervision of a Professional Engineer experienced in design of this work and licensed at the place where the Project is located.

1.9 REGULATORY REQUIREMENTS

- A. Conform to ASME B31.9 for installation of piping system.
- B. Welding Materials and Procedures: Conform to ASME SEC 9 and applicable state labor regulations.
- C. Welders Certification: In accordance with AWS D1.1. and state and local requirements.
- D. Products Requiring Electrical Connection: Listed and classified by UL, as suitable for the purpose indicated.
- E. Refrigerant Safety: Conform with ASHRAE 15, state and local codes and manufacturer's requirements for safe handling to avoid exposure to workers or to occupants.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Division 01 Section "Product Requirements."
- B. Deliver and store piping and specialties in shipping containers with labeling in place.
- C. Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.
- D. Dehydrate and charge components such as piping and receivers, seal prior to shipment, until connected into system.

1.11 MAINTENANCE MATERIALS

- A. Provide maintenance materials under provisions of Division 01 Section "Closeout Procedures."
- B. Provide 2 refrigeration oil test kits, each containing everything required to conduct 1 test.
- C. Provide 2 filter-dryer cartridges of each type.

PART 2 - PRODUCTS

2.1 PIPING

- A. Copper Tubing: ASTM B280, Type ACR hard drawn, degreased, nitrogen charged and sealed. Annealed (soft) tubing may be used only for underfloor or below grade runs or for short (6 feet (1.8 m) or less) above-grade connections to valves and equipment.
1. Fittings: ASME B16.22 wrought copper.
 - a. Fittings shall be packaged and labeled for ACR use.
 - b. Elbows: Use long-radius elbows wherever possible. Do not use 45-degree elbows, because they are more likely to break at their inner surface in refrigeration service.
 2. Joints:
 - a. Braze, 15 percent silver for copper, brass, and bronze.
 - b. Braze, 35 percent silver, for brazing to ferrous metals (steel).
 - c. Solder (for use only at equipment and valve connections where required by the equipment manufacturer).
 - d. Other: If a valve or equipment manufacturer recommends a joint material other than those specified, submit it for approval.
 - e. Flux: Use as recommended by alloy manufacturer. Should not be needed for copper-to-copper brazed joints.
- B. Copper Tubing to 7/8 inch (22 mm) OD: ASTM B88, Type K, annealed.
1. Fittings: ASME B16.26 cast copper.
 2. Joints: Flared.
- C. Steel Pipe: ASTM A53, Schedule 40, 0.365 inch (10 mm) wall for sizes 12 inch (300 mm) and over, black.
1. Fittings: ASTM A234, forged steel welding type.
 2. Joints: AWS D1.1, welded.
- D. [PVC Conduit: ASTM D2665, Type DWV or Schedule 40, with long-sweep fittings.
1. Joints: Solvent Cemented.
 2. Primer: ASTM F 656, purple.
 3. Cement: ASTM D 2564, non-purple.]
- E. [Polyethylene Conduit: ASTM F405 or F667, flexible, corrugated, black, seamless.]
1. Manufacturers:
 - a. ADS.
 - b. Infiltrator Corrugated Pipe.
 - c. JM Eagle.
 2. Couplings below grade: Watertight.]

2.2 PIPE SUPPORTS AND ANCHORS

- A. See Division 23 Section “Hangers and Supports for HVAC Piping and Equipment.”

2.3 PIPE SLEEVES

- A. See Division 23 Section “Sleeves and Escutcheons for HVAC Piping.”

2.4 BRAZING MATERIALS - 15% Silver

- A. Manufacturers:
1. Harris (Product: Stay-Silv 15).
 2. Lucas-Milhaupt (Product: Silvaloy 15).
 3. No substitutions.
- B. Nominal Composition: 5.0 percent phosphorus, 15.0 percent silver, 0.15 percent other elements (total), remainder copper. Cadmium-free.
- C. Physical Properties:
1. Color: Yellow/Gray
 2. Solidus: 1190 degrees F (643 degrees C)
 3. Liquidus: 1480 degrees F (802 degrees C)
 4. Brazing Range: 1300–1500 degrees F (704-816 degrees C)
 5. Electrical Conductivity: 9.9 percent IACS
 6. Electrical Resistivity: 17.40 microhm-cm
- D. Specification Compliance:
1. ANSI/AWS A5.8, class BCuP-5
 2. ASME SFA5.8, class BCuP-5
 3. Optional:
 - a. QQB 650C, class BCuP-5
 - b. QQB 654A, class BCuP-5
 - c. QQB 654, class BCuP-5
- E. Flux:
1. Harris (Stay-Silv For copper-to-brass joints. No flux required for copper-to-copper joints).

2.5 BRAZING MATERIALS – 35 percent Silver

- A. Manufacturers:
1. Harris (Product: Safety-Silv 35).
 2. Lucas-Milhaupt (Product: Silvaloy A-35).
 3. No substitutions.
- B. Nominal Composition: 35.0 percent silver, 33 percent Zinc, 0.15 percent other elements (total), remainder copper. Cadmium-free.
- C. Physical Properties:
1. Color: Yellow/Gray
 2. Solidus: 1250 degrees F (677 degrees C)
 3. Liquidus: 1410 degrees F (732 degrees C)
 4. Electrical Conductivity: 19.8 percent IACS

5. Electrical Resistivity: 8.2 microhm-cm

D. Specification Compliance:

1. ANSI/AWS A5.8, class BAg-5
2. ASME SFA5.8, class BCuP-5

E. Flux:

1. Harris (Stay-Silv white flux, or where heating cycles are extended, Stay-Silv black flux).

2.6 SOLDER MATERIALS:

A. Manufacturers:

1. Harris (Product: Stay-Brite).
2. Lucas-Milhaupt (Product: Silvabrite).
3. No substitutions.

B. Nominal Composition: Alloy of silver and tin (3-6 percent Ag, remainder Sn). Antimony-free.

C. Physical Properties:

1. Color: Bright Silver
2. Solidus: 430 degrees F (221 degrees C)
3. Liquidus: 430 degrees F (221 degrees C)
4. Electrical Conductivity: 16.4 percent IACS
5. Shear Strength: 10,600 psi (73 MPa)
6. Tensile Strength: 14,000 psi (96 MPa)
7. Elongation: 48 percent

D. Specification Compliance:

1. NSF 51
2. ASTM B32-89, Alloy Grade Sn96
3. Federal Spec. QQ-S-571E, Class Sn 96 with exception to QPL paragraph 3.1
4. J-STD-006, Sn96Ag04A

E. Flux:

1. Harris (Product: Stay Clean Paste Flux, Stay Clean Liquid Flux (used with 4 inches or larger copper tubing also stainless steels), or Bridgit Water Soluble Paste Flux).
2. Canfield (Product: Aqua-Brite or AB Cream Flux). Glycerin-based, water soluble.

2.7 REFRIGERANTS AND LUBRICANTS

A. Refrigerant: ASHRAE 34;

1. R-410a: Blend of R-32/125. Suitable for new equipment.

B. Oils and Other Lubricants: Provide as required by the refrigerant manufacturer and the equipment manufacturer(s).

2.8 MOISTURE AND LIQUID INDICATORS

- A. Manufacturers:
1. Sporlan Valve Co, Model "See-All".
 2. Emerson Climate Technologies.
 3. Henry Technologies.
 4. Mueller.
- B. Indicators: Double port type, UL listed, with steel body, flared or copper plated solder ends, leak proof fused sight glass, replaceable color coded paper moisture indicator and plastic cap; for maximum working pressure of 500 psig (3450 kPa) for connection sizes 1-1/8 inch (29 mm) O.D. and smaller, 430 psig (2960 kPa) for sizes 1-3/8 inch (35 mm) O.D. and larger, and maximum temperature of 200 degrees F (93 degrees C). Synthetic gaskets are not allowed.

2.9 VALVES

- A. Diaphragm Packless Valves:
1. Manufacturers:
 - a. Henry Technologies.
 - b. Mueller.
 - c. Superior.
 2. UL listed, globe or angle pattern, forged brass body and bonnet, phosphor bronze and stainless steel diaphragms, rising stem and handwheel, stainless steel spring, nylon seat disc, solder or flared ends, with positive backseating; for maximum working pressure of 500 psig (3450 kPa) and maximum temperature of 275 degrees F (135 degrees C).
- B. Packed Angle Valves:
1. Manufacturers:
 - a. Henry Technologies.
 - b. Mueller.
 - c. Superior.
 2. Forged brass (or brass and copper), forged brass seal caps with copper gasket, rising stem and seat with backseating, molded stem packing, solder or flared ends; for maximum working pressure of 500 psig (3450 kPa) and maximum temperature of 275 degrees F (135 degrees C).
- C. Ball Valves:
1. Manufacturers:
 - a. Henry Technologies.
 - b. Mueller.
 - c. Superior.
 2. Two piece forged brass body with teflon ball seals and copper tube extensions, brass bonnet and seal cap, chrome plated ball, stem with neoprene ring stem seals; for maximum working pressure of 500 psig (3450 kPa) and maximum temperature of 325 degrees F (163 degrees C).
- D. Service Valves:
1. Manufacturers:
 - a. Henry Technologies.

- b. Mueller.
- c. Superior.
- 2. Forged brass body with copper stubs, brass caps, removable valve core, integral ball check valve, flared or solder ends, for maximum pressure of 500 psig (3450 kPa).

2.10 CHECK VALVES

- A. Globe Type:
 - 1. Manufacturers:
 - a. Henry Technologies.
 - b. Mueller.
 - c. Superior.
 - 2. Cast bronze or forged brass body, forged brass cap with neoprene seal, brass guide and disc holder, phosphor-bronze or stainless steel spring, teflon seat disc; for maximum working pressure of 500 psig (3450 kPa) and maximum temperature of 300 degrees F (149 degrees C).
- B. Straight Through Type:
 - 1. Manufacturers:
 - a. Henry Technologies.
 - b. Mueller.
 - c. Superior.
- C. Brass body and disc, phosphor-bronze or stainless steel spring, neoprene seat; for maximum working pressure of 500 psig (3450 kPa) and maximum temperature of 250 degrees F (121 degrees C).

2.11 EXPANSION VALVES

- A. Manufacturers:
 - 1. Sporlan.
 - 2. Henry Technologies.
 - 3. Parker Hannifin.
- B. Angle or Straight Through Type: ARI 750; balanced port or two-port design suitable for refrigerant, brass body, flare or solder connections, internal or external equalizer, resealable bleed hole, adjustable superheat setting, replaceable inlet strainer, with replaceable thermostatic power element with capillary tube and remote sensing bulb. Joints to the body at the removable power element and at the strainer shall be knife-edge type not requiring a synthetic seal.
- C. Selection: Evaluate refrigerant pressure drop through system to determine available pressure drop across valve. Select valve for maximum load at design operating pressure and minimum 10 degrees F (6 degrees C) superheat. Select to avoid being undersized at full load and excessively oversized at part load. Select thermostatic charge for the particular application.

2.12 ELECTRONIC EXPANSION VALVES

- A. Manufacturers:
 - 1. Sporlan.

2. Henry Technologies.
3. Parker Hannifin.

B. Valve:

1. Brass body with flared or solder connection, needle valve with floating needle and machined seat, stepper motor drive.
2. Capacity: To meet the load of the equipment served.
3. Electrical Characteristics: Compatible with the control system.

C. Evaporation Control System:

1. Electronic microprocessor based unit in enclosed case, proportional integral control with adaptive superheat, maximum operating pressure function, pre-selection allowance for electrical defrost and hot gas bypass.
2. Electrical Characteristics: Compatible with the control system.

D. Refrigeration System Control: Electronic microprocessor based unit in enclosed case, with proportional integral control of valve, on/off thermostat, air temperature alarm (high and low), solenoid valve control, liquid injection adaptive superheat control, maximum operating pressure function, night setback thermostat, timer for defrost control.

2.13 PRESSURE REGULATORS

A. Manufacturers:

1. Sporlan.
2. Parker Hannifin.

B. Brass body, stainless steel diaphragm, pilot operated with internal pressure pilot, adjustable over 0 to 100 psig (0 to 690 kPa) range, for maximum working pressure of 450 psig (3100 kPa).

2.14 PRESSURE RELIEF VALVES

A. Manufacturers:

1. Henry Technologies.
2. Mueller.
3. Superior.

B. Straight Through or Angle Type: Brass body and disc, neoprene seat, factory sealed and stamped with ASME UV and National Board Certification NB; for standard setting; selected to ASHRAE 15.

2.15 SOLENOID VALVES

A. Manufacturers:

1. Sporlan.
2. Henry Technologies.
3. Parker Hannifin.

B. Valve: ARI 760, pilot operated, brass or steel body and internal parts, teflon seat, stainless steel stem and plunger assembly, with flared, solder, or threaded ends; for maximum working

pressure of 500 psig (3450 kPa). Stem shall have a knife-edge joint to the body and shall permit manual operation in case of coil failure.

- C. Coil Assembly: UL listed, replaceable with molded electromagnetic coil, moisture and fungus proof, with surge protector and color coded lead wires, integral junction box with pilot light.
- D. Electrical Characteristics: 10 to 15 watts, voltage compatible with control system, single phase, 60 Hz.

2.16 FILTER-DRIERS

- A. Replaceable Cartridge Angle Type:
 - 1. Manufacturers:
 - a. Sporlan, Model CW Catch-All.
 - b. Emerson Climate Technologies.
 - 2. Shell: ARI 710, UL listed, steel with epoxy paint finish, copper sweat fittings, removable cap with zinc-plated fasteners, for maximum working pressure of 500 psig (3450 kPa), size as recommended by manufacturer.
 - 3. Suction Filter Cartridge: Pleated media with integral end rings, stainless steel support, ARI 730 rating for capacity of the equipment served.
 - 4. Filter/Dryer Cartridge: Pleated media with solid core molecular sieve with activated alumina, ARI 730 rating for capacity of the equipment served.
 - 5. Wax Removal Cartridge: Molded bonded core of activated charcoal with integral gaskets, with filter surface area, desiccant volume and ARI 710 moisture rating as recommended by the manufacturer based on line size and refrigeration system horsepower (kW).
- B. Permanent Straight Through Type:
 - 1. Manufacturers:
 - a. Sporlan, Model CW Catch-All.
 - b. Emerson Climate Technologies.
 - 2. ARI 710, UL listed, steel shell with copper plated steel sweat or flare fittings, molded molecular sieve/activated alumina desiccant filter core, for maximum working pressure of 500 psig (3450 kPa).
 - 3. Rating: ARI 730 flow capacity of the equipment served.

2.17 FLEXIBLE CONNECTORS

- A. Manufacturers:
 - 1. Metraflex.
 - 2. Mason Industries.
 - 3. Keflex.
- B. Corrugated bronze hose with single layer of exterior braiding, minimum 9 inches (230 mm) long with copper tube ends; for maximum working pressure 500 psig (3450 kPa).

2.18 RECEIVERS

- A. Manufacturers:
 - 1. Henry Technologies.
 - 2. Refrigeration Research Inc.
 - 3. Sporlan.
 - 4. Standard Refrigeration Co.

- B. Internal Diameter 6 inch (150 mm) and Smaller: ARI 495, UL listed, steel, brazed; 400 psig (2760 kPa) maximum pressure rating, with tappings for inlet, outlet, liquid level gauge, sight glasses and pressure relief valve. Provide at least 2 bullseye liquid level sight glasses. Size receiver to hold at least 120 percent of fully charged system.

- C. Internal Diameter Over 6 inch (150 mm): ARI 495, welded steel, tested and stamped in accordance with ASME SEC 8D; 400 psig (2760 kPa) with tappings for liquid inlet and outlet valves, pressure relief valve, sight glasses and magnetic liquid level indicator. Provide at least 2 bullseye liquid level sight glasses. Size receiver to hold at least 120 percent of fully charged system.

2.19 STRAINERS

- A. Straight Line or Angle Line Type:
 - 1. Manufacturers:
 - a. Henry Technologies.
 - b. Sporlan.
 - c. Superior.
 - 2. Brass or steel shell, steel cap and flange, and replaceable cartridge, with screen of stainless steel wire or monel reinforced with brass; for maximum working pressure of 430 psig (2960 kPa).

- B. Straight Line, Non-Cleanable Type:
 - 1. Manufacturers:
 - a. Henry Technologies.
 - b. Mueller.
 - 2. Steel shell, copper plated fittings, stainless steel wire screen, for maximum working pressure of 430 psig (2960 kPa).

- C. Screens: 80 mesh (0.007 in. (0.18 mm) square openings) in most uses, 60 mesh (0.010 in. (0.25 mm) square openings) in line sizes above 1-1/8 inch (29 mm), and 40 mesh (0.015 in. (0.38 mm) square openings) for use in suction lines.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

- B. Remove scale and dirt on inside and outside before assembly.

- C. Prepare piping connections to equipment with flanges or unions.

3.2 INSTALLATION

- A. Follow ASHRAE 15 procedures for charging and purging of systems and for disposal of refrigerant.
- B. Comply with Federal, State, and local Codes and regulations regarding the handling and disposal of refrigerants and oil. Provide documentation of quantities installed in the system. Document handling and disposal; see “Project Closeout” in this Section.
- C. Install refrigeration specialties in accordance with manufacturer's instructions.
- D. Flood piping system with nitrogen when brazing.
- E. Route piping in orderly manner, parallel or perpendicular to building structure, and maintain gradient.
- F. Install annealed piping free of kinks, and with bends only as necessary.
- G. Install piping to conserve building space and not interfere with use of space.
- H. Group piping whenever practical at common elevations and locations. Slope piping one percent in direction of oil return.
- I. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- J. Arrange piping to return oil to compressor. Provide traps and loops in piping, and provide double risers as required.
- K. Provide liquid line replaceable cartridge (unless sealed type is indicated) filter-driers, with isolation valves and valved bypass. On low temperature systems, or after a hermetic motor burnout, provide wax removal cores. Provide upstream and downstream pressure-testing access valves.
- L. Provide suction line replaceable cartridge filters, with isolation valves and valved bypass. Provide upstream and downstream pressure testing access valves. On low temperature systems, or after a hermetic motor burnout, provide temporary wax removal cores. After cleanup of the system, replace cores with filter elements for lower pressure drop.
- M. Locate expansion valve sensing bulb immediately downstream of evaporator on suction line.
- N. Provide external equalizer piping on expansion valves with refrigerant distributor connected to evaporator.
- O. Install flexible connectors at right angles to axial movement of compressor, parallel to crankshaft.

- P. Pipe Sleeves and Escutcheons:
 - 1. Provide sleeves, sized to fit outside the pipe insulation with at least 1/4 inch (6 mm) clearance, at penetrations of building assemblies. Interrupt insulation where required by fire ratings.
 - 2. Extend floor sleeves to 2 inches (50 mm) above finished floor and seal watertight.
 - 3. For below-grade penetrations and where indicated, provide watertight link-type pipe seals.
 - 4. Secure sleeves in place, and caulk, grout or firestop into the building assembly.
 - 5. Provide split chrome or painted escutcheons where exposed to occupancy.
 - Q. Provide clearance for installation of insulation and access to valves and fittings.
 - R. Provide access to concealed valves and fittings. Coordinate size and location of access doors with Division 08 Section "Access Doors and Frames."
 - S. Where pipe support members are welded to structural building frame, brush clean, and apply one coat of zinc rich primer to welding.
 - T. Prepare unfinished pipe, fittings, supports, and accessories ready for finish painting. Refer to Division 09 Section "Painting."
 - U. Insulate piping and equipment; refer to Division 23 Sections "HVAC Piping Insulation" and "HVAC Equipment Insulation"
 - V. Fully charge completed system with refrigerant after testing.
 - W. Provide electrical connection to solenoid valves. Refer to Division 26 - Electrical.
- 3.3 FIELD QUALITY CONTROL
- A. Perform field inspection and testing under provisions of Division 01 Section "Quality Requirements."
 - B. Test refrigeration system in accordance with ASME B31.5.
 - C. Pressure test system with dry nitrogen to 200 psig (1470 kPa). Perform final tests at 27 inches of mercury (92 kPa) vacuum and 200 psig (1470 kPa) pressure using electronic leak detector. Test to no leakage.
 - D. Evacuate the system as required by Codes and by equipment manufacturer, including a vacuum test at 0.02 inches of mercury (500 microns). The system shall be valved off and tested for 2 hours with a pressure rise of no more than 0.002 inches of mercury (50 microns).
- 3.4 SYSTEM STARTUP
- A. Lubricate motors and other moving parts as necessary before operating them.
 - B. Charge the system with liquid refrigerant into the low pressure side of the system, where the liquid will evaporate. Expel air from the system. Operate the compressor, condenser, water

cooling pumps and evaporator fans during charging. Monitor compressor discharge pressure. Monitor oil levels for a period of 24 hours.

- C. Coordinate control setpoints and wiring prior to startup.
- D. Change suction filter elements if the pressure drop exceeds 1 Psi (6.9 kPa) after the initial 24 hours of operation. Change suction wax removal cores to filter elements after system cleanup.
- E. Adjust expansion valve superheat using a thermistor or thermocouple temperature sensor at the bulb location and a pressure gauge at the external equalizer line (or the compressor). Adjust under full system load, and again when the system stabilizes.
- F. Check the system again after seven full days of operation.
- G. Periodically clean strainers until no more accumulation occurs.

3.5 PROJECT CLOSEOUT

- A. Indicate exact locations of buried piping conduits on As-Built Drawings.
- B. Submit records of handling and disposal of refrigerant and oil to verify compliance with Federal, State, and local Codes and regulations.
- C. Submit records of installed quantities of refrigerants and oils in each system. Submit manufacturer's product sheets, MSDS, and instructions in the Operation and Maintenance Manuals.

END OF SECTION 232300

SECTION 232500 – HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Cleaning of piping systems.
- B. Chemical treatment.

1.2 SUBMITTALS

- A. Submit under provisions of Division 01 Section “Submittal Procedures.”
- B. Product Data: Provide chemical treatment materials, chemicals, and equipment including electrical characteristics and connection requirements.
- C. Manufacturer's Field Reports: Indicate start-up of treatment systems when completed and operating properly. Indicate analysis of system water after cleaning and after treatment.
- D. Submit certificate of compliance from authority having jurisdiction indicating approval of chemicals and their proposed disposal.

1.3 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Division 01 Section “Operation and Maintenance Data.”
- B. Operation and Maintenance Data: Include data on chemical feed pumps, agitators, and other equipment including spare parts lists, procedures, and treatment programs. Include step by step instructions on test procedures including target concentrations.

1.4 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum 3 years’ experience. Company shall have local representatives with water analysis laboratories and full time service personnel.
- B. Installer: Company specializing in performing the work of this Section with minimum 3 years’ experience and approved by manufacturer.

1.5 REGULATORY REQUIREMENTS

- A. Conform to applicable code for addition of non-potable chemicals to building mechanical systems, and for discharge to public sewage systems.
- B. Products Requiring Electrical Connection: Listed and classified by UL as suitable for the purpose specified and indicated.

1.6 MAINTENANCE SERVICE

- A. Furnish service and maintenance of treatment systems for 6 months from Date of Substantial Completion.

1.7 MAINTENANCE MATERIALS

- A. Provide maintenance materials under provisions of Division 01 Section "Product Requirements."
- B. Provide sufficient chemicals for treatment and testing during warranty period.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Chemical Treatment Systems Products, and Services:
 - 1. Barclay Water Management, Inc., Watertown, MA office.
 - 2. Nalco Company, Windham, ME office.
 - 3. Secondwind Water Systems, Inc., Manchester, NH office.
- B. Chemical Treatment Products:
 - 1. Nu-Calgon.
 - 2. Cascade Water Services, Inc.
 - 3. Culligan.
 - 4. DuBois Chemicals.
 - 5. H-O-H Water Technology, Inc.
 - 6. Wesco Chemicals, Inc.

2.2 MATERIALS

- A. System Cleaner:
 - 1. Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products.
- B. Closed System Treatment (Water):
 - 1. Sequestering agent to reduce deposits and adjust pH; polyphosphate.
 - 2. Corrosion inhibitors; liquid boron-nitrite, sodium nitrite and borax, sodium totyltriazone, low molecular weight polymers, phosphonates, sodium molybdate, or sulphites.
 - 3. Conductivity enhancers; phosphates or phosphonates.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Systems shall be operational, filled, started, and vented prior to cleaning. Use water meter to record capacity in each system.
- B. Place terminal control valves in open position during cleaning.
- C. Verify that electric power is available and of the correct characteristics.

3.2 CLEANING SEQUENCE

- A. Concentration:
 - 1. As recommended by manufacturer.
 - 2. 1 pound per 100 gallons of water contained in the system.
 - 3. 1 pound per 100 gallons of water for hot systems and 1 pound per 50 gallons of water for cold systems.
- B. Hot Water Heating Systems:
 - 1. Apply heat while circulating, slowly raising temperature to 160 degrees F and maintain for 12 hours minimum.
 - 2. Remove heat and circulate to 100 degrees F or less; drain systems as quickly as possible and refill with clean water.
 - 3. Circulate for 6 hours at design temperatures, then drain.
 - 4. Refill with clean water and repeat until system cleaner is removed.
- C. Use neutralizer agents on recommendation of system cleaner supplier and approval of Engineer/Engineer.
- D. Remove, clean, and replace strainer screens.
- E. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

3.3 INSTALLATION

- A. Install in accordance with manufacturer's instructions.

END OF SECTION 232500

SECTION 233113 – METAL DUCTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Metal Ductwork.
- B. Air Duct Leakage Tests.

1.2 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. Division 23: Sensors and airflow measuring stations furnished under Division 23 Section “Instrumentation and Control for Mechanical Systems”; gauges and meters.
- B. Division 26 – Electrical: Smoke detectors.

1.3 RELATED SECTIONS

- A. Division 01 Section “Testing, Adjusting and Balancing for HVAC.”
- B. Division 09 Section “Painting”: Weld priming, weather resistant, paint or coating.
- C. Division 23 Section “Hangers and Supports for HVAC Piping and Equipment”: Sleeves.
- D. Division 23 Section “Duct Insulation”: External insulation.

1.4 REFERENCES

- A. ASTM A 90 - Standard Test Method for Weight of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
- B. ASTM A 167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
- C. ASTM A 480 - General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
- D. ASTM A 568 - Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled.
- E. ASTM A 653 - Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- F. ASTM A 1008 - Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.
- G. ASTM A 1011 - Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.

- H. ASTM B 209 - Aluminum and Aluminum-Alloy Sheet and Plate.
- I. AWS D9.1 - Welding of Sheet Metal.
- J. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
- K. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems.
- L. SMACNA - HVAC Air Duct Leakage Test Manual.
- M. SMACNA - HVAC Duct Construction Standards - Metal and Flexible (SMACNA HVACDCS).
- N. SMACNA - Fibrous Glass Duct Construction Standards.
- O. UL 181 - Factory-Made Air Ducts and Connectors.

1.5 PERFORMANCE REQUIREMENTS

- A. No variation of duct configuration or sizes is permitted except by written permission from the Architect. Size proposed substitutions of round ducts in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts.

1.6 SUBMITTALS

- A. Submit under provisions of Division 01 Section "Submittal Procedures".
- B. Shop Drawings: Indicate duct fittings, particulars such as gauges, sizes, welds, and configuration. Submit prior to start of work.
- C. Product Data: Provide data for duct materials, duct liner and duct connectors.
- D. Test Reports: Submit testing apparatus, procedures, and preliminary forms prior to performing tests. On final reports, indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA HVAC Air Duct Leakage Test Manual.

1.7 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Division 01 Section "Closeout Procedures."
- B. Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Indicate additional fittings used.

1.8 QUALITY ASSURANCE

- A. Perform Work in accordance with SMACNA HVACDCS.

1.9 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this Section with minimum 3 years' experience.

- B. Installer: Company specializing in performing the work of this Section with minimum 3 years' experience.

1.10 REGULATORY REQUIREMENTS

- A. Construct ductwork to NFPA 90A, NFPA 90B and NFPA 96 standards.

1.11 ENVIRONMENTAL REQUIREMENTS

- A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.
- B. Maintain temperatures during and after installation of duct sealants.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Flexible Ducts:
 - 1. Atco Rubber Products, Inc. – 30 Series (insulated).
 - 2. Flexible Technologies Group - Thermaflex product line.
 - 3. Flexmaster U.S.A. – Type 6 product line.
 - 4. Hart and Cooley – F246 Commercial Series.
 - 5. Buckley Associates - Flexmaster Triple-Lock Buck Duct product line.
 - 6. No substitutions.
- B. Plastic Drawbands:
 - 1. Panduit.
 - 2. Thomas and Betts.
 - 3. Tyton.
- C. Tape for Flexible Ducts:
 - 1. Ideal Tape Co., division of American Biltrite Inc.
 - 2. 3M Company.
 - 3. Nashua Tape Products, division of Berry Plastics Corp.
 - 4. Venture Tape Corporation.
 - 5. No substitutions.
- D. Manufactured Ductwork - Round and Flat Oval:
 - 1. McGill AirFlow LLC, a subsidiary of United McGill Corporation.
 - 2. Aero Heating & Ventilating, Inc.; Portland, ME.
 - 3. Air Purchases, Inc.; Manchester, NH – spiral duct lengths.
 - 4. Atlantic Air Products LLC; Bow, NH.
 - 5. Central City Sheet Metal; Brewer, Caribou, and Gorham, ME.
 - 6. Hahnel Brothers; Bangor and Lewiston, ME.
 - 7. Hranec Corporation; Uniontown, PA.
 - 8. Lindab, Inc. – duct fittings only.
 - 9. Macy Industries, Inc.; Hookset, NH. [<http://www.macyindustries.com/>]

10. Monroe Metal Mfg. Inc.; Monroe, NC.
11. Northeastern Sheet Metal Inc.; Goffstown, NH.
12. [Omni Duct Systems. ****West Coast projects only****]
13. [Pacific Duct Inc.; Montclair, CA. ****West Coast projects only****]
14. Semco Inc., division of the Flakt Woods Group.
15. S.G. Torrice Co.; Wilmington, MA – spiral duct lengths.
16. Sheet Metal Connectors Inc.; Minneapolis, MN.
17. Spiral Manufacturing Co. Inc.; Minneapolis, MN.
18. Total Air Supply; Nashua, NH – spiral duct lengths.
19. No substitutions.

E. Manufactured Ductwork - Transverse Duct Connection System:

1. Ductmate.
2. HFC Enterprises; Baldwin Park, CA – Dura Flange product line, for round and flat oval ducts only.

F. Sealants:

1. Hardcast, a division of Carlisle Corporation.
2. 3M Company.
3. Ductmate.
4. Foster.
5. McGill AirSeal LLC, a subsidiary of United McGill Corporation.
6. Mon-Eco Industries, Inc - Eco product line.
7. Polymer Adhesive Sealant Systems.

2.2 MATERIALS

A. Galvanized Steel Ducts:

1. Steel sheet metal components of galvanized ductwork in this Specification Section shall be galvanized steel sheet, lock-forming quality, having G60 or heavier zinc coating (G90 minimum for outdoor or moist applications) conforming to ASTM A653 rating system and tested in accordance with ASTM A90.
2. Provide paint-grip exterior surfaces for exposed ducts, where available.
3. Sheet metal gauge shall be not less than 26 gauge (0.56 mm).

B. Carbon Steel Ducts: ASTM A1008, A1011. Also known as black iron.

C. Aluminum Ducts: ASTM B209; aluminum sheet, alloy 3003-H14. Aluminum Connectors and Bar Stock: Alloy 6061-T6 or of equivalent strength.

D. Stainless Steel Ducts: ASTM A167, Type [304 or 316.] [304.] [316.] Material for exposed ducts shall have a finish at least equal to Mill Polished No. 4.

2.3 FLEXIBLE DUCTS

A. Insulated Flexible Ducts:

1. Semi-Rigid Flexible Aluminum Ductwork:
 - a. Flexmaster Triple-Lock Buck Duct - Insulated.
 - b. Triple lock mechanical joint aluminum flex duct, constructed entirely without the

- use of adhesive.
 - c. Fiberglass insulation and fire-retardant polyethylene vapor retarder film.
 - d. Pressure Rating: Positive pressure 12 in. WG (2988 Pa) for all sizes. Negative pressure 12 in. WG (2988 Pa) for sizes thru 16 in. (406 mm) diameter, 8 in. WG (1993 Pa) for sizes 18 and 20 in. (457 and 508 mm) diameter.
 - e. Maximum Velocity: 5500 fpm (27.9 m/sec).
 - f. Inside bend radius: Minimum one diameter.
 - g. Temperature Range: -40 to 250 degrees F (-40 to 121 degrees C).
 - h. UL 181, Class 0 air duct.
 - i. Meets NFPA 90A and 90B standards.
2. Fabric-Core Flexible Ductwork:
- a. Thermaflex Model M-KC.
 - b. Greenguard certified.
 - c. UL 181, Class 1, heavy fiberglass cloth fabric supported by helically wound spring steel wire; fiberglass insulation; reinforced metalized vapor barrier film.
 - d. Pressure Rating: 10 inches WG (2.5 kPa) positive and 2.0 inches WG (500 Pa) negative.
 - e. Maximum Velocity: 6000 fpm (30.4 m/sec).
 - f. Temperature Range: -20 to 250 degrees F (-28 to 121 degrees C).
- B. Non-Insulated Flexible Ducts:
1. Semi-Rigid Flexible Aluminum Ductwork:
- a. Flexmaster Triple-Lock Buck Duct - Bare.
 - b. Triple lock mechanical joint aluminum flex duct, constructed entirely without the use of adhesive.
 - c. Pressure Rating: 12 inches WG (2988 Pa) positive for all sizes, 12 inches WG (2988 Pa) negative for sizes thru 16 in. diameter (406 mm), 8 inches WG (1992 Pa) negative for sizes 18 in. (457 mm) and 20 in. (508 mm) diameter.
 - d. Maximum Velocity: 5500 fpm (27.9 m/sec).
 - e. Inside bend radius: Minimum one diameter.
 - f. Temperature Range: -40 to 250 degrees F (-40 to 121 degrees C).
 - g. UL 181, Class 0 air duct.
 - h. Meets NFPA 90A and 90B standards.
- C. Return and Exhaust: Use either semi-rigid flexible aluminum type (insulated or bare), or fabric-core type (insulated). Non-insulated fabric-core type does not have adequate negative pressure rating.
- 2.4 ACCESSORIES
- A. Drawbands for Flexible Ducts:
- 1. Stainless Steel: ½ inch (13 mm) wide with screw-driven worm gear.
 - 2. Plastic: Panduit PLT5H or PLT8H; Thomas and Betts Dukt-Rap, VAL-26-50, or VAL-275X-25; or Tyton T150L or LX. Install with manufacturer's lever-action tightening tool.
- B. Tape for Flexible Ducts: Ideal-Seal 587A/B, UL 181B-FX listed, aluminum foil with pressure-sensitive acrylic adhesive, -20 to 250 degrees F (-28 to 121 degrees C) temperature range, 25.0 lb/in. width (109.4 N/25.4 mm width) tensile strength.

- C. Fasteners: Rivets, bolts, or sheet metal screws.
- D. Sealants: See Duct Sealant portion of this Specification.
- E. Hanger Rod: ASTM A36; galvanized steel; threaded both ends, threaded one end, or continuously threaded.
- F. Wire Rope Hanging System: At the Contractor's option, Ductmate Industries' Clutcher hanger system may be used with Ductmate wire rope (no substitutions). System use and installation shall conform with manufacturer's requirements. System shall not be painted or otherwise coated. System shall not be used in corrosive environments.

2.5 DUCTWORK FABRICATION

- A. Fabricate and support in accordance with SMACNA HVACDCS, as specified or as indicated on the drawings. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.
- B. SMACNA Duct Construction Manuals:
 - 1. The SMACNA recommendations shall be considered as mandatory requirements.
 - 2. Substitute the word "shall" for the word "should" in these manuals.
 - 3. Where the Contract Specifications differ from SMACNA recommendations, the more stringent requirements (as determined by the Architect) shall take precedence.
 - 4. Details on the Contract Drawings take precedence over SMACNA standards.
- C. Sheet metal shall be galvanized steel as specified in Part 2 paragraph "Materials" in this Section, unless otherwise indicated or specified.
- D. Construct Tees, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline.
 - 1. Where space is too restricted for full-radius elbows, provide mitered (square-throat) elbows with single wall turning vanes. Do not use air foil turning vanes.
 - 2. Mitered elbows in round or flat-oval ductwork shall be factory-manufactured.
 - 3. Radiused elbows with throat radius 1/2 times width of duct (centerline radius 1 width of duct) may be used instead of mitered elbows, but only where space is too restricted for full radius.
 - 4. Fittings not conforming to these requirements will be ordered removed and replaced with proper fittings.
- E. Increase duct sizes gradually, not exceeding 15 degrees divergence or convergence (per side) wherever possible; maximum 30 degrees divergence (per side) upstream of equipment and 45 degrees convergence (per side) downstream.
- F. Fabricate continuously welded round and oval duct fittings two gauges heavier than duct gauges indicated in SMACNA Standard. Joints shall be minimum 4 inch (100 mm) cemented slip joint, brazed or electric welded. Prime coat welded joints.
- G. Provide standard 45 degree lateral wye takeoffs unless otherwise indicated where 90 degree conical tee connections may be used.

- H. Longitudinal locks or seams known as “button-punch-snap-lock” and other “snap-lock” types will not be permitted in rectangular duct. Snap-lock longitudinal seams may be used on round ducts up to 8 inches diameter, with screws provided to secure the seams at 24 inches (609 mm) on center maximum spacing.
- I. Exposed Ducts: Select and handle materials with care for a neat appearance. Joint connections on round and flat oval ducts shall be sleeve or flanged type; drawbands are not acceptable.

2.6 MANUFACTURED DUCTWORK AND FITTINGS

- A. Manufactured ductwork and fittings listed below are acceptable alternatives to standard ductwork systems. For exposed round and flat oval ductwork, factory-manufactured ductwork and fittings are required.
- B. Manufacture in accordance with SMACNA HVACDCS, and as specified or as indicated on the drawings. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.
- C. Exposed Round and Flat Oval Ductwork: Shall be manufactured ductwork by one of the listed manufacturers.
 - 1. Spiral Ductwork Acceptable Products:
 - a. McGill Airflow: Standard Uni-Seal product line (smooth surface between spiral lockseams) or Uni-Rib product line (one standing seam reinforcement between each pair of spiral lockseams).
 - b. Monroe Metal Inc.: Standard spiral product line (smooth surface between spiral lockseams). V-Rib product line is not allowed.
 - c. Other Manufacturers: Standard spiral product line (smooth surface between spiral lockseams).
 - d. Ductwork and fittings shall be products of a single manufacturer.
- D. Exposed Ducts:
 - 1. Select and handle materials with care for a neat appearance.
 - 2. Joint connections on round and flat oval ducts shall be sleeve or flanged type; drawbands are not acceptable. Joint connections on flat oval ducts 42 inches (1.07 m) and wider shall be flanged type to ensure tight fit and good appearance.
 - 3. Provide exterior reinforcing only where required, with prior approval from the Architect.
 - 4. External reinforcement of flat-oval ducts shall be full-perimeter angle rings. Straight angles along flat sides only are not allowed.
- E. Galvanized and stainless steel sheet metal used in fabrication shall be not less than 26 gauge (0.551 mm) thickness. Aluminum shall be not less than 0.025 in. (0.635 mm) nominal thickness. This requirement supersedes SMACNA requirements.
- F. Round and Flat Oval Duct and Fittings:
 - 1. Shall be suitable for at least 4 in. WG (996 Pa) positive pressure and 2 in. WG (498 Pa) negative pressure in accordance with SMACNA HVACDCS standards. This is a minimum; provide higher ratings where required.
 - 2. Fittings shall be fabricated of sheet metal at least one gauge heavier than straight duct of the same size.

3. Fittings shall be factory-sealed so that no field sealing of joints between gores or segments is required. Acceptable methods of construction are fully welded, spot-welded with inner sealant, or standing-seam crimped joints.
- G. Radiused Elbows in Round and Flat Oval:
1. In exposed ductwork shall be non-adjustable type, factory-sealed.
 2. In concealed ductwork may be adjustable type, with full long radius as detailed on the Drawings. Short-radius elbows are not allowed.
 3. Shall be constructed of the following minimum number of segments or gores: 90-degree: 4 gores; 60-degree: 3 gores; 45-degree: 3 gores; 30-degree: 2 gores; 22-1/2-degree: 2 gores.
 4. 1-piece stamped elbows are acceptable up to 12 inches (305 mm) diameter. Pleated elbows are acceptable up to 10 inches (254 mm) diameter.
- H. Mitered Elbows in Round and Flat Oval:
1. Available in both 90-degree and 45-degree elbows.
 2. Shall have minimum number of welded single-wall vanes as follows (size is duct width in plane of bend):
 - a. 3 to 9 inch (76 to 229 mm): 2.
 - b. 10 to 14 inch (254 to 356 mm): 3.
 - c. 15 to 19 inch (381 to 483 mm): 4.
 - d. 20 to 60 inch (508 to 1524 mm): 5.
 - e. Larger Sizes: 12-inch (305 mm) maximum spacing.
- I. Inner tie-rod reinforcement is not allowed. Increase duct sheet metal gauge or external reinforcement as required.
- J. Double Wall Insulated Round Ducts: Round spiral lockseam duct with galvanized steel outer wall, 1 inch (25 mm) thick fiberglass insulation, [perforated] galvanized steel inner wall; fittings with solid inner wall.
- K. Transverse Duct Connection System: SMACNA "F" rated or SMACNA "J" rated rigidity class connection, interlocking angle and duct edge connection system with sealant, gasket, cleats, and corner clips. Product shall be Ductmate factory-manufactured connectors, or field-formed flanges using a specialized machine.
- 2.7 CASINGS
- A. Fabricate casings in accordance with SMACNA HVACDCS and construct for operating pressures indicated.
- B. Mount floor mounted casings on 4 inch (100 mm) high concrete curbs. At floor, rivet panels on 8 inch (200 mm) centers to angles. Where floors are acoustically insulated, provide liner of 18 gauge (1.20 mm) galvanized expanded metal mesh supported at 12 inch (300 mm) centers, turned up 12 inches (300 mm) at sides with sheet metal shields.
- C. Reinforce door frames with steel angles tied to horizontal and vertical plenum supporting angles. Install hinged access doors where indicated or required for access to equipment for cleaning and inspection.

- D. Fabricate acoustic casings with reinforcing turned inward. Provide 16 gauge (1.50 mm) back facing and 22 gauge (0.80 mm) perforated front facing with 3/32 inch (2.4 mm) diameter holes on 5/32 inch (4 mm) centers. Construct panels 3 inches (75 mm) thick packed with 4.5 lb/cu ft (72 kg/cu m) minimum glass fiber media, on inverted channels of 16 gauge (1.50 mm).

2.8 PRESSURE CLASSIFICATION

- A. Ratings as indicated on the Drawings or as specified. See Ductwork Pressure Class Schedule in Part 3 of this Section.
- B. If no ratings are indicated, ductwork shall be rated for the external static pressure of the system plus 25 percent.
 - 1. If 4 dampers (of any type) or fewer can isolate a duct system, that portion of the system shall be rated for the shut-off pressure of the system fans.

2.9 DUCT SEALING

- A. Seal ductwork as outlined in the SMACNA HVACDCS. Seal ductwork to a minimum of class A (transverse joints, longitudinal seams, and duct wall penetrations), regardless of pressure class.
- B. Seal ductwork systems as required to ensure that maximum duct leakage does not exceed that allowed by the latest edition of the SMACNA HVAC Air Duct Leakage Test Manual. Allow sealant to dry in accordance with manufacturer's requirements of time and environmental conditions before ductwork systems are pressurized.
- C. Duct sealing materials used shall be non-flammable and non-combustible in both liquid and solid states.
- D. Seal Pittsburgh hammered lockseams by flooding the joint with sealant prior to assembly.
- E. Seal exposed ducts by applying mastic-type or gasket-type sealer just before the joint or seam is made; remove excess sealant for a neat appearance.
- F. Fill (with matching duct material such as sheet metal) any gaps in duct which exceed the recommendations of the sealant manufacturer, and in no case shall liquid or mastic sealant be used to fill gaps or openings which exceed 1/8 inch (3.2 mm) in any direction. Verify that system air pressure acting on a wide gap will not exert enough force to damage or loosen the sealant.
- G. Materials for Sealing:
 - 1. Hardcast: Flex-Grip 550 or Iron-Grip 601 mastic.
 - 2. Hardcast: gypsum-based tape and mastic, waterproof type when used on moist-air exhaust or in humid or outdoor locations.
 - 3. Ductmate: Flanged lateral joints with gaskets.
 - 4. Ductmate: PROseal.
 - 5. Foster: Duct-Fas or Safetee mastic sealant. Duct-Fas is UV resistant and recommended for applications exposed to sunlight.
 - 6. Mon-Eco: Eco-Duct Seal 4450 (red color) or 4452 (grey color). Use grey color where

ducts will be unpainted and exposed to public view.

7. Polymer Adhesives Sealant Systems: Airseal No. 11 premium sealant.

2.10 UNIFORMITY OF MATERIALS

- A. Ductwork accessories, including but not limited to volume dampers, smoke dampers, fire dampers, combination fire/smoke dampers, backdraft dampers and motorized dampers, shall be fabricated of materials that are similar to the ductwork in which they are installed.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install components furnished under other Section and Divisions of the Specifications. Such items may include but are not limited to: Sensors and airflow measuring stations furnished under Division 23 Section "Instrumentation and Control for Mechanical Systems"; gauges and meters; and smoke detectors furnished under Division 26 – Electrical.
- C. Install ducts in accordance with SMACNA HVACDCS.
- D. Duct Sizes are inside clear dimensions. For lined ducts, maintain sizes inside lining.
- E. "Fishmouth" duct connections are not allowed.
- F. Inner tie-rod reinforcement is not allowed. Increase duct sheet metal gauge or external reinforcement as required.
- G. Exposed Ducts:
 1. Handle with care for a neat appearance. Repair or replace dented or damaged ductwork as required by the Architect. Select hangers for appearance, and to prevent sagging or distortion of duct.
 2. Remove labels attached to ducts before receiving paint.
- H. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- I. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- J. Use crimp joints with or without bead for joining round duct sizes 8 inch (200 mm) and smaller with crimp in direction of air flow.
- K. Use double nuts and lock washers on threaded rod supports. Strap hangers shall be minimum 16 gauge (1.50 mm) x 1 inch (25 mm) galvanized straps. Hanger and support components

including but not limited to “unistrut” shall be galvanized steel except that where other duct materials are used, the hanger materials shall be compatible and non-corrosive to the duct. Wire hangers are not acceptable.

L. Flexible Ducts:

1. Connect diffusers or light troffer boots to low pressure supply ducts directly or with 5 feet (1.5 m) maximum length of flexible duct held in place with strap or clamp.
2. Minimum bend radius shall be one and one half times the duct diameter. Support the bend to maintain this radius.
3. Bends shall not exceed 45 degrees.
4. Connect flexible ducts to metal ducts with 2 turns of duct tape and metal draw bands. Plastic drawbands may be used if they are installed using the band manufacturer’s lever-action tightening tool. On insulated flexible ducts, provide an additional seal of tape and drawband on the insulation’s vapor barrier.

M. Set plenum doors 6 to 12 inches (150 to 300 mm) above floor. Arrange door swings so that fan static pressure holds door in closed position.

N. During construction, provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system. Do not start ducted air moving equipment until construction is completed to a stage where airborne construction dust is no longer present. At the time of substantial completion, the entire air distribution system shall be turned over to the Owner clear of construction dust and debris. If the interior surfaces of any ducted air moving equipment or the interior surfaces of any portion of the ductwork distribution system are found, as determined by the Architect, to contain significant construction dust and debris, the entire air distribution system shall be cleaned in accordance with **Division 23**. If proper precautions are taken to prevent construction dust and debris from entering the ductwork during construction and if the Architect finds all ductwork to be free from such dust and debris, air duct cleaning shall not be required.

O. For fresh air intake and exhaust plenums connected to louvers or brick or block vents, pitch bottom of plenums down to bottom of louver at minimum 1/4 inch per foot (2 percent). Seal connections and joints on bottom of plenums watertight with mastic. Connect bottom of plenum to top-inside edge of bottom louver blade or waterstop as detailed on the Drawings, to ensure positive drainage

P. Install duct-mounted components furnished under other Sections of this Specification, such as smoke dampers, control dampers, control sensors, and smoke detectors. Install with straight lengths of duct as required for proper operation. Provide access at such components as required. Install in accessible locations for maintenance; notify the Architect if a location indicated or selected requires addition of access by other trades.

3.2 AIR DUCT LEAKAGE TESTS

A. Perform air duct leakage tests in accordance with the testing procedures outlined in the latest edition of the SMACNA HVAC Air Duct Leakage Test Manual.

B. Leakage testing shall be performed on complete ductwork including fittings and accessories such as dampers, access doors, branch connections, and inlets and outlets. Flexible ducts, VAV

boxes, air handling units, and duct coils may be excluded. Ducts may be temporarily sectioned and capped for testing, for reasons of limited test apparatus capacity, or requirements of construction phasing.

- C. Leakage tests, including retests as required, shall be performed prior to concealment and insulation.
- D. The Following Duct Systems Shall Be Tested for Leakage, regardless of whether or not SMACNA recommends testing:
 - 1. Ductwork associated with equipment installed under this project, whether or not the ductwork was installed as part of this project.
- E. Submit testing apparatus, procedures, and preliminary forms prior to performing tests.
- F. Once leakage tests are complete, submit leakage test report. Leakage test report forms shall include the following:
 - 1. Project and system identification data
 - 2. Description of ductwork under test
 - 3. Leakage class specified
 - 4. Test pressure specified
 - 5. Duct construction pressure class
 - 6. Duct design air flow
 - 7. Surface area of ductwork under test
 - 8. Maximum allowable leakage factor
 - 9. Calculated allowable leakage
 - 10. Test apparatus
 - a. Blower
 - b. Orifice, tube size
 - c. Orifice size
 - d. Orifice coefficient
 - e. Calibration date
 - 11. Test orifice differential pressure
 - 12. Leakage for tested section
 - 13. Total leakage for system
 - 14. Date of test
 - 15. Witnesses
- G. Air duct leakage testing shall be performed by an experienced agency that is independent of the Testing, Adjusting and Balancing (TAB) Agency specified in Division 01 - Testing, Adjusting and Balancing.
- H. The TAB Agent shall witness the duct leakage tests performed under Division 23. At a minimum, the first duct leakage test shall be witnessed and approved by the TAB Agent and the Engineer. At a minimum, subsequent duct leakage tests shall be witnessed and approved by the TAB Agent. The TAB Agent shall confirm proper testing procedures and shall give written approval of the leakage tests. If deficiencies are discovered, the TAB agent shall document these deficiencies to the Contractor and the Engineer. Once deficiencies are corrected, the TAB Agent shall witness follow-up leakage tests.

I. Coordinate with TAB Agency and receive written sign-off of the leakage tests by the TAB Agent prior to submitting leakage test report.

J. Leakage Class Schedule:

DUCT PRESSURE CLASS	DUCT TYPE	LEAKAGE CLASS
Below 3 inch W.G.	Rectangular Metal	12
Below 3 inch W.G.	Round Metal	6
3 inch W.G. and above	Rectangular Metal	6
3 inch W.G. and above	Round Metal	3

3.3 SCHEDULES

A. Ductwork Material Schedule

AIR SYSTEM	MATERIAL
Low Pressure Supply (Heating Systems)	Galvanized Steel, Aluminum
Low Pressure Supply (System with Cooling Coils)	Galvanized Steel, Aluminum
Medium and High Pressure Supply	Galvanized Steel
Return and Relief	Galvanized Steel, Aluminum
General Exhaust	Galvanized Steel, Aluminum
Outside Air Intake	Galvanized Steel, Aluminum
Combustion Air	Galvanized Steel, Aluminum

B. Ductwork Pressure Class Schedule

AIR SYSTEM	SMACNA PRESSURE CLASS
Supply (Heating Systems)	2 inch (500 Pa)
Supply (System with	2 inch (500 Pa)
Return and Relief	2 inch (500 Pa)
General Exhaust	2 inch (500 Pa)
Outside Air Intake	2 inch (500 Pa)

Combustion Air

1 inch (250 Pa)

END OF SECTION 233113

SECTION 233700 - AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Diffusers.
- B. Registers/Grilles.
- C. Louvers.

1.2 RELATED SECTIONS

- A. Division 09 Section "Interior Painting": Painting of ductwork visible behind outlets and inlets.
- B. Division 23 Section "Particulate Air Filtration".

1.3 REFERENCES

- A. AAMA 611 - Voluntary Specification for Anodized Architectural Aluminum.
- B. ADC 1062 - Certification, Rating and Test Manual.
- C. AMCA 500 - Test Method for Louvers, Dampers and Shutters.
- D. AMCA 511 - Certified Ratings Program for Air Control Devices
- E. ARI 650 - Air Outlets and Inlets.
- F. ASHRAE 70 - Method of Testing for Rating the Air Flow Performance of Outlets and Inlets.
- G. ASTM E90 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
- H. ASTM E413 - Classification for Rating Sound Insulation.
- I. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.
- J. NFPA 70 - National Electrical Code.
- K. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.

1.4 SUBMITTALS

- A. Submit under provisions of Division 01 Section "Submittal Procedures."
- B. Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets

indicating type, size, application, rated airflow, noise level, pressure drop, and throw distance as applicable. Submit both manufacturer's standard performance tables and graphs, AND tabulated selection data specific to this project. NOTE: Submittals without complete and sufficient information to verify the performance specified and scheduled on the Drawings will be rejected.

1.5 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Division 01 Section "Closeout Procedures."
- B. Record actual locations of air outlets and inlets.

1.6 QUALITY ASSURANCE

- A. Test and rate air outlet and inlet performance in accordance with ADC Equipment Test Code 1062 and ASHRAE 70.
- B. Test and rate louver performance in accordance with AMCA 500.

1.7 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this Section with minimum 3 years' experience.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Diffusers, Registers, and Grilles:
 - 1. Anemostat.
 - 2. Krueger.
 - 3. Metalaire.
 - 4. Price.
 - 5. Titus.
- B. Louvers:
 - 1. Greenheck.
 - 2. American Warming and Ventilating.
 - 3. Arrow.
 - 4. Ruskin.
 - 5. United Enertech.
- C. No substitutions.

2.2 RECTANGULAR CEILING DIFFUSERS

- A. Type: Square and rectangular, multi-louvered directional diffuser to discharge air in pattern as indicated. Removable and interchangeable core for cleaning and changing patterns without

tools.

- B. Frame: Surface mount, inverted T-bar, snap-in, or spline type, as indicated and as required to be compatible with ceiling. In plaster ceilings, provide plaster frame and ceiling frame.
- C. Fabrication: Aluminum with baked enamel off-white finish.
- D. Accessories: Opposed blade damper and multi-louvered equalizing grid, with damper adjustable from diffuser face.

2.3 CEILING EXHAUST AND RETURN REGISTERS/GRILLES

- A. Type: Streamlined blades, 3/4 inch (19 mm) minimum depth, 3/4 inch (19 mm) maximum spacing, with blades set at 45 degrees, vertical or horizontal face as indicated.
- B. Frame: 1-1/4 inch (32 mm) margin with countersunk screw concealed mounting.
- C. Fabrication: Steel with 20 gauge (0.90 mm) minimum frames and 22 gauge (0.80 mm) minimum blades, steel and aluminum with 20 gauge (0.90 mm) minimum frame, or aluminum extrusions, as indicated, with factory off-white enamel finish.
- D. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face where not individually connected to exhaust fans.
- E. Gymnasiums: Provide front pivoted or welded-in-place blades, securely fastened to be immobile.

2.4 WALL SUPPLY REGISTERS/GRILLES

- A. Type: Streamlined and individually adjustable blades, 3/4 inch (19 mm) minimum depth, 3/4 inch (19 mm) maximum spacing with spring or other device to set blades, vertical or horizontal face as indicated, double deflection.
- B. Frame: 1-1/4 inch (32 mm) margin with countersunk screw concealed mounting and gasket.
- C. Fabrication: Steel with 20 gauge (0.90 mm) minimum frames and 22 gauge (0.80 mm) minimum blades, steel and aluminum with 20 gauge (0.90 mm) minimum frame, or aluminum extrusions, as indicated, with factory off-white enamel finish.
- D. Damper: Integral, gang-operated opposed blade type with removable key operator, operable from face.
- E. Gymnasiums: Provide front pivoted or welded in place blades, securely fastened to be immobile.

2.5 WALL EXHAUST AND RETURN REGISTERS/GRILLES

- A. Type: Streamlined blades, 3/4 inch (19 mm) minimum depth, 3/4 inch (19 mm) maximum spacing, with blades set at 45 degrees, vertical or horizontal face as indicated.

- B. Frame: 1-1/4 inch (32 mm) margin with countersunk screw concealed mounting.
- C. Fabrication: Steel with 20 gauge (0.90 mm) minimum frames and 22 gauge (0.80 mm) minimum blades, steel and aluminum with 20 gauge (0.90 mm) minimum frame, or aluminum extrusions, as indicated, with factory off-white enamel finish.
- D. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face where not individually connected to exhaust fans.
- E. Gymnasiums: Provide front pivoted or welded-in-place blades, securely fastened to be immobile.

2.6 LOUVERS (4-INCH)

- A. Louvers shall be equal to, and shall have free areas no less than, Greenheck Model ESD-435.
- B. For reference, free area of a model ESD-435 in 48 inch x 48 inch (1.2 m x 1.2 m) size is 8.9 sq. ft (0.82 m²).
- C. Free area velocity at beginning of water penetration shall be at least 989 fpm (5.0 m/sec). Beginning of water penetration is defined by AMCA as 0.01 oz. per sq. ft (3 g/m²).
- D. Air pressure drop for intake air at an air velocity of 1000 fpm (5.0 m/sec) in intake mode shall not exceed 0.19 in. wg (47.3 Pa).
- E. Testing for water penetration and air performance shall be in accordance with AMCA Standard 511, using a 48 inch x 48 inch (1.2 m x 1.2 m) louver.
- F. Type: 4 inch (100 mm) deep with drainable blades on approximately 37 to 45 degree slope, heavy channel frame, removable expanded aluminum bird screen with 1/2 inch (13mm) mesh mounted on interior face.
- G. Fabrication: 0.081 inch (2.05 mm) thick 6063-T5 extruded aluminum alloy, welded assembly.
- H. Mounting: Furnish with standard box frame and angles for installation. Provide accessories including flanged frame, extended sills, and clip angles as necessary for installation in accordance with Architectural details.
- I. Finish: Factory 2-coat, 1.2-mil (0.03 mm) thickness 70 percent Kynar 500/Hylar 5000 fluoropolymer finish, with 10-year warranty. Submit manufacturer's standard color chart in electronic and hard copy formats. The Architect will select color for each louver individually, with up to 4 different colors for the project. Accessories visible from outdoors or exposed to the airstream, such as interior and exterior screens, shall have finish identical to the louver.
- J. Louvers shall bear the AMCA rating seal for water penetration and air performance.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Check location of outlets and inlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.
- C. Install outlets and inlets to ductwork with air tight connection.
- D. Slope ducts or plenums at louvers to drain outward, and seal bottoms watertight.
- E. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.
- F. Paint ductwork visible behind air outlets and inlets matte black. Refer to Division 09 Section "Interior Painting."
- G. Surfaces exposed to view shall be clean, and free of stains, smudges, and scratches.

END OF SECTION 233700

SECTION 236313 – AIR-COOLED REFRIGERANT CONDENSERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Condenser package.
- B. Charge of refrigerant and oil.
- C. Controls and control connections.
- D. Refrigerant piping connections.
- E. Motor starters.
- F. Electrical power connections.

1.2 RELATED SECTIONS

- A. Division 23 Section “Refrigerant Piping.”
- B. Division 26 “Electrical.”

1.3 REFERENCES

- A. ARI 210/240 - Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
- B. ARI 270 - Sound Rating of Outdoor Unitary Equipment.
- C. ASHRAE 15 - Safety Code for Mechanical Refrigeration.
- D. ASHRAE 90.1 - Energy Standard for Buildings Except Low-Rise Residential Construction.
- E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- F. NEMA MG 1 - Motors and Generators.
- G. UL 207 - Refrigerant-Containing Components and Accessories, Non-Electrical.
- H. UL 427 – Refrigerating Units.

1.4 SUBMITTALS

- A. Division 01 Section “Submittal Procedures”: Procedures for submittals.
- B. Shop Drawings: Indicate components, assembly, dimensions, weights and loadings, required clearances, and location and size of field connections.

- C. Product Data: Provide rated capacities, weights specialties and accessories, electrical nameplate data, and wiring diagrams.

1.5 SUBMITTALS AT PROJECT CLOSEOUT

- A. Submit under provisions of Division 01 Section “Closeout Procedures”: Procedures for submittals.
- B. Operation and Maintenance Data: Include start-up instructions, maintenance instructions, parts lists, controls, and accessories. Submit under provisions of Division 01 Section “Operation and Maintenance Data.”

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this Section with minimum 3 years’ experience.

1.7 REGULATORY REQUIREMENTS

- A. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.8 DELIVERY, STORAGE, AND PROTECTION

- A. Division 01 Section “Product Requirements”: Transport, handle, store, and protect products.
- B. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.
- C. Protect units on site from physical damage. Protect coils.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. York.
- B. McQuay International.
- C. Bohn, a division of Heatcraft Worldwide Refrigeration.
- D. No substitution.

2.2 MANUFACTURED UNITS

- A. Description: Factory assembled and tested; consisting of casing, coils, fans and motors, fan guards, mounting legs, and unit controls. Fan motors shall be factory wired to a common electrical junction box.

2.3 CABINET

- A. The cabinet shall be aluminum or G90 galvanized steel. Motors shall be supported by 11 ga galvanized steel rail fastened to the coil center and end supports. Each fan section shall be in an individual compartment, separated from other fan sections by cabinetry.
- B. Legs and lifting brackets shall be 11 ga galvanized steel. Leg height shall be 20 in. (500 mm) unless otherwise indicated. Provide extended legs, in height indicated on the Drawings. Available heights include 30, 36, or 42 in. (760, 914, or 1066 mm).
- C. Mount starters and controls in weatherproof panel provided with full opening access doors. Provide disconnect switch on the outside of the panel.
- D. Provide removable access doors or panels with quick fasteners and piano hinges.

2.4 CONDENSER COILS

- A. Coils: Seamless copper tubes on a staggered tube pattern. Tubes shall be mechanically expanded into continuous, corrugated, rippled [aluminum] [copper] plate type fins for permanent metal-to-metal contact. The fins shall have full depth fin collars completely covering the copper tube.
- B. The coil shall be "floating tube type" with refrigerant carrying tubes not touching the galvanized end plates. The coil shall be supported by non-refrigerant carrying copper tubes that are expanded into the coil.
- C. Heavy wall copper headers shall have dimpled stub tubes from the coil and a beaded hole for the large connection tube, both items to assure good brazing surface and joint strength. Headers shall be field piped to prevent excessive vibration from discharge gas pulsations.
- D. Coil shall have an integral subcooler pre-piped from the condenser outlet. Subcooler shall be rated at 10 degrees F (5.5 degrees C) of subcooling at a 25 degrees F (13.8 degrees C) temperature difference between the ambient and the condensing temperature.
- E. Coils shall have a working pressure of 400 psig (2758 kPa). A field-supplied 450 psig (3100 kPa) relief device, one per circuit, is required on units up to two circuits.
- F. Coils shall be factory leak tested, dehydrated and connection ends spun closed. Unit shall be shipped under pressure with a dry air or nitrogen holding charge.
- G. Coil Coating: Completely coat the fins and tubes. Provide 3000-hour salt spray protection (ASTM B117).
 - 1. Manufacturers:
 - a. ElectroFin, a division of Luvata – E-Coat water-based flexible epoxy polymer coating, with a UV-resistant urethane mastic topcoat.
 - b. Heresite Protective Coatings, LLC – modified baked phenolic coating, with a UV-resistant polyurethane topcoat.
 - c. No substitutions.

2.5 FANS AND MOTORS

- A. Vertical discharge direct driven propeller type condenser fans with aluminum blades and steel spider, and PVC coated steel fan guard on discharge.
- B. Fan blades shall be designed for low noise, and shall provide the noise level as scheduled on the Drawings, tested in accordance with ARI 270.
- C. Open drip-proof motors suitable for outdoor use, 3-phase or single-phase permanent split capacitor or electronically commutated (EC), with permanent lubricated ball bearings and built in current and thermal overload protection.
- D. Motors as indicated, in compliance with Division 23 Section "Common Motor Requirements for HVAC Equipment."

2.6 CONTROLS

- A. On unit, mount weatherproof steel control panel, NEMA 250, containing power and control wiring, factory wired with single point power connection.
- B. For each condenser fan, provide a contactor with fuses or circuit breaker.

2.7 HEAD PRESSURE CONTROL

- A. Provide a means of fan cycling. This shall be automatic in operation without daily or seasonal adjustment. Controls shall be factory-mounted and wired in a weatherproof electric panel. Control shall one of the following options:
 - 1. Terminal board to individual contactor for field connection to the building controller that cycles fans based on load requirements and ambient temperature.
 - 2. Pressure control for each contactor cycling individual motors.
 - 3. Variable speed motor controlled by sensing head pressure to modulate speed of header fan in relation to changing pressures, in combination with A or B.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's installation instructions.
- B. Complete structural, mechanical, and electrical connections in accordance with manufacturer's installation instructions.
- C. Provide for connection to electrical service. Refer to Division 26.
- D. Install units on vibration isolation. Refer to Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
- E. Provide connection to refrigeration piping system and evaporators. Refer to Division 23

Section "Refrigerant Piping." Comply with ASHRAE 15.

- F. Furnish charge of refrigerant and oil.

3.2 DEMONSTRATION AND INSTRUCTIONS

- A. Division 01 Section "Closeout Procedures": Demonstrating installed work.
- B. Supply initial charge of refrigerant and oil for each refrigeration system. Replace losses of oil or refrigerant prior to end of correction period.
- C. Charge system with refrigerant and test entire system for leaks after completion of installation. Repair leaks, put system into operation, and test equipment performance.
- D. Shut-down system if initial start-up and testing takes place in winter and machines are to remain inoperative. Repeat start-up and testing operation at beginning of first cooling season.
- E. Provide cooling season start-up, and winter season shut-down for first year of operation.
- F. Inspect and test for refrigerant leaks every [month] [2 months] during first year of operation.

END OF SECTION 236313

SECTION 237423.13 - PACKAGED, DIRECT-FIRED, OUTDOOR, HEATING-ONLY MAKEUP-AIR
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 outdoor, direct, gas-fired heating-only, makeup air units, including the following components:
 - 1. Casings.
 - 2. Outdoor-air intake hood.
 - 3. Fans, drives, and motors.
 - 4. Air filtration.
 - 5. Dampers.
 - 6. Direct, gas-fired burners.
 - 7. Unit control panel.
 - 8. Controls.
 - 9. Accessories.

1.3 ACTION SUBMITTALS

- A. Product Data: For each outdoor, direct, gas-fired heating-only, makeup air 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 filters with performance characteristics.

7. Include direct, gas-fired burners with performance characteristics.
8. Include dampers, including housings, linkages, and operators.

B. Shop Drawings: For each outdoor, direct, gas-fired, heating-only, makeup air 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. Detail fabrication and assembly of gas-fired heating and ventilating units, as well as procedures and diagrams.
4. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For vibration isolation 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 for designing vibration isolation bases.

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. Sample Warranty: For manufacturer's warranty.

C. Seismic Qualification Data: Certificates for outdoor, direct, gas-fired, heating-only, makeup air 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.

D. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force 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.

- E. Startup service reports.
- F. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For direct, gas-fired, heating-only, makeup air 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 unit.
 - 2. Gaskets: One set(s) for each access door.
 - 3. Fan Belts: One set(s) for each unit.

1.7 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of direct-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Entire Unit: Manufacturer's standard, but not less than one year(s) from date of Substantial Completion.
 - 2. Warranty Period for Burners: 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 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, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- F. Seismic Performance: Indoor, indirect gas-fired, heating and ventilating units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 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."

2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CaptiveAire Systems.
 - 2. Modine Manufacturing Company.
 - 3. Rapid Engineering, Inc.

2.3 UNIT CASINGS

- A. General Fabrication Requirements for Casings:
 - 1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
 - 2. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
 - 3. Makeup Air Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.
- B. Configuration: Horizontal unit with horizontal discharge for concrete-base installation.
- C. Double-Wall Construction:
 - 1. Outside Casing Wall: Galvanized steel, minimum 18 gauge (1.3 mm) thick, with manufacturer's standard finish.
 - 2. Inside Casing Wall:
 - a. Inside Casing, Burner Section: Galvanized steel, solid, minimum 14-gauge-(0.759-mm-) thick steel.
 - b. Inside Casing, All Other Sections: Galvanized steel solid steel.
 - 3. Floor Plate: Galvanized steel, minimum 18 gauge (1.3 mm) thick.
 - 4. Casing Insulation:
 - a. Materials: Glass-fiber blanket or board insulation, Type I or Type II ASTM C1071.
 - b. Casing Panel R-Value: Minimum <Insert value>.

- c. Insulation Thickness: [**1 inch (25 mm)**] [**2 inches (50 mm)**].
 - d. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.
 5. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
- D. 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 airflow.
 - c. Gasket: Neoprene, applied around entire perimeters of panel frames.
 - d. Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components.
 2. Doors:
 - a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
 - b. 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 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 unobstructed access for inspection and maintenance of unit's internal components.
 3. Locations and Applications:
 - a. Fan Section: Doors and inspection and access panels.
 - b. Access Section: Doors.
 - c. Gas-Fired Burner 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.
 4. Service Light: 100-W vaporproof fixture with switched junction box located adjacent to door.
 - a. Locations: Each section accessed with door.

2.4 OUTDOOR-AIR INTAKE HOOD

- A. Type: Manufacturer's standard hood or louver.
- B. Materials: Match cabinet.
- C. Bird Screen: Comply with requirements in ASHRAE 62.1.
- D. Filter: Aluminum, [**1 inch (25 mm)**] [**2 inches (50 mm)**] <Insert dimension> cleanable.
- E. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.

2.5 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. Fans: Centrifugal, rated according to AMCA 210; galvanized steel; mounted on solid-steel shaft.
 - 1. Shafts: With field-adjustable alignment.
 - 2. Shaft Bearings: Heavy-duty[, **self-aligning, permanently lubricated ball bearings**][, **pillow-block bearings**] with an L50 rated life of 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.
 - 4. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 1 inch**25 mm**.
 - 5. Shaft Lubrication Lines: Extended to a location outside the casing.
 - 6. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches (89 mm) wide, attached to two strips of minimum 2-3/4-inch- (70-mm-) wide by 0.028-inch- (0.7-mm-) 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: Factory-mounted V-belt drive, with adjustable alignment and belt tensioning, and with 1.5 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- (2.7-mm-) thick, 3/4-inch(20-mm) diamond-mesh wire screen, welded to steel angle frame; prime coated.
- D. 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. Motor Sizes: Maximum sizes 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: Open, dripproof.
4. Enclosure Materials: Cast iron.
5. Motor Bearings: <Insert requirements>.
6. Efficiency: Premium efficient as defined in NEMA MG 1.
7. NEMA Design: <Insert designation>.
8. 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.

2.6 SHAFT GROUNDING RINGS

- A. Manufacturers:
 1. Electro Static Technology Inc. - Aegis SGR product line.
 2. Inpro/Seal, a division of Waukesha Bearings Corporation - CDR product line.
- B. Provide shaft grounding rings (SGRs) on 3-phase motors which are intended to be used with variable-frequency drives (VFDs). The SGRs may be furnished by the motor manufacturer as an integral part of the motor, furnished factory-installed by the equipment manufacturer, or furnished for field installation by the equipment installer.
- C. Description: Circumferential micro-fiber ring with metal frame, designed to conduct VFD-induced bearing currents from the motor shaft to ground. Provides protection recommended in NEMA MG 1. Provide with mounting kit including bolts and bracket, or conductive epoxy to adhere to motor casing, to ensure ground connection from the SGR to the motor frame.
- D. Provide SGRs on at least one end of the motor. On motors above 100 hp (74.5 kW), provide a bearing insulation kit on the end of the motor without an SGR.

2.7 AIR FILTRATION

- A. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
- B. Panel Filters:
 1. Description: Flat, non-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.
 4. Filter-Media Frame: Beverage board with perforated metal retainer, or metal grid, on outlet side.
- C. Cleanable Filters:

1. Cleanable metal mesh.
- D. Adhesive, Sustainability Projects: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
- E. Adhesive, LEED for Schools Projects: As recommended by air-filter manufacturer and that complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- F. Side-Access Filter Mounting Frames:
 1. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. Galvanized steel track.
 - a. 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.

2.8 DAMPERS

- A. Dampers: Comply with requirements in Section 230923.12 "Control Dampers."
- B. 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 sintered bronze or nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. (20 L/s per sq. m) at 1-inch wg (250 Pa) and 8 cfm/sq. ft. (40 L/s per sq. m) at 4-inch wg (1.0 MPa) rated in accordance with AMCA 500D.
- 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. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
6. Size dampers for running torque calculated as follows:
 - a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.
 - b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. (62 kg-cm/sq. m) of damper.
 - c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft (49.6 kg-cm/sq. m) of damper.
 - d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
 - e. Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
 - f. Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): 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]**.
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 (Minus 30 to plus 50 deg C)] [40 to 104 deg F (5 to 40 deg C)]**.
14. Run Time: **[12 seconds open, 5 seconds closed] [30 seconds] [60 seconds] [120 seconds]**.

2.9 DIRECT-FIRED GAS BURNER

- A. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47 and with NFPA 54.
- B. CSA Approval: Designed and certified by and bearing label of CSA.
- C. Burners: Aluminized steel with stainless-steel inserts.
 1. Rated Minimum Turndown Ratio: 30 to 1.
 2. Fuel: **[Natural] [Propane]** gas.
 3. Ignition: Electronically controlled electric spark with flame sensor.
 4. Gas Control Valve: **[Single stage] [Two stage] [Modulating]**.

5. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, **[hydraulic] [electronic]**-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
6. High-Altitude **[Model] [Kit]**: For Project elevations more than **2000 feet (610 m)** above sea level.

D. Safety Controls:

1. Gas Manifold: Safety switches and controls complying with ANSI standards **[and] [FM Global] <Insert insurer>**.
2. Vent Flow Verification: **[Differential pressure switch to verify open vent] [Flame rollout switch]**.
3. High Limit: Thermal switch or fuse to stop burner.
4. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
5. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
6. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
7. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
8. Control Transformer: 24 V ac.

2.10 UNIT CONTROL PANEL

- A. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.
- B. Control Panel: **[Surface-mounted] [Recessed, with trim ring,]** remote panel, with engraved plastic cover and the following lights and switches:
 1. **[On-off] [On-off-auto]** fan switch.
 2. Heat-vent-off switch.
 3. Supply-fan operation indicating light.
 4. Heating operation indicating light.
 5. Thermostat.
 6. Damper position potentiometer.
 7. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
 8. Safety-lockout indicating light.
 9. Enclosure: NEMA 250, **[Type 1] [Type 3R] [Type 4] [Explosion proof]**.

2.11 CONTROLS

- A. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for control equipment and sequence of operation.

B. Control Devices:

1. Remote Thermostat: Adjustable room thermostat with temperature readout.
2. Remote Setback Thermostat: Adjustable room thermostat without temperature readout.
3. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
4. Fire-Protection Thermostats: Fixed or adjustable settings to operate at not less than **75 deg F (24 deg C)** above normal maximum operating temperature.
5. Timers, Seven Day:
 - a. Programming-switch timer with synchronous-timing motor and seven-day dial.
 - b. Continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover.
 - c. Multiple-switch trippers.
 - d. Minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.
6. Timers, Solid State:
 - a. Programmable time control with four separate programs.
 - b. 24-hour battery carryover.
 - c. Individual on-off-auto switches for each program.
 - d. 365-day calendar with 20 programmable holidays.
 - e. Choice of fail-safe operation for each program.
 - f. System fault alarm.
7. Ionization-Type Smoke Detectors:
 - a. 24-V dc, nominal.
 - b. Self-restoring.
 - c. Plug-in arrangement.
 - d. Integral visual-indicating light.
 - e. Sensitivity that can be tested and adjusted in place after installation.
 - f. Integral addressable module.
 - g. Remote controllability.
 - h. Responsive to both visible and invisible products of combustion.
 - i. Self-compensating for changes in environmental conditions.

C. Fan Control, Interlocked: Fan to start with exhaust fan(s) to which this heating and ventilating unit is associated for makeup air.

D. Fan Control, Timer: Timer starts and stops direct-fired heating and ventilating unit and exhaust fan(s).

E. Outdoor-Air Damper Control, 100 Percent Outdoor-Air Units: Outdoor-air damper shall open when supply fan starts, and close when fan stops.

F. Mixed Outdoor- and Return-Air Damper Control: When fan is running, outdoor- and return-air dampers shall modulate to supply minimum outdoor air as follows:

1. Minimum [30] <Insert number> percent outdoor air.
2. Outdoor-air quantity adjusted by potentiometer on control panel.
3. Outdoor-air quantity to maintain minimum building static pressure.

G. Temperature Control:

1. Operates gas valve to maintain discharge-air temperature with factory-mounted sensor in blower outlet.
2. Operates gas valve to maintain space temperature with wall-mounting, field-wired sensor[**with temperature adjustment,**] [**and unit-mounted control adjustment**] [**and adjustment on remote-control panel**].
3. Timer shall select remote setback thermostat to maintain space temperature at [**50 deg F (10 deg C)**] <Insert temperature>.
4. Burner Control, Stepped: Two or four steps of control using one or two burner sections in series.
5. Burner Control, Modulating: 20 to 100 percent modulation of the firing rate. 10 to 100 percent with dual burner units.

H. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display status and alarms of heating and ventilating unit.

1. Hardwired Points:

- a. Room temperature.
- b. Discharge-air temperature.
- c. Burner operating.

2. ASHRAE 135.1 (BACnet) communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the heating and ventilating unit from an operator workstation. Control features and monitoring points displayed locally at heating and ventilating unit control panel shall be available through the DDC system for HVAC.

2.12 ACCESSORIES

- A. Electric heater with integral thermostat maintains minimum **50 deg F (10 deg C)** temperature in gas burner compartment.
- B. 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.
- C. Low-ambient kit using staged condenser fans for operation down to **35 deg F (1.7 deg C)**.
- D. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
- E. Coil guards of painted, galvanized-steel wire.

- F. Hail guards of galvanized steel, painted to match casing.

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.

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 roughing-in for piping, ducts, and electrical systems to verify actual locations of piping and electrical connections before equipment installation.
- C. Verify cleanliness of airflow path to include inner-casing surfaces, filters, coils, turning vanes, fan wheels, and other components.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Unit Support: Install unit level on structural steel supports. Coordinate roof penetrations and flashing with roof construction. Secure units to structural support with anchor bolts. Coordinate sizes and locations of steel supports with actual equipment provided.
 1. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- B. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."

- C. Install controls and equipment shipped by manufacturer for field installation with direct-fired heating and ventilating units.

3.3 PIPING CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
 - 1. Gas Piping: Comply with requirements in [**Section 231123 "Facility Natural-Gas Piping."**] [**Section 231126 "Facility Liquefied-Petroleum Gas Piping."**] Connect gas piping with shutoff valve and union, and with sufficient clearance for burner removal and service. Make final connections of gas piping to unit with corrugated, stainless-steel tubing flexible connectors complying with ANSI LC 1/CSA 6.26 equipment connections.
- B. Drain: Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for traps and accessories on piping connections to condensate drain pans under condensing heat exchangers.
- C. Where installing piping adjacent to heating and ventilating units, allow space for service and maintenance.

3.4 DUCT CONNECTIONS

- A. Duct Connections: Connect supply ducts to direct-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.

3.5 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 (13 mm)** high.

3.6 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.7 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - 1. Inspect for visible damage to burner combustion chamber.
 - 2. Inspect casing insulation for integrity, moisture content, and adhesion.
 - 3. Verify that clearances have been provided for servicing.
 - 4. Verify that controls are connected and operable.
 - 5. Verify that filters are installed.
 - 6. Purge gas line.
 - 7. Inspect and adjust vibration isolators.
 - 8. Verify bearing lubrication.
 - 9. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 - 10. Adjust fan belts to proper alignment and tension.
- C. Start unit according to manufacturer's written instructions.
 - 1. Complete startup sheets and attach copy with Contractor's startup report.
 - 2. Inspect and record performance of interlocks and protective devices; verify sequences.
 - 3. Operate unit for run-in period recommended by manufacturer.
 - 4. Perform the following operations for both minimum and maximum firing, and adjust burner for peak efficiency:
 - a. Measure gas pressure at manifold.
 - b. Measure combustion-air temperature at inlet to combustion chamber.
 - c. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
 - 5. Calibrate thermostats.
 - 6. Adjust and inspect high-temperature limits.
 - 7. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
 - 8. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
 - 9. Measure and record airflow. Plot fan volumes on fan curve.
 - 10. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:

- a. High-limit heat.
- b. Alarms.

- 11. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
- 12. Verify drain-pan performance.
- 13. Verify outdoor-air damper operation.

3.8 ADJUSTING

- A. Adjust initial temperature set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- 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.

3.9 CLEANING

- A. After completing system installation and testing, adjusting, and balancing makeup air 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.

3.10 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- 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 tests and inspections with the assistance of a factory-authorized service representative.
- E. Units will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

3.11 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain heating and ventilating units.

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END OF SECTION 237423.13

SECTION 238126 - SPLIT-SYSTEM AIR-CONDITIONERS

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 split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.
- C. Samples for Initial Selection: For units with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For split-system air-conditioning 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 QUALITY ASSURANCE

- 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. ASHRAE Compliance:
 - 1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
 - 2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Procedures," and Section 7 - "Construction and System Start-up."
- C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

1.8 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."
- B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period:
 - a. For Compressor: Five year(s) from date of Substantial Completion.
 - b. For Parts: Five year(s) from date of Substantial Completion.
 - c. For Labor: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Daikin.
2. Mitsubishi Electric & Electronics USA, Inc.
3. YORK; a Johnson Controls company.

2.2 INDOOR UNITS (5 TONS (18 kW) OR LESS)

- A. Wall-Mounted, Evaporator-Fan Components:

1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
3. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
4. Fan: Direct drive, centrifugal.
5. Fan Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
 - c. Enclosure Type: Totally enclosed, fan cooled.
 - d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
 - e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 - f. Mount unit-mounted disconnect switches on interior of unit.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
7. Condensate Drain Pans:
 - a. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
 - 1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.

- 2) Depth: A minimum of **1 inch (25 mm)** deep.
 - b. Single-wall, galvanized-steel sheet.
 - c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
 - 1) Minimum Connection Size: **NPS 1 (DN 25)**.
 - d. Pan-Top Surface Coating: Asphaltic waterproofing compound.
8. Air Filtration Section:
- a. General Requirements for Air Filtration Section:
 - 1) Comply with NFPA 90A.
 - 2) Minimum MERV according to ASHRAE 52.2.
 - 3) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.
 - b. Disposable Panel Filters:
 - 1) Factory-fabricated, viscous-coated, flat-panel type.
 - 2) Thickness: **1 inch (25 mm)**.
 - 3) MERV according to ASHRAE 52.2: 8.
 - 4) Media: Interlaced glass fibers sprayed with nonflammable adhesive.
 - 5) Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, and hinged; with pull and retaining handles.
 - c. Extended-Surface, Disposable Panel Filters:
 - 1) Factory-fabricated, dry, extended-surface type.
 - 2) Thickness: **1 inch (25 mm)**.
 - 3) MERV according to ASHRAE 52.2: 8.
 - 4) Media: Fibrous material formed into deep-V-shaped pleats and held by self-supporting wire grid.
 - 5) Media-Grid Frame: Galvanized steel.
 - 6) Mounting Frames: Welded, galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

2.3 OUTDOOR UNITS (**5 TONS (18 kW)** OR LESS)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - a. Compressor Type: Scroll.
 - b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
 - c. Refrigerant: R-410A.
 - d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.
3. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
4. Fan: Aluminum-propeller type, directly connected to motor.
5. Motor: Permanently lubricated, with integral thermal-overload protection.
6. Low Ambient Kit: Permits operation down to 45 deg F (7 deg C).
7. Mounting Base: Polyethylene.

2.4 ACCESSORIES

- A. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- B. Thermostat: Low voltage with subbase to control compressor and evaporator fan.
- C. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:
 1. Compressor time delay.
 2. 24-hour time control of system stop and start.
 3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
 4. Fan-speed selection including auto setting.
- D. Automatic-reset timer to prevent rapid cycling of compressor.
- E. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
- F. Drain Hose: For condensate.
- G. Monitoring:
 1. Monitor constant and variable motor loads.
 2. Monitor variable-frequency-drive operation.
 3. Monitor economizer cycle.
 4. Monitor cooling load.
 5. Monitor air distribution static pressure and ventilation air volumes.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install units level and plumb.
- B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- C. Install roof-mounted, compressor-condenser components on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.
- D. Equipment Mounting:
 - 1. Install ground-mounted, compressor-condenser components on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Install ground-mounted, compressor-condenser components on polyethylene mounting base.
 - 3. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 4. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
 - 1. Water Coil Connections: Comply with requirements specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Connect hydronic piping to supply and return coil connections with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
 - 2. Remote, Water-Cooled Condenser Connections: Comply with requirements specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Connect hydronic piping to supply and return connections with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
- B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

- C. Duct Connections: Duct installation requirements are specified in Section 233113 "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Section 233300 "Air Duct Accessories."

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.4 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.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 238126