PROJECT MANUAL FOR

HVAC UPGRADES
LAUDERDALE COUNTY
MERIDIAN, MS

Lauderdale County

CONSTRUCTION DOCUMENTS
OCTOBER 4, 2022

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ERN PN: 22.006.00

October 4, 2022

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PROCUREMENT AND CONTRACTING REQUIREMENTS

SECTION 002113 – INSTRUCTIONS TO BIDDERS

PART 1 - GENERAL

1.1 OWNER

A. Lauderdale County, Mississippi

1.2 PROJECT

A. HVAC Upgrades
Lauderdale County
Meridian, MS

1.3 QUESTIONS

A. Questions should be directed to Engineering Resource Group (ERG). Should a Bidder find discrepancies in, or omissions from the plans and specifications, or be in doubt as to their meaning, the Bidder should immediately notify ERG in writing. Engineering Resource Group (ERG) will send written instruction(s) or interpretation(s) to all known holders of the documents. Neither the Owner nor the Design Professional will be responsible for nor bound by any oral instruction or interpretation. Contact Engineering Resource Group, Inc., (bsaxton@ergms.com), Phone- (601)362-3552; Facsimile – (601)366-6418.

1.4 BIDDERS QUALIFICATIONS

A. The Owner may make such investigation as he deems necessary to determine the ability of the Bidder or subcontractors or suppliers to perform the Work, and the Bidder shall furnish to the Owner all such information and data for this purpose as the Owner may request. The Owner reserves the right to reject any bid if the evidence submitted by, or investigation of such Bidder fails to satisfy the Owner that such Bidder is properly qualified to carry out the obligations of the Contract and/or to complete the work contemplated therein within the time required.

B. The Bidder is specifically advised that any person, firm or other party to whom it proposes to award a subcontract or purchase order under this Contract must be acceptable to the Owner.

1.5 PERFORMANCE BOND

A. On construction projects that exceed twenty-five thousand dollars ($25,000.00), a Performance Bond is required. The performance bond must be issued through a licensed MS agent and will be made a part of the construction contract agreement. See Section 006000 – Contract Bonds.

1.6 TAX ON CONSTRUCTION

A. It is incumbent upon the bidder to be familiar with the laws of the state concerning tax on construction.

1.7 DISQUALIFICATION OF BIDDER

A. The Owner reserves the right to award to other than the low Bidder when, in the Owner's judgment, it is in his best interest to do so. A Bidder may be disqualified for such reasons as:

1. Bidder's failure to sign Bidder's Proposal Form, Section 004113 – Bid Proposal Form, or to otherwise properly complete the Proposal Form.
2. Bidder being in arrears on existing contracts.
3. Bidder being in litigation with the Owner.
4. Bidder having defaulted on a previous contract.
5. Bidder having performed unsatisfactorily on a previous contract, including but not limited to the Bidder's failure to fulfill the warranty obligations of a previous contract with the Owner.
6. Firms that have worked for the Owner in the previous twelve months prior to the bid date of the project whose work has been considered by the Owner to be below the quality generally accepted in the industry; or firms who, in the same period, have failed to deliver work in a timely manner on prior Owner's construction projects will not be permitted to bid on this project.
7. The above is not an inclusive list.

1.8 CONDITIONS OF WORK

A. Each Bidder must fully inform himself of all conditions relating to the construction of the Project and employment of labor thereon. Failure to do so will not relieve a successful Bidder of obligations to furnish all material and labor necessary to carry out the provisions of the Contract. Insofar as possible, the Bidder must employ methods, or means, which will not cause interruption of, or interference with, the work of any other Bidder, or Contractor.

1.9 EXAMINATION OF SITE

A. All Bidders, including subcontractors, shall visit the Project site, compare the plans and specifications with any work in place and be informed of all conditions. Failure to visit the site will in no way relieve the successful Bidder from furnishing any materials or performing any work required to complete work in accordance with the plans and specifications without additional cost to the Owner.

1.10 LAWS AND REGULATIONS

A. The Bidder must comply with applicable laws, rules and regulations of all authorities having jurisdiction over the Project at no additional costs to the Owner whether such laws, ordinances, rules and regulations are adopted or enacted before or after bid opening.

1.11 OBLIGATION OF BIDDER

A. At the bid opening, each Bidder will be presumed to have inspected the site, read and become thoroughly familiar with the plans and specifications, including all addenda.

1.12 PRE-BID CONFERENCE

A. A pre-bid conference will be scheduled, and notification sent out via memorandum or addendum. The pre-bid conference will be held at the project site.

PART 2 - PROPOSAL FORM

2.1 METHOD OF BIDDING

A. Lump sum bids received from General Contractors which shall include general, mechanical, electrical and demolition work as well as other work shown on and reasonably inferable from the plans and specifications.

2.2 PROPOSAL FORMS

A. The Bidder shall submit its proposal in duplicate on forms provided and shall fill all applicable blank spaces without interlineation or alteration and must not restate the work to be done. Forms must be typed or written in ink and any alterations to bid prices must be initialed. No oral proposals will be considered.

B. All received bid proposals shall be binding for a minimum of sixty (60) days from bid date.

C. By submission of its bid, Bidder agrees to commence work on or before the date specified in a written notice to proceed and to fully complete the work within the time stated in the bid proposal form.

2.3 ALTERNATES

A. The Proposal Form shall contain a brief description of each alternate modifying the scope. The Bidder shall write out the amount in words and include the numerical amount for each alternate. The written word shall govern.

2.4 SUBSTITUTIONS

A. No substitutions, qualifications or redefining of the Specification requirements are allowed to be marked on the Proposal Form, unless specifically required by the Bid Documents.

2.5 BIDDER IDENTIFICATION

A. Signature: The Proposal Form shall be signed in ink by any individual authorized to bind the Bidder.

B. Name of Bidder: The name appearing on the Proposal Form should be the same as the name appearing in the current Mississippi State Board of Contractors Roster.

C. Legal Address: The address appearing on the Proposal Form should be the same address appearing in the current Mississippi State Board of Contractors Roster.

D. Certificate of Responsibility Number(s): The Certificate of Responsibility Number(s) appearing on the Proposal Form should be the same number appearing in the current Mississippi State Board of Contractors Roster.

2.6 BID SECURITY

A. The Bid Security, which must accompany each Bid, shall be in the form of a Bid Bond, or a Certified Check:

1. Bid Bond: The Bidder may submit a Bid Bond by a Surety licensed in Mississippi in the amount of five percent (5%) of the base Bid. The Bid Bond shall be duly executed by the Bidder, the Surety and a Mississippi resident agent. (No standard form is required for the Bid Bond.)
2. Certified Check: The Bidder may submit a certified check payable to Owner in the amount of five percent (5%) of the base Bid. All checks received from Bidders will be returned upon request, unless a Bidder is one (1) of the three (3) apparent low Bidders. The three (3) apparent low Bidder's' checks will be held for forty-five (45) days, unless a Contract is awarded and executed in less time. Personal and company checks that are not bank encumbered are not acceptable bid securities.
3. Bids received that do not accompany the Bid Security will not be considered.

2.7 POWER OF ATTORNEY

A. Each bid bond must be accompanied by an appropriate Power of Attorney.

PART 3 - SUBMITTING THE PROPOSAL FORM

3.1 SUBMITTAL

A. A bid must be delivered to the address indicated on the Advertisement for Bids prior to the time and date stated for opening of Bids. Bids shall be submitted in sealed opaque envelope marked, mailed or hand-delivered as follows:

Name of Bidder
(As it appears in the current Mississippi State Board of Contractors Roster)

Lauderdale County Administrator, Chris Lafferty
410 Constitution Avenue, 11th Floor
Meridian, MS 39301

Bid for: HVAC Upgrades Lauderdale County
Date:

B. If the Bid is mailed, the bid envelope shall be placed inside a second envelope to prevent inadvertent premature opening of the Proposal.

3.2 MODIFICATION TO BID

A. A modification or qualification to the bid written on the outside of the sealed envelope containing the bid will be accepted. The change will be read aloud prior to the bid envelope being publicly opened. The Agent of the company that modified the bid on the sealed envelope must initial and date the modification. A facsimile modification will not be accepted.

3.3 WITHDRAWAL OF BID

A. Any bid may be withdrawn prior to the scheduled time for opening of bids or authorized postponement of same. Any bid received after the date and time specified will not be considered. However, bids received at the scheduled time constitute irrevocable offers to contract at the price in the bid and may not be withdrawn until sixty (60) days after opening of bids. 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 4 - BID OPENING AND AWARD OF CONTRACT

4.1 OPENING OF BIDS

A. Bids will be opened privately by the Owner.

4.2 IRREGULARITIES

A. The omission of any information requested on the Proposal Form may be considered as an informality, or irregularity, by the Owner when in his opinion the omitted information does not alter the amount contained in the submitted bid proposal, or place other Bidders at a disadvantage.

4.3 ERRORS

A. Any claim of error and request for release from bid must be delivered in writing to the Owner within twenty-four (24) hours after the bid opening. The Bidder shall provide sufficient documentation with the written request clearly proving an error was made and the Bidder’s intended bid.

4.4 AWARD OF CONTRACT

A. The Owner reserves the right to reject any or all bids and to waive any and all irregularities. If awarded, a contract will be awarded, as soon as possible, to a responsible Bidder whose responsive bid proposal is the lowest and best bid, provided the bid is reasonable and it is to the best interest of the Owner to accept it.

4.5 FAILURE TO ENTER INTO A CONTRACT

A. The Bidder shall forfeit the Bid Security to the Owner as liquidated damages for failure, or refusal, to execute and deliver the Contract, Bond and Certificate of Insurance within the required ten (10) days after notice of the acceptance of the bid.

4.6 SECURITY FOR FAITHFUL PERFORMANCE

A. Simultaneously, with delivery of the executed Contract, the Contractor will furnish Performance and Payment Bonds, as security for faithful performance, the payment of all persons performing labor on the project, and furnishing materials in connection with this Contract. The Surety on such Bonds will be a duly authorized surety company licensed to do business in Mississippi and satisfactory to the Owner and meeting all of the following requirements:

1. Licensed at the time of award by the State of Mississippi's Commissioner of Insurance for the purpose of providing surety.
2. Listed at the time of award in the Department of the Treasury's Federal Register as a company holding certificates of authority as acceptable sureties on Federal Bonds, commonly referred to as the Treasury List.
3. All Bonds shall be executed on the form acceptable to Owner.
4. All Bonds shall be countersigned by a Mississippi resident agent with the name and address typed, or lettered legibly.
5. All Bonds must be accompanied by an appropriate Power of Attorney.

4.7 INSURANCE

A. Prior to beginning work on the site, a Certificate of Insurance must be delivered to the Owner. See Project Specifications for requirements.

PART 5 - BIDDER'S CHECKLIST

5.1 PROPOSAL FORM

A. Base Bid.

( ) Write in the amount of the base bid in words and numbers.

B. Alternates.

( ) Write in each alternates amount in words and numbers.

C. Addenda.

( ) Acknowledge the receipt of each addendum by writing in the number of the addendum and the date received.

D. Acceptance.

( ) Proposal is signed by authorized person.
( ) Name of Business as it appears in the current Mississippi State Board of Contractors Roster.
( ) Legal address of the business listed above.
( ) Correct Certificate of Responsibility Number(s) as it appears in the current Mississippi State Board of Contractors Roster.

5.2 BID SECURITY

A. Bid security.

( ) Included Bid Bond
or
( ) Included Certified Check

5.3 POWER OF ATTORNEY

A. Power of attorney.

( ) Included Power of Attorney for Bid Bond

END OF SECTION 002113

SECTION 004113 – BID PROPOSAL FORM

To: Lauderdale County Administrator
Chris Lafferty
410 Constitution Avenue, 11th Floor
Meridian, MS 39301

Project: HVAC Upgrades
Lauderdale County
Meridian, MS

Having carefully examined all conditions of the Contract and all Amendments, Supplements and Addenda thereto, having visited the site and being familiar with the conditions thereof, I or We propose to furnish all labor, materials and equipment to complete all work required by the Contract Documents entitled HVAC UPGRADES, LAUDERDALE COUNTY for the amount set forth below:

BASE BID (Write in the amount of the base bid in words and numbers. The written word shall govern.)

Words _____ Dollars ($_____)

TIME OF COMPLETION

I propose to complete all work in accordance with the Project Manual and Drawings within 365 consecutive calendar days from written Notice to Proceed.

LIQUIDATED DAMAGES

The stipulated liquidated damages described in Paragraph 9.11 of the Supplementary Conditions are in the amount of Two Hundred Fifty Dollars and No/100--------- Dollars ($250.00) for each calendar day.

ALLOWANCES

None

ADDENDA ACKNOWLEDGEMENT

Bidder acknowledges receipt of the following Addenda:

Addendum No. _____ Dated _____
Addendum No. _____ Dated _____
Addendum No. _____ Dated _____
Addendum No. _____ Dated _____
Addendum No. _____ Dated _____

ACCEPTANCE

I certify that I am authorized to enter into a binding contract, if this Proposal is accepted.

Signature _____ Date _____

Name & Title _____

Business Name _____

Complete spelling of bidder's name and address – exact as recorded at the Secretary of State

Address (mailing) _____

Address (physical) _____

City/State/Zip Code _____

Phone _____ Fax _____ email _____

I, or We, agree to hold our bid open for acceptance for sixty (60) calendar days from the date of opening of bids.

Enclosed herewith is Bid Bond or Certified Check in an amount equal to five percent (5%) of the Base Bid, guaranteeing the Owner the execution of the Performance and Payment Bonds and the Contract.

BIDDER'S CERTIFICATE OF RESPONSIBILITY NUMBER(S) _____

GUARANTEE OF WORK

Upon completion of work and prior to final payment, the Contractor shall provide the Owner with a written guarantee warranting that all workmanship and materials are free from defects and that he shall promptly repair or replace without additional cost to the Owner any defects which evidence themselves within one (1) year after date of completion and acceptance of work.

MECHANICAL / PLUMBING / ELECTRICAL CONTRACTORS

Regarding said Divisions of the Specifications of the Standard Form of Agreement Between The Owner and The Contractor: List any Mechanical, Plumbing and/or Electrical Sub-Contractors that will perform work of this contract. COR must be included where sub-contract exceeds $50,000.00. If no sub-contractor is listed, and such work is within scope of contract and over $50,000.00, bidder's own COR classification(s) must be sufficient to self-perform any such work. If no sub-contractor is listed, then use of sub-contractor to perform such scope will not be permitted.

Mechanical Contractor _____ Certificate of Responsibility No. _____

Plumbing Contractor _____ Certificate of Responsibility No. _____

Electrical Contractor _____ Certificate of Responsibility No. _____

END OF SECTION 004113

SECTION 005214 – STANDARD FORM OF AGREEMENT BETWEEN OWNER AND CONTRACTOR

PART 1 - GENERAL

1.1 DESCRIPTION

A. The Owner will use the Standard Form of Agreement between Owner and Contractor where the basis of payment is a Stipulated Sum, AIA Document A101, 2007 as a part of the Contract Documents.

END OF SECTION 005214

SECTION 006000 – CONTACT BONDS

PART 1 - GENERAL

1.1 PEFORMANCE BOND

A. The Contractor shall provide an executed AIA Document A312, 2010 Performance Bond as part of the contract Documents.

B. Performance bond shall be issued by a company on the Department of the Treasury's List of Approved Sureties, as per Circular 570.

1.2 PERFORMANCE BOND SUPPLEMENTS

A. The following supplements modify, change, delete from or add to the Performance Bond AIA Document A312, 2010 and must be included in the executed document.

1. Add the phrases "all of its obligations of" after the word "performs" and "in accordance with the terms thereof" after the words "the Construction Contract".

1.3 PAYMENT BOND

A. The Contractor shall provide an executed AIA Document A312, 2010 Payment Bond as part of the Contract Document. No modifications, changes or deletions are required for the Payment Bond.

1.4 STATE LAW

A. The above mentioned documents are construction industry standards but whenever a conflict arises between the documents and State of Mississippi Law, the State law governs.

1.5 POWER OF ATTORNEY

A. Each Bond must be accompanied by an appropriate Power of Attorney.

END OF SECTION 006000

SECTION 006500 – CERTIFICATE OF INSURANCE

PART 1 - GENERAL

1.1 DESCRIPTION

A. The *Certificate of Insurance* is a tabulation of insurance required for this Project as specified in Article 11 entitled *Insurance and Bonds* in the General Conditions (AIA Document A201, 2007 edition).

B. The *Certificate of Insurance* must be completed, certified by the original signature of a Mississippi Resident Insurance Agency and bound in each set of the Contract Documents.

C. Indicate Insured, Project, Companies providing coverage, policy numbers and policy periods in the blanks as applicable.

D. If the “OWNERS / CONTRACTORS PROTECTIVE LIABILITY” insurance is part of the Commercial General Liability Insurance Policy, or included by endorsement, indicate the policy number and period of the CGL policy in the “OWNERS / CONTRACTORS PROTECTIVE LIABILITY” blank spaces.

E. Automobile Liability Insurance may be provided which covers Bodily Injury and Property Damage in one (1) Combined Single Limit, or may be provided with separate minimum limits as shown on the Certificate of Insurance and specified in Article 11 of the Supplementary Conditions. The person signing the Certificate of Insurance should show which option the Contractor has selected by marking out the coverage that is not provided under the policies indicated.

1.2 CERTIFICATION

A. Certification wording may not be changed without specific written approval from the Owner.

1. “Riders” or other unsolicited attachments are not allowed as part of the *Certificate of Insurance* unless specifically requested in writing by the Owner, or specified as part of the requirements for this Project.

1.3 CAUTION

A. The *Certificate of Insurance* is intended to be used for all Projects. The Contractor must provide all insurance specified in the Contract Documents for this Project, whether indicated on this form, or not. The Contractor must verify all insurance has been provided as required.

B. The Owner and Professional and all of their agents and employees are included as additional insureds on the Contractor’s insurance.

END OF SECTION 006500

SECTION 007213 – GENERAL CONDITIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The General Conditions for this project shall be AIA Document A201, 2007 – General Conditions of the Contract for Construction. This document shall be made a part of the Contract Documents as if fully stated herein. Contractors are presumed to be familiar with this document; however a copy may be examined in the Architect's office.

END OF SECTION 007213

SECTION 007313 – SUPPLEMENTARY CONDITIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The following Supplementary Conditions modify the "General Conditions of the Contract for Construction," AIA Document A201, 2007. Where a portion of the General Conditions is modified or deleted by the Supplementary Conditions, the unaltered portions of the General Conditions shall remain in effect. In the event of a conflict between the General Conditions of the Contract for Construction and Section 007313, Section 007313 shall control even if the conflicting provision in the General Conditions of the Contract for Construction is not expressly revised or deleted by reference in Section 007313.

B. The General Conditions may also be supplemented or amplified elsewhere in the Contract Documents by provisions located in, but not necessarily limited to, Division 01 of the Specifications.

1.2 SUPPLEMENTS

ARTICLE 1 – GENERAL PROVISIONS

1.1 BASIC DEFINITIONS

1.1.1 THE CONTRACT DOCUMENTS

1.1.1 Delete the last sentence in Article 1.1.1 and insert the following:

The Contract Documents shall include the Instructions to Bidders, plans, the Project Manual, including Division 00 and the specifications, Divisions 01 through 32, all Addenda and modifications to the plans and/or specifications, the Agreement between Owner and Contractor, the performance and payment bonds, the notice to proceed and any executed change orders. Information and documentation pertaining to soil investigation data, laboratory investigations, soil borings and related information included herein are not part of the Contract Documents. In the event of a conflict between the provisions of Division 00 and any other section of the Contract Documents, such other sections(s) shall govern.

1.1.5 THE DRAWINGS

1.1.5 Add the following to the end of Article 1.1.5:

Large scale drawings shall govern over small scale drawings where there are differences or conflicts between such drawings. Where the word “similar” appears on the plans, it shall not be interpreted to mean “identical” and shall require the Contractor to coordinate the actual conditions and dimensions of the location where the “similar” conditions are shown to occur.

1.1.9 MISCELLANEOUS DEFINITIONS

1.1.9 Add the following Article 1.1.9:

The term "products" as used in these Supplementary Conditions includes materials, systems and equipment.

1.2 CORRELATION AND INTENT OF THE CONTRACT DOCUMENTS

1.2.4 Add the following to the end of Article 1.2.4:

It is the intent of the Contract Documents that the Contractor shall properly execute and complete the Work described by the Contract Documents, and unless otherwise provided in the Contract, the Contractor shall provide all labor, materials, equipment, tools, construction equipment and machinery, water, heat, utilities, transportation, and other facilities and services, whether temporary or permanent and whether or not incorporated in the Work, in full accordance with the Contract Documents and reasonably inferable from them as necessary to produce the indicated results.

1.2.5 Add the following to the end of Article 1.2.5:

The Contract Documents shall be interpreted collectively, each part complementing the others and consistent with the intent of the Contract Documents. Unless an item shown or described in the Contract Documents is specifically identified to be furnished or installed by the Owner or others or is identified as “Not In Contract” (“N.I.C.”), the Contractor’s obligation relative to that item shall be interpreted to include furnishing, assembling, installing, finishing, and/or connecting the item at the Contractor’s expense to produce a product or system that is complete, appropriately tested, and in operable condition ready for use or subsequent construction or operation of the Owner or separate contractors. The omission of words or phrases for brevity of the Contract Documents, the inadvertent omission of words or phrases, or obvious typographical or written errors shall not defeat such interpretation as long as it is reasonably inferable from the Contract Documents as a whole.

Words or phrases used in the Contract Documents which have well-known technical or construction industry meanings are to be interpreted consistent with such recognized meanings unless otherwise indicated.

Except as noted otherwise, references to standard specifications or publications of associations, bureaus, or organizations shall mean the latest edition of the referenced standard specification or publication as of the date of the Advertisement of Bids.

In the case of inconsistency between Drawings and Specifications or within either document not clarified by addendum, the better quality or greater quantity of Work shall be provided in accordance with the Professional’s interpretation.

Generally, portions of the Contract Documents written in longhand take precedence over typed portions, and typed portions take precedence over printed portions.

Any doubt as to the meaning of the Contract Documents or any obscurity as to the wording of them shall be promptly submitted in writing to the Professional for written interpretation, explanation, or clarification.

1.6 TRANSMISSION OF DATA IN DIGITAL FORMAT

1.6 Delete the phrase “they shall endeavor to” in the second line and insert the phrase “the Professional shall” and add the following to the end of the sentence:

…, which protocols shall be the same as or similar to the Digital Data Protocol Exhibit, AIA Doc. E201, 2007.”

ARTICLE 2 – OWNER

2.2 INFORMATION AND SERVICES REQUIRED OF THE OWNER

2.2.1 Delete this subparagraph in its entirety.

2.2.2 Delete this subparagraph in its entirety.

2.2.3 Delete this subparagraph in its entirety.

2.3 OWNER'S RIGHT TO STOP THE WORK

2.3 Delete this subparagraph in its entirety and insert the following:

If the Contractor fails to correct Work which is not in accordance with the requirements of the Contract Documents as required by Paragraph 12.2 or fails to carry out Work in accordance with the Contract Documents or fails to perform any of its obligations under the Contract Documents, the Owner may issue a written order to the Contractor to stop the Work, or any portion thereof, until the cause for such order has been eliminated; however, the right of the Owner to stop the Work shall not give rise to a duty on the part of the Owner to exercise this right for the benefit of the Contractor or any other person or entity, except to the extent required by Subparagraph 6.1.3.

The rights and remedies under this Article 2.3 are in addition to and do not in any respect limit any other rights of the Owner, including its termination rights under Article 14.

2.4 OWNER'S RIGHT TO CARRY OUT THE WORK

2.4 Delete this subparagraph in its entirety and insert the following:

If the Contractor defaults or neglects to carry out the Work in accordance with the Contract Documents and fails, within a seven (7) day period, after receipt of written notice from the Owner, to commence and continue correction of such default or neglect with diligence and promptness, the Owner may, without prejudice to other remedies the Owner may have, correct such deficiencies without further notice to the Contractor and/or its Surety. In such case an appropriate Change Order shall be issued deducting from payments then or thereafter due the Contractor for the reasonable cost of correcting such deficiencies, including Owner's expenses and compensation for the Professional's additional services made necessary by such default, neglect or failure. Such action by the Owner and amounts charged to the Contractor are both subject to prior approval of the Professional. If payments then or thereafter due the Contractor are not sufficient to cover such amounts, the Contractor or its Surety shall pay the difference to the Owner.

ARTICLE 3 – CONTRACTOR

3.1 GENERAL

3.1.1 Add the following at the end of Article 3.1.1:

The relationship of Contractor to Owner shall be that of independent contractor, and nothing in Contract Documents is intended to nor should it be construed as creating any other relationship, expressed or implied, between Owner and Contractor.

3.4 LABOR AND MATERIALS

3.4.2 Add the following to the end of Article 3.4.2:

Some Sections of the Specifications do not allow substitution of materials, products or equipment. Where “or equal” substitution is allowed the request for substitution will only be considered if made in strict accordance with the requirements of Article 3.4.4 and Section 002113 – Instructions to Bidders.

3.4.4 Add the following Article 3.4.4.

After the Contract has been executed, the Owner and the Professional may consider a request for the substitution of products in place of those specified only under the conditions set forth in the Project Specifications.

By making requests for substitutions, the Contractor:

1. Represents that the Contractor has personally investigated the proposed substitute product and determined that it is equal or superior in all respects to that specified.
2. Represents that the Contractor will provide the same warranty for the substitution that the Contractor would for that specified;
3. Certifies that the cost data presented is complete and includes all related costs under this Contract except the Professional's redesign costs, and waives all claims for additional costs related to the substitution which subsequently becomes apparent; and
4. Will coordinate the installation of the accepted substitute, making such changes as may be required for the work to be completed in all respects.

All substitutions shall be submitted within 30 days of the Notice to Proceed, as per the Project Specifications.

3.4.5 Add the following Article 3.4.5:

Contractor represents that it has independently investigated, considered and understands the labor conditions in the area surrounding the Project and acknowledges that such conditions may impact the Contractor’s cost and/or time of performance of the Contract. Therefore, Contractor further represents that the Contract Price is based upon Contractor’s independent investigations into such labor conditions and that the Contract time is reasonable and the date of Substantial Completion is obtainable. As a result, Contractor assumes the risk of increased costs, if any, incurred by, or arising out of, or related to such labor conditions and acknowledges that Contractor and its surety will reimburse Owner for any additional costs Owner incurs arising out of or related to such labor conditions.

3.4.6 Add the following Article 3.4.6:

E-Verification: Contractor represents and warrants that it will ensure its compliance with the Mississippi Employment Protection Act (Senate Bill 2988 from the 2008 Regular Legislative Session) and will register and participate in the status verification system for all newly hired employees. The term “employee” as used herein means any person that is hired to perform work within the State of Mississippi. As used herein, “status verification system” means the Illegal Immigration Reform and Immigration Responsibility Act of 1996 that is operated by the United States Department of Homeland Security, also known as the E-Verify Program, or any other successor electronic verification system replacing the E-Verify Program. Contractor agrees to maintain records of such compliance and, upon request of the State, to provide a copy of each such verification to the State. Contractor further represents and warrants that any person assigned to perform services hereunder meets the employment eligibility requirements of all immigration laws of the State of Mississippi. Contractor understands and agrees that any breach of these warranties may subject Contractor to the following: (a) termination of this Agreement

and ineligibility for any state or public contract in Mississippi for up to three (3) years with notice of such cancellation/termination being made public, or (b) the loss of any license, permit, certification or other document granted to Contractor by an agency, department or governmental entity for the right to do business in Mississippi for up to one (1) year, or (c) both. In the event of such termination/cancellation, Contractor would also be liable for any additional costs incurred by the State due to contract cancellation or loss of license or permit. See E-Verification / Good Faith Compliance attached.

3.7 PERMITS, FEES AND NOTICES

3.7.1 Delete Article 3.7.1 entirely and insert the following:

The Contractor shall secure and pay for the building permit and all other permits, fees, licenses, inspections and all other approvals and charges necessary for proper execution and completion of the Work.

3.7.3 Delete Article 3.7.3 and insert the following:

At no additional cost to the Owner, the Contractor shall comply with all laws, statutes, ordinances, building codes, rules, and regulations of whatever nature that applies to the Project, whether enacted or adopted before or after bid opening. If the Contractor observes that portions of the Contract Documents are at variance therewith, the Contractor shall promptly notify the Professional and Owner in writing, and necessary changes shall be accomplished by appropriate modification. The Professional shall not administer the Contractor's safety performance, or any other matter relating to Contractor's means, methods, techniques, sequences and procedures, which are not a part of Contractor's scope of Work which is to be administered by the Professional as part of the Professional's obligations.

3.8 ALLOWANCES

3.8.2.3 Add the following to the end of Article 3.8.2.3;

Except when installation is specified as part of the allowance in the General Requirements (Division 01 of the specifications).

3.9 SUPERINTENDENT

3.9.1 Add the following to the end of Article 3.9.1.

The superintendent shall be designated by the Contractor at the preconstruction conference. After Owner's approval of such superintendent, he shall not be replaced by the Contractor without the Owner's prior written consent, which consent is required unless the Contractor submits proof satisfactory to the Owner that the superintendent should be terminated by the Contractor for cause.

3.10 CONTRACTOR'S CONSTRUCTION SCHEDULES

3.10.3 Delete Article 3.10.3 and insert the following:

Time being of the essence, the Contractor shall perform the Work in accordance with the most recent schedule submitted to and approved by the Owner and Professional.

3.12 SHOP DRAWINGS, PRODUCT DATA AND SAMPLES

3.12.6 Delete Article 3.12.6 and insert the following:

By approving and submitting Shop Drawings, Product Data, Samples and similar submittals, the Contractor thereby represents that the Contractor has determined and verified all dimensions, quantities, field dimensions, relationships to existing Work, coordinated with Work to be installed later, coordinated with information on previously accepted shop drawings, Product Data, Samples, and similar submittals and verified compliance with all requirements of the Contract Documents. The accuracy of all such information is the responsibility of the Contractor. In reviewing Shop Drawings, Product Data, Samples and similar submittals the Professional shall be entitled to rely upon the Contractor's representation that such information is correct and accurate.

3.12.8 Add the following to the end of Article 3.12.8:

Unless such written notice has been given, the Professional's approval of a Shop Drawing, Product Data, Sample or similar submittal shall not constitute approval of any changes not requested on the prior submittal.

3.12.9 Add the following to the end of Article 3.12.9:

The Professional's review of the Contractor's submittals will be limited to examination of an initial submittal and one (1) resubmittal. The Professional's review of additional submittals will be made only with the consent of the Owner after notification by the Professional. The Owner shall be entitled to deduct from the Contract Sum amounts paid to the Professional for evaluation of such additional resubmittals.

3.18 INDEMNIFICATION

3.18.1 Modify Article 3.18.1 with the following:

Add the word "defend" before the word "indemnify" in the first line, to add the words "or nonperformance" after the word "performance" in the third line and to delete the phrase "provided that such claim damage, loss or expense is attributable to bodily injury, sickness, disease or death, or to injury to or destruction of tangible property (other than the Work itself)".

ARTICLE 4 – ADMINISTATION OF THE CONTRACT

4.1 PROFESSIONAL

4.1.1 Add the following at the end of this subparagraph:

The terms "Architect", "Professional", "Engineer" or "Design Professional" as used in the Contract Documents refers to the Engineering Resource Group, Inc., 350 Edgewood Terrace Drive, Jackson, MS 39206; Phone: (601) 362-3552; Fax: (601) 366-6418.

4.2 PROFESSIONAL'S ADMINISTRATION OF THE CONTRACT

4.2.10 Delete this subparagraph in its entirety.

ARTICLE 5 – SUBCONTRACTORS

5.2 AWARD OF SUBCONTRACTS AND OTHER CONTRACTS FOR PORTIONS OF THE WORK

5.2.1 Delete the phrase “Unless otherwise stated in the Contract Documents or the bidding requirements, the Contractor, as soon as practicable after award of the Contract” from the first sentence of Article 5.2.1 and replace with the following:

“The Contractor, with its first Application for Payment and as a condition to the Owner’s obligation to make payments to Contractor under Article 9 of the General Conditions as supplemented herein…”

5.2.5 Add the following Article 5.2.5:

The Contractor’s unauthorized substitution of any subcontractor, supplier, person or entity previously listed by Contractor shall entitle the Owner to reject the work, materials or products furnished and require removal and replacement at no additional cost to the Owner.

ARTICLE 6 – CONSTRUCTION BY OWNER OR BY SEPARATE CONTRACTS

6.1 OWNER’S RIGHT TO PERFORM CONSTRUCTION AND TO AWARD SEPARATE CONTRACTS

6.1.1 Delete Articles 6.1, 6.1.1, 6.1.2, 6.1.3, 6.1.4 entirely and insert the following new Article 6.1:

Owner’s Right to Perform Construction and to Award Separate Contracts. The Owner reserves the right to perform construction or operations related to the Project with the Owner’s own forces and to award separate Contracts either in connection with other portions of the Project or other construction or operation on the site. In such event, the Contractor shall coordinate its activities with those of the Owner and of other Contractors so as to facilitate the general progress of all work being performed by all parties. Cooperation will be required in the arrangement for the storage of materials, and in the detailed execution of the work.

The Contractor, including his subcontractors, shall keep informed of the progress and the detailed work of the Owner or other Contractors and shall immediately notify the Professional of lack of progress or delays by the Owner or other Contractors which are affecting Contractor’s Work. Failure of Contractor to keep informed of the progress of the work of the Owner or other Contractors and/or failure of Contractor to give notice of lack of progress or delays by the Owner or other Contractors shall be deemed to be acceptance by Contractor of the status of progress by other Contractors for the proper coordination and completion of Contractor’s Work. If, through acts or neglect on the part of the Contractor, the Owner or any other Contractor or subcontractor shall suffer loss or damage or assert any claims of whatever nature against the Owner, the Contractor shall defend, indemnify and hold harmless the Owner and Professional from any such claims or alleged damages, and the Contractor shall resolve such alleged damages or claims directly with the other Contractors or Subcontractors.

6.2.3 Delete Article 6.2.3 entirely.

ARTICLE 7 – CHANGES IN THE WORK

7.1 CHANGES

7.1.3 Add the following to the end of Article 7.1.3:

Except as permitted in Article 7.3, a change in the Contract Sum or the Contract Time shall only be accomplished by written change order. Therefore, the Contractor acknowledges that it is not entitled to a change in the Contract Sum or the Contract Time in the absence of a written Change

Order on the basis of the course of conduct or dealings between the parties, the Owner's express or implied acceptance of alterations or additions to the Work, the Owner has been unjustly enriched by the Contractor's Work or any other basis otherwise allowed by law or the facts and Contractor agrees that any such extra or changed work was performed by it as a volunteer.

7.2 CHANGE ORDERS

7.2.2 Add the following Article 7.2.2:

Contractor's execution of a change order constitutes a final settlement to the Contract Sum and construction schedule and the Contract Time for all matters relating to or arising out of the change in the Work that is the subject of the change order including, but not limited to, all direct and indirect costs associated with such change, all extended direct job site and home office overhead costs and any and all delay and impact cost for the change, whether alone or in combination with other changes, including any impact, ripple or cumulative effect resulting therefrom, if any.

7.2.4 Add the following Article 7.2.4.:

In order to facilitate consideration of change order requests, all such requests, except those involving an amount less than $500 must be accompanied by a complete itemization of costs, including labor, materials and subcontractor costs which shall likewise be itemized. Changes for more than $500 will not be approved without such itemization.

7.3 CONSTRUCTION CHANGE DIRECTIVES

7.3.7 Modify Article 7.3.7 to the following:

In the first sentence, delete the words "a reasonable amount" and substitute "a reasonable allowance for the combined overhead and profit in accordance with subparagraph 7.3.11 below." Delete Sections 7.3.7.4 and 7.3.7.5 entirely.

7.3.8 Delete the first sentence and insert the following:

The amount of credit to be given by the Contractor to the Owner for a deletion or change which results in a net decrease in the Contract Sum shall be the actual net cost plus a reasonable allowance for overhead and profit thereon as approved by the Professional and Owner.

7.3.11 Add the following Article 7.3.11:

The allowance for overhead, taxes, fees, bonds, insurance and profit attributable to a change included in the total cost to the Owner shall be based on the following schedule. The overhead includes general home office, field personnel, superintendents, labor burden and all costs attributable to field and office personnel.

1. For the Contractor, for work performed by the Contractor's own forces, 16 percent of the cost.
2. For the Contractor, for work performed by the Contractor's subcontractor, 10 percent of the amount due the sub-contractor.
3. For each sub-contractor or sub-subcontractor involved, for work performed by that subcontractor's or sub-subcontractor's own forces, 16 percent of the cost.
4. For each subcontractor, for work performed by the subcontractor's sub-subcontractor's,10 percent of the amount due the sub-subcontractor.
5. Costs to which overhead and profit is to be applied shall be determined in accordance with Subparagraph 7.3.7.

ARTICLE 8 – TIME

8.3 DELAYS AND EXTENSIONS OF TIME

8.3.1 Delete Article 8.3.1 and Insert the following:

If the Contractor is delayed at any time in the commencement or progress of the Work by an act or neglect of the Owner or Professional, or of an employee of either, or of a separate contractor employed by the Owner; or by changes ordered in the Work; or by fire, natural disasters, unavoidable casualties beyond the Contractor's control; or by delay authorized by the Owner pending mediation and arbitration; or by other causes that the Professional determines may justify delay, then the Contract Time shall be extended by Change Order for such reasonable time as the Professional may determine.

8.3.3 Add the following to the end of Article 8.3.3:

No delay, interference, hindrance or disruption, from whatever source or cause, in the progress of the Contractor's Work shall be a basis for an extension of time and/or additional compensation, unless the delay, interference, hindrance or disruption (1) is without the fault and not the responsibility of the Contractor, its subcontractors and suppliers and (2) directly affects the overall completion of the Work as reflected on the critical path of the Contractor's updated and accepted construction schedules. The Contractor expressly agrees that the Owner shall have the benefit of any float in the construction schedule and that delays to construction activities, which do not affect the overall completion of the Work, do not entitle the Contractor to any extension in the Contract Time and/or increase in Contract Sum.

8.3.4 Add the following Article 8.3.4:

Any claims by the Contractor for an increase in the Contract Time must follow the procedures set forth in Articles 15.1.2, 15.1.5 and 15.2, including the requirement that the Contractor give written notice of any claim within twenty-one (21) days after occurrence of the event giving rise to such claim or within twenty-one (21) days after the claimant first recognizes the condition giving rise to the claim, whichever is later.

8.3.5 Add the following Article 8.3.5:

If the Contractor submits a schedule indicating or otherwise expressing intent to complete the Work prior to the date of substantial completion, the Owner shall have no liability to the Contractor for any failure by the Contractor to complete the Work prior to the expiration of the Contract Time.

8.3.6 Add the following Article 8.3.6:

Weather Delays: The Contractor agrees that normal weather occurrences and disruption to construction activities are included in the schedule. Weather occurrences or delays beyond normal are defined as days beyond the NOAA average for this area. Impacted days may be determined by the occurrence of weather events (precipitation > = 0.10inch) that occurred in excess of the average as indicated by NOAA.

The table below defines the monthly anticipated adverse weather days for the contract period and is based upon the NOAA Summary for this area.

7	January	7	April	6	July	5	October
7	February	8	May	5	August	6	November
7	March	6	June	4	September	8	December

The Contractor is responsible for providing the NOAA data as stated above and the observed deviation in excess of the average as defined by the table above. The weather data is to be received monthly with the Application for Payment.

All requests for time extensions shall be made monthly in writing with the Application for Payment. No monetary change in the contract value is considered due to impacted days. The Owner reserves the right to review any requests for consideration of value for extenuating circumstances by the Contractor in regard to schedule and value. The Owner is not obligated under this review for additional compensation as per Article 15.1.5.2.

ARTICLE 9 – PAYMENTS AND COMPLETION

9.3 APPLICATION FOR PAYMENTS

9.3.1 Add the following to the end of Article 9.3.1:

The Form of Application for Payment will be AIA Document G702, Application and Certification for Payment supported with AIA Document G702A, Continuation Sheet.

9.3.1.3 Add the following Article 9.3.1.3:

The Owner will retain, until the Work is one hundred percent (100%) complete, five percent (5%) of the amount due the Contractor on account of progress payments. No reduction in retainage will be made until final payment is made except that when the initial Contract award is in an amount equal to or greater than $750,000, then whenever such Work is fifty percent (50%) complete and on schedule and satisfactory, in the opinion of the Professional and the Owner, fifty percent (50%) of the retainage may be returned to the Contractor and five percent (5%) will be retained on all subsequent progress payments. The Owner may subsequently increase the retainage if the Contractor's manner of completion of the Work and/or its progress does not remain satisfactory to the Professional and/or Owner or if the Surety withholds its consent to payment for other good and sufficient reasons.

9.3.2.1 Add the following Article 9.3.2.1:

Payment on materials stored at some location other than the building site may be approved by the Professional and the Owner after the Contractor has submitted the following items:

1. An acceptable Lease Agreement between the General Contractor and the owner of the land, or building, where the materials are stored covering the specific area where the materials are located.
2. Consent of Surety or other acceptable bond to cover the materials stored off-site.
3. All Perils Insurance coverage for the full value of the materials stored off-site.
4. A Bill of Sale from the Manufacturer to the General Contractor for the stored materials.
5. A complete list and inventory of materials manufactured stored and delivered to the storage site and of materials removed from the storage site and delivered to the job site.
6. A review by the Professional of the materials stored off-site prior to release of payment.
7. Proof of payment of stored materials verified by the supplier must be submitted to the Professional within thirty (30) days of the Application for Payment on which payment for said material was made. If proof of payment is not submitted within thirty (30) days, then payment for said materials will be deducted from the next application for payment and withheld until proof of payment is received.

9.3.2.2 Add the following Article 9.3.2.2:

Affidavit Certifying Payment to All Subcontractors

1. Submit to the Owner, an Affidavit Certifying Payment to All Subcontractors on a monthly basis after the submittal, approval and payment of Application for Payment #1.

9.5 DECISIONS TO WITHHOLD CERTIFICATION

9.5.1.7 Delete the word “failure”.

9.6 PROGRESS PAYMENTS

9.6.1 Delete Article 9.6.1 and insert the following:

Subject to the conditions of the Contract, the Owner shall make payment to the Contractor in the amount certified within forty-five (45) days after receipt of the Certificate for Payment from the Professional. Payment shall not be considered late until forty-five (45) days after Owner’s receipt of the approved Certificate for Payment from the Professional.

9.6.1.1 Add the following Article 9.6.1.1:

Contractor’s Applications for Payment shall be submitted on or before the 15th day of each month. Any application not submitted on or before this date may not be processed or approved until the following month.

9.6.7 Add the following to the end of Article 9.6.7:

The amount retained by the Contractor from each payment to each Subcontractor and material supplier shall not exceed the percentage retained by the Owner from the Contractor.

9.7 FAILURE OF PAYMENT

9.7.1 In the first sentence, delete the words "or awarded by binding dispute resolution".

9.8 SUBSTANTIAL COMPLETION

9.8.1 Delete this subparagraph in its entirety and insert the following:

Substantial completion for purposes of this Contract occurs only upon Contractor’s compliance with the following conditions precedent: (a) the Contractor furnishes to the Professional all close-out documents required by the Contract Documents in a form satisfactory to the Professional and the Owner, (b) the Contractor furnishes the manufacturers’ certifications required by the Contract Documents; (c) the Contractor furnishes the Guarantee of Work required by Section 00 73 13, Paragraphs 12.2.2.1.1; and (d) the Professional certifies that the Work is sufficiently complete in accordance with the Contract Documents so that the Owner can occupy or utilize the Work for its intended purpose.

9.8.2.1 Add the following Article 9.8.2.1:

The Contractor shall be responsible for the costs of inspections made by the Professional including any and all other related expenses incurred by the Professional for providing services for the Project required by failure of the Contractor to achieve final acceptance / completion of the Project within 30 days after the first occurrence of the below described events:

1. Specified date of Substantial Completion; or
2. Actual date of Substantial Completion.

The costs of the Professional's additional services shall be deducted by the Owner from the Contractor's final application for payment to pay the Professional for additional services required by the Contractor's failure to achieve final completion of the project within the 30 day period described above.

9.8.4 Delete the last sentence of Article 9.8.4 and insert the following:

Warranties required by the Contract Documents shall commence on the date of final acceptance / completion unless otherwise provided in the Contract Documents.

9.8.5 Add the following to the end of Article 9.8.5:

Contractor's execution of the Certificate of Substantial Completion constitutes Contractor's representation that the items on the list accompanying the Certificate can and will be completed by Contractor and his subcontractors within thirty (30) days of Contractor's execution of the Certificate. Based upon this representation by Contractor and upon the acknowledgement of the Professional that the listed items remaining can be completed within thirty (30) days, the Owner agrees to execute the Certificate of Substantial Completion. If Contractor fails to complete the items on the list within thirty (30) days of Contractor's execution of the Certificate, then the Owner, at its option and without prejudice to any other rights or remedies it may have under this Contract or otherwise and without notice to Contractor, may proceed to have same completed and to deduct the reasonable costs thereof from the amounts then due or thereafter to become due to Contractor.

9.8.6 Add the following Article 9.8.6:

The costs of inspections requested by Contractor and made by Professional which are not required by Articles 4, 9.8, 9.10.1 or 12 of the General Conditions and any other inspection required by Article 12 other than the year-end inspection itself, will be the responsibility of the Contractor and will be deducted by the Owner from the Application for Payment submitted after the Owner's receipt of the Professional's statement for its costs of additional inspections. These costs are not the result of Contractor's failure to timely complete the Contract within the specified time and, therefore, such costs are in addition to and not a part of any liquidated damages calculation, if any.

9.8.7 Add the following Article 9.8.7:

Upon the Owner's acceptance of the Work as substantially complete and upon Contractor's compliance with all conditions precedent to substantial completion as stated in Section 00 73 13, Paragraph 9.8.1 and upon application by the Contractor, the Owner will pay to the Contractor all retainage held by the Owner less an amount equal to the greater of (a) two percent (2%) of the Contract sum, or (b) two hundred percent (200%) of the estimated cost of the Work remaining to be performed by the Contractor in accordance with the Professional's determination. Final payment, including all retainage, shall be made at the time and in the manner provided for final payment in accordance with the provisions of Article 9.10 and the additional conditions precedent to final acceptance / payment set forth in Section 00 73 13, Paragraphs 9.8.5 and 9.10.

9.9 PARTIAL OCCUPANCY OR USE

9.9.1.2 Add the following new subparagraph:

The Owner's occupancy or use of any completed or partially completed portions of the Work shall not affect Contractor's obligation to complete incomplete items on the list attached to the Certificate of Substantial Completion within the time fixed in the Certificate and does not waive

Owner's right to obtain completion of incomplete items at Contractor's expense upon Contractor's failure to timely complete same.

9.10 FINAL COMPLETION AND FINAL PAYMENT

9.10.2.1 Add the following Article 9.10.2.1:

Final acceptance / completion for purposes of this Contract occurs only upon Contractor's compliance with the following conditions precedent: (a) The Contractor furnishes to the Professional all required close-out documents in a form satisfactory to the Professional and the Owner; (b) the Contractor furnishes all required manufacturers' certifications (c) the Contractor furnishes the signed Guarantee of Work required by Section 00 73 13, Paragraph 12.2.2.1.1; (d) the Professional certifies final acceptance / completion of the Project through issuance of a "Certificate of Final Completion".

9.11 LIQUIDATED DAMAGES

9.11.1 Add Section 9.11 LIQUIDATED DAMAGES and insert the following Article 9.11.1:

Time being of the essence of this Contract and a matter of material consideration thereof, a reasonable estimate in advance is established to cover losses incurred by the Owner if the project is not substantially complete on the date set forth in the Contract Documents. The Contractor and his Surety will be liable for and will pay the Owner the sums hereinafter stipulated as fixed and agreed as liquidated damages for each calendar day for delay until the Work is substantially complete. The Contractor and his Surety acknowledge that the Owner's losses caused by the Contractor's delay are not readily ascertainable and that the amount estimated per day for liquidated damages is reasonable and is not a penalty.

The amount established per day for liquidated damages is $ 250.00.

ARTICLE 10 – SAFETY

10.1 Add the following to the end of Article 10.1:

The Professional shall not administer the Contractor's performance of Article 10 (including subparagraphs 10.1 through 10.4) because the initiation, maintenance and supervision of safety precautions and programs is the sole responsibility of the Contractor as means, methods, techniques, sequences and procedures of construction and, therefore, is not part of the Contractor's scope of Work which is to be administered by the Professional.

ARTICLE 11 – INSURANCE AND BONDS

11.1 CONTRACTOR'S LIABILITY INSURANCE

11.1.1.5 Delete the words "other than the Work itself".

11.1.1.9 Add the following Article 11.1.1.9:

Liability insurance will include all major divisions of coverage and be on a comprehensive basis including:

1. Premises - operations.
2. Independent Contractor's Protective.
3. Products and completed operations.

4. Contractual - including specified provisions for the Contractor's obligations under 3.18.
5. Owned, non-owned and hired motor vehicles.
6. Broad form coverage for property damage.
7. Owner and Professional will be listed as additional insures on policy.

11.1.2 Delete Article 11.1.2 in its entirety and insert the following:

1. GENERAL LIABILITY	
Commercial General Liability (Including XCU)	
General Aggregate	$2,000,000 Aggregate
Products & Completed Operations	$2,000,000 Aggregate
Personal & Advertising Injury	$1,000,000 per Occurrence
Bodily Injury & Property Damage	$1,000,000 per Occurrence
Fire Damage Liability	$500,000 per Occurrence
Medical Expense	$10,000 per Person
2. OWNERS & CONTRACTORS PROTECTIVE LIABILITY	
Bodily Injury & Property Damage	$2,000,000 Aggregate
Bodily Injury & Property Damage	$1,000,000 per Occurrence
3. AUTOMOBILE LIABILITY	
(Owned, non-owned & hired vehicles)	
Contractor Insurance Option No. 1	
Bodily Injury & Property Damage (Combined Single Limit)	$1,000,000 per Occurrence
Contractor Insurance Option No. 1	
Bodily Injury	$500,000 per Person
Bodily Injury	$1,000,000 per Accident
Property Damage	$100,000 per Occurrence
4. EXCESS LIABILITY (UMBRELLA ON PROJECTS OVER $500,000)	
Bodily Injury & Property Damage (Combined Single Limit)	$2,000,000 Aggregate $1,000,000 per Occurrence
5. WORKERS' COMPENSATION EMPLOYERS' LIABILITY (AS REQUIRED BY STATUTE)	
Accident	$100,000 per Occurrence
Disease	$500,000 Policy Limit
Disease	$100,000 per Employee
6. PROPERTY INSURANCE	
Builder's Risk Or	$ Equal to Value of Work
Installation Floater	$ Equal to Value of Work
7. CONTRACTOR'S ERRORS & OMISSIONS AND POLLUTION LIBABILITY	
Contractor's Errors & Omissions and pollution liability	$1,000,0000 per Occurrence
8. COMMERCIAL CONSTRUCTION UMBRELLA	
Commercial Umbrella Insurance	$5,000,000

11.1.5 Add the following Article 11.1.5:

Furnish one copy of certificate herein required for each copy of the Agreement, specifically set forth evidence of all coverage required by Articles 11.1.1, 11.1.1.7 and 11.1.2. The form of the certificate will be AIA Document G705 or a similar form acceptable to Owner. Furnish to the Owner and Professional, copies of any endorsements that are subsequently issued amending coverage or limits. If the coverages are provided on a claims-made basis, the policy date or retroactive date shall predate the Contract and termination date of the policy or applicable extended reporting period shall be no earlier than the termination date of coverages required to be maintained after final payment.

11.2 OWNER'S LIABILITY INSURANCE

11.2 Delete Article 11.2 in its entirety and insert the following:

The Contractor will pay for and maintain such insurance as will protect the Owner and Professional from their contingent liability to others for damages because of bodily injury, including death, which may arise from operations under this Contract and other liability for damages which the Contractor is required to insure under any provision of this Contract. Certificate of this insurance shall be filed with the Owner and Professional and will be the same limits set forth in Article 11.1.2.

11.3 PROPERTY INSURANCE (BUILDERS' RISK OR INSTALLATION FLOATER)

11.3.1 Change the first line of the Article 11.3.1 to read as follows:

"The Contractor shall purchase...."

11.3.1 Add the following to the end of the paragraph:

Such property insurance shall be maintained, unless otherwise provided in the Contract Documents, or otherwise agreed in writing by all persons and entities who are beneficiaries of such insurance, until final payment has been made, as provided in Paragraph 9.10, or until no person or entity other than the Owner has an insurable interest in the property required by this Paragraph 11.3 to be covered, whichever is later.

11.3.1.2 Delete Article 11.3.1.2 in its entirety.

11.3.1.3 Delete Article 11.3.3 in its entirety and insert the following:

If the property insurance requires minimum deductibles and such deductibles are identified in the Contract Documents, the Contractor shall pay the deductible and all other costs not covered because of such deductibles. If the Contractor or insurer increases the required minimum deductibles above the amounts so identified or if the Contractor elects to purchase this insurance with voluntary deductible amounts, the Contractor shall be responsible for payment of the additional costs not covered because of such increased or voluntary deductibles. If deductibles are not identified in the Contract Documents, the Contractor shall pay the amount of the deductible and all costs not covered because of deductibles.

11.3.2 Delete this Subparagraph in its entirety.

11.3.3 Delete this Subparagraph in its entirety.

11.3.4 Delete this Subparagraph in its entirety.

11.3.5 Delete this Subparagraph in its entirety.

11.3.6 Delete this Subparagraph in its entirety.

11.3.10 Delete Article 11.3.10 in its entirety and insert the following:

The Owner, as fiduciary, shall have power to adjust and settle a loss with insurers unless one of the parties in interest shall object in writing within five (5) days after occurrence of loss.

11.5 OWNER'S AND PROFESSIONAL'S PROTECTION

11.5.1 Add Section 11.5 OWNER'S AND PROFESSIONAL'S PROTECTION and insert the following Article 11.5.1:

In addition to the above, the Contractor shall take out in the Owner's and Professional's names, and maintain during the same time period, Public Protective Liability Insurance and Property Damage Insurance in the amount of not less than $1,000,000.000 combined single limit, which policies shall cover the operations of the Contractor, and those of his subcontractors to protect the Owner and Professional from loss. This protection shall not be considered as a separate policy by the Contractor, but shall be a rider to the Contractor's coverage.

ARTICLE 12 – UNCOVERING AND CORRECTION OF WORK

12.2.2.1 Add the following to the end of Article 12.2.2.1:

Prior to the end of the one-year period, the Professional may schedule a warranty inspection, which shall be attended by the Professional, the Owner, the Contractor and all major subcontractors. During this inspection, the parties shall identify all defective and/or nonconforming items and fix a time within which all defective and/or nonconforming items shall be repaired and/or replaced.

12.2.2.1.1 Add the following Article 12.2.2.1.1:

As a condition to Substantial Completion of the Work under Section 007313, Article 9.8.4, Contractor, upon completion of the Work, shall prepare and submit to the Owner a Guarantee of Work, sworn to by the Contractor, stating:

As required by Section 007313, Paragraphs 12.2.2.1.1 and 12.2.2.6, Contractor and Contractor's Surety hereby guarantee that all Work performed on the above captioned project is free from defective and/or nonconforming materials and workmanship and that for a period of one-year for construction, from the date of final completion or such longer period of time as may be called for in the Contract Documents for such portions of the Work, Contractor will repair and/or replace any defective and/or nonconforming materials and workmanship in accordance with the requirements of the Contract Documents.

12.2.6 Add the following Article 12.2.6:

Within the one-year period, if repairs or replacement are requested by Owner in connection with guaranteed Work which, in the opinion of the Owner, are rendered necessary as a result of the use of materials, equipment or workmanship which are inferior, defective or not in accordance with the Contract Documents, the Contractor and/or its Surety shall promptly, upon receipt of notice from and without expense to the Owner, place in satisfactory condition in every particular, all such guaranteed Work, correct all defects therein and make good all damages to the building, site, equipment or contents thereof which, in the opinion of the Owner, are the result of the use of materials, equipment or workmanship which are inferior, defective or not in accordance with the terms of the Contract Documents; and make good any work or materials or the equipment

and contents of said buildings or site disturbed in fulfilling any such guaranty. If, after notice or within the time agreed upon by the parties at the warranty inspection, the Contractor and/or its Surety fail to proceed promptly to comply with the terms of the guarantee, the Owner may have the defects corrected in accordance with Article 2.4 and the Contractor and his Surety shall be liable for all expenses incurred. All special guarantees applicable to definite parts of the Work stipulated in the Contract Documents shall be subject to the terms of this paragraph during the first year of the life of such special guarantee.

ARTICLE 13 – MISCELLANEOUS PROVISIONS

13.6 Delete this Article in its entirety and insert the following:

Payments due and unpaid under the Contract Documents shall bear interest as provided by Mississippi Code, Section 87-7-3.

ARTICLE 14 – TERMINATION OR SUSPENSION OF THE CONTRACT

14.1 TERMINATION BY THE CONTRACTOR

14.1.1.4 Delete Article 14.1.1.4 entirely.

14.2 TERMINATION BY THE OWNER FOR CAUSE

14.2.1.1 Delete the word “repeatedly” from Article 14.2.1.1.

14.2.1.3 Delete the word “repeatedly” from Article 14.2.1.3.

14.2.1.5 Add the following Articles 14.2.1.5 and 14.2.1.6:

5. fails to achieve substantial completion of the Project as described in Section 00 73 13, Article 9.8.5, within the time stated therein;
6. fails to meet any deadline required by the Contract. Contractor acknowledges that time is of the essence for this Contract and that all deadlines required by the Contract are critical to timely completion of the Contract. Therefore, Contractor agrees that its failure to meet any deadline constitutes a substantial and material breach of this Contract, entitling the Owner to terminate the Contract.

14.2.5 Add the following Article 14.2.5:

If the Owner terminates the Contract for cause, and it is determined for any reason that the Contractor was not actually in default under the Contract at the time of termination, the Contractor shall be entitled to recover from the Owner the same amount as the Contractor would be entitled to receive under a termination for convenience as provided by Article 14.4. The foregoing shall constitute the Contractor’s sole and exclusive remedy for termination of the Contract. In no event shall the Contractor be entitled to special, consequential, or exemplary damages, nor shall the Contractor be entitled to anticipated profits resulting from termination of this Contract.

14.4 TERMINATION BY THE OWNER FOR CONVENIENCE

14.4 Delete Articles 14.4.1, 14.4.2, and 14.4.3 entirely and insert the following:

14.4.1 The Owner may, without cause or fault of either the Contractor or the Owner, terminate the Contract in whole or in part if the Owner, in its sole discretion, determines it to be in the Owner's best interest.

14.4.2 Upon the Owner's termination for convenience, the Contractor shall only be entitled to payment as provided in Subparagraph 14.1.2.

14.4.3 In case of such termination for the Owner's convenience, the Contractor shall be entitled to receive payment for reasonable profit and overhead on work performed. The Contractor shall not be entitled to receive any payment for either overhead or profit on work not performed.

ARTICLE 15 – CLAIMS AND DISPUTES

15.1.5 CLAIMS FOR ADDITIONAL TIME

15.1.5.2 Add the following to the end of Article 15.1.5.2:

"The Contractor must submit each month with his Application for Payment a separate letter stating that he is requesting an extension of time for abnormal adverse weather or that he has no claim for an extension for that period of time. Payment is not due on a monthly application until the letter is received. Complete justification, including weather reports, daily reports, correspondence and any other supporting data must be provided for each day for which an extension is requested. A letter or statement that the Contractor was delayed is not an adequate justification. The receipt of this request and data by the Professional will not be considered as Owner or Professional approval of a time extension in any way."

15.2.1 Delete all references to mediation.

15.2.5 Delete the last sentence and its references to mediation.

15.2.6 Delete this paragraph in its entirety.

15.2.8 Delete this paragraph in its entirety.

15.3 Delete the entire paragraph entitled "MEDIATION", including subparagraphs 15.3.1, 15.3.2, and 15.3.3.

15.4 ARBITRATION

15.4.1 Delete this paragraph in its entirety and add the following paragraph as follows:

The Owner shall have the sole option of selecting arbitration as the means for resolving the parties' dispute and the Contractor shall, before initiating any proceeding against the Owner, notify the Owner in writing that it intends to initiate legal proceedings against the Owner which notice shall include a description of the claim(s) and amount(s) thereof. Within ten (10) business days after receipt of such notice, the Owner shall advise the Contractor whether the dispute is to be arbitrated or litigated. If arbitration is selected by the Owner, then any Claim arising out of or related to the Contract, except Claims relating to aesthetic effect and except those waived as provided for in Sections 15.1.6, 9.10.4 and 9.10.5, shall, after decision by the Professional or 30 days after submission of the Claim to the Professional, be subject to arbitration If selected by the Owner at its sole and exclusive option,

15.4.1.1 Delete paragraph 15.4.1.1 in its entirety.

14.4.2 Delete this paragraph and substitute the following:

Claims shall be decided by arbitration, if selected by the Owner, which, unless the parties mutually agree otherwise, shall be in accordance with the Construction Industry Arbitration Rules of the American Arbitration Association currently in effect but not administered by the American Arbitration Association. The demand for arbitration shall be filed in writing with the other party to the Contract and with the American Arbitration Association if the arbitration is to be administered by the American Arbitration Association, and a copy shall be filed with the Professional.

15.4.3 Delete this paragraph and substitute the following:

If arbitration is selected by the Owner, a demand for arbitration shall be made within the time limits specified in Sections 4.4.6 and 4.6.1 as applicable, and in other cases within a reasonable time after the Claim has arisen, and in no event shall it be made after the date when institution of legal or equitable proceedings based on such Claim would be barred by the applicable statute of limitations as determined pursuant to Section 13.7.

15.4.4 Delete Article 15.4.4 CONSOLIDATION OF JOINDER, including subparagraph 15.4.4.1, 15.4.4.2 and 15.4.4.3 in its entirety.

END OF SECTION 007313

SECTION 007314 – PROFESSIONAL'S SPECIAL CONDITIONS

PART 1 - GENERAL

1.1 TERMINOLOGY

A. Professional - Wherever the term or "Professional" is used in the specifications, it refers to Engineering Resource Group, Inc., 350 Edgewood Terrace Drive, Jackson, MS 39206, which is authorized to prepare all drawings, specifications, and details for this work, and to act as the Owner's representative during construction.

B. Owner: Wherever the term "Owner" is used in the specifications, it refers to Alliance Heath Center.

C. Notice: The term "notice" as used herein shall mean and include all written notices, demands, instructions, claims, approvals, and disapprovals required to obtain compliance with contract requirements. 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, firm or corporation constituting the other part of the contract, or to his, their, or its duly authorized agent, representatives, or officer; or when enclosed in a postage prepaid envelope addressed to such last known business address and deposit in a United States mailbox.

D. As Directed: The term "as directed," where used in the specifications, shall mean according to instructions issued by the Professional.

E. Approved - Acceptable - Satisfactory: The term "approved", "acceptable," and "satisfactory" when used in the specifications, shall mean approved by the Professional.

1.2 SCOPE OF WORK

A. This section is the Professional's requirements for implementation of the construction requirements. See Section 007213 – General Conditions and Section 007313 – Supplementary Conditions.

1.3 CONSTRUCTION DOCUMENTS

A. The drawings are intended to show the general arrangement of the work and are not intended to be scaled or to serve as shop drawings. Omission of details concerning local code requirements or proper or normal installations of equipment specified shall not be cause for additional charges or claims. The specifications and the drawings are intended to be in agreement with each other, and to be mutually explanatory. They are also intended to be complementary and any work or material called for by either shall be performed and/or furnished as if called for by both.

B. Any discrepancies within the documents shall be brought to the attention of the Professional a minimum of 5 days before bids are received. After bids are received, any discrepancies will be as interpreted by the Professional and there will be no additional cost to the Owner for these discrepancies.

C. All drawings and specifications are a part of the work to be coordinated by each trade. All subcontractors are responsible to review all of the documents and coordinate heights,

locations, clearances, with all of the drawings. Any discrepancies should be brought to the Architect's attention at least one week before the bid date.

1.4 GENERAL REQUIREMENTS

A. All materials shall be maintained with the established construction laydown area as coordinated and agreed upon with the Owner and Engineer in advance.

B. All construction materials must be submitted at one time for review and approval. It must include all materials to be provided and included in the Contractor's warranty and certifications with no exceptions or exclusions as indicated in the documents.

1.5 BUILDING CODE REQUIREMENTS

A. All parts of building work under contract by General Contractor and other contractors or subcontractors shall be executed in compliance with building codes of governing bodies, such as State Codes and Regulations also, the National Electrical Code and NFPA Life Safety Code. These requirements shall take precedence over the Professional's specifications or plans wherever a conflict exists.

1.6 VERIFICATION OF DIMENSIONS

A. Before starting the construction work, all measurements shall be checked by contractor against dimensions of the plans to insure the intent of the ground floor base dimensions. Differences shall be called to the attention of the Professional for adjustment.

B. Prior to starting the project work, the mechanical contractor and general subcontractor shall field verify all dimensions and wall conditions prior to starting the work.

C. Before ordering any materials or doing any work, each contractor shall verify the dimensions and shall be responsible for the accuracy of such dimensions as they affect the work. No extra compensation will be allowed on account of differences between the dimensions shown on the drawings and actual dimensions.

D. Shop drawing dimensions shall be checked with the building conditions and Professional's drawings for correctness before submitting same for approval to the Professional.

1.7 ENGINEERING AND LAYOUT

A. The Contractor shall provide competent engineering services to execute the work in accordance with the contract requirements. He shall verify the figures shown on the survey and working drawings before undertaking any construction work and shall be responsible for the accuracy of the finished work.

B. The Owner has established or will establish, such general reference points as will in his judgment, enable the Contractor to proceed with the work. If the Contractor finds that any previously established reference points have been destroyed or displaced, he shall promptly notify the Owner.

C. The Contractor shall protect and preserve the established benchmarks and monuments and shall make no change in locations without the written approval of the Owner. Any of them which may

be lost or destroyed or which require shifting because of necessary changes in grades or locations, shall be subject to prior approval by the Owner, be replaced and accurately located by the Contractor.

1.8 OWNER'S RIGHT TO EXPEDITE

A. The Owner reserves the right to aid in expediting materials whenever it is necessary to maintain the building schedule but does not relieve the Contractor of any responsibility in securing materials.

1.9 CONTRACT COORDINATION

A. Multiple contracts could be under way on site during the duration of this contract. Coordination and cooperation will be required to complete the work identified. The Contractor is required to coordinate with the Professional any work which would interfere with other activities on site.

1.10 EXPERIENCE VERIFICATION

A. Immediately after receipt of bids, and upon notification of Owner and/or Professional, furnish the following information for evaluation by the Owner (the Owner reserves the right to evaluate the following information prior to award of contract:

1. Similar Experience: Furnish a complete listing of completed project or on-going projects similar in size and scope to this project, listing complete names, addresses, and telephone numbers of Owners, cost of project, and year completed or anticipated to be completed.
2. Office Staff: Furnish a complete listing of all office staff listing name, address, and title.
3. Superintendent: Furnish a complete resume for the proposed project superintendent, listing previous experience as either Assistant Superintendent or Superintendent. Experience listing shall show scope of projects and proposed superintendent's duties on these projects.

1.11 WORKMANSHIP

A. All work as described or required shall be executed in a neat, skillful manner, in accordance with the best recognized trade practice. Only competent workmen (including the superintendent) who work and perform their duties satisfactory shall be employed on the project, and when requested by the Professional or Owner's Officials, the Contractor shall discharge and shall not re-employ on the project, any person who commits trespass or who is, in the opinion of the Professional, dangerous, disorderly, insubordinate, incompetent, or otherwise objectionable.

1.12 EXISTING UTILITIES

A. Existing structures, plantings, trees, utility lines, and building or landscaping systems, within the work area and outside the work area, which are to be retained unchanged, shall be protected from damage by the Contractor, prior to the start of construction. Any streets, roadways, sidewalks, grounds, plantings, trees, utility line, building or landscaping systems, or other property that are damaged, as a result of the Contract Work, shall be properly repaired or fully replaced by the Contractor to the full satisfaction of the Owner.

B. All utility meters, valves, switches, etc. within the work area shall remain accessible to Owner's employees for the duration of the project.

C. The Contractor shall take all precautions to protect all existing sewer manholes, sewer lines, and storm drains from be infiltrated by construction debris and eroded silt.

D. Utility interruptions and Utility Connections planned as part of the Work shall be coordinated a minimum or ten (10) calendar days prior to interruption of service or occurrence of work. The Owner maintains the right to withhold authorization until it is practical for the work to occur. The Owner utility infrastructure cannot be shut down to make connections without prior notification to all affected Owners Properties and nearby.

E. The Contractor shall notify the Engineer, the Owner, and the Hospital facility director to schedule for any work to occur outside of the established construction area in each phase. The Contractor will coordinate all access to other areas in advance with the Owner and the Architect at least 48 hours in advance.

1.13 UTILITIES, ELECTRICITY, GAS, WATER, FENCE

A. Renovations With-in Existing Buildings.

1. The Owner will not bill the Contractor for utilities unless the practice becomes abusive.

1.14 RESPONSIBILITY OF CONTRACTOR TO ACT IN EMERGENCY

A. In case of an emergency which threatens loss or injury of property and/or safety of life, the Contractor shall act without previous instructions from the Owner, as the situation may warrant. He shall notify the Owner immediately thereafter. Any compensation claimed by the Contractor, together with substantiating documents in regard to expense, shall be submitted to the Owner within twenty-eight (28) consecutive calendar days after each occurrence and the amount of compensation shall be determined by the agreement or arbitration.

1.15 PROTECTION OF PROPERTY, SITE SAFETY AND PROTECTIVE MEASURES

A. The Contractor shall at all times safeguard the Owner’s property from injury or loss in connection with this contract. He shall at all times safeguard and protect his own work and that of adjacent property (as provided by law and the contract documents) from damage. All passageways, guard fences, lights and other facilities required for protection by state or municipal laws and regulations and local conditions must be provided and maintained.

B. The owner will not be responsible for the safety of the Contractor's work, materials or equipment. Protection of the property within the contract work area both day and night shall be the responsibility of the Contractor. The Contractor shall provide a chain and lock for the security gate that can be “double locked” with a Contractor's furnished lock so that the Owner can have access to the job site during emergencies.

C. Precaution shall be exercised at all times for the protection of persons (including employees) and property. The safety provisions of applicable laws, building and construction codes shall be observed. Machinery, equipment, and all hazards shall be guarded or eliminated in accordance with the safety provisions of the latest edition of the Manual of Accident Prevention in Construction, published by the Associated General Contractors of America, to the extent that such provisions are not in contravention of applicable laws and codes.

D. Organized safety measures shall be enforced on all construction work. Daily safety meetings shall be held by the Contractor prior to start of construction each day. The Contractor shall meet all applicable OSHA, and other Federal, State, and local agencies' codes and requirements regarding safety on and adjacent to the construction site.

E. The Contractor shall provide the Owner with a copy of all accident reports for any occurrences on site.

F. The Contractor shall provide protective devices such as signs, lights, barricades, covered walkways, signals, fences and etc., shall be utilized night and day to protect students and personnel on the campus. All temporary construction shall conform to or exceed the requirements of Chapter 33, Safeguards During Construction, of the IBC latest edition.

G. Contractor shall install and maintain a chain link perimeter fence at the edge of designated lay down area and construction boundary. Lay down area shall be graded, fertilized and sodded to the limits of the construction area and maintained throughout the duration of the project.

1. The perimeter fence shall be 6'-0" high with wind screen. Wind screen color shall be selected by Owner.

1.16 FIRE PROTECTION

A. The General Contractor will provide general temporary fire protection as required.

1.17 RISK MANAGEMENT

A. These procedures are intended to enhance occupants' safety, workers' safety, and reduce contractor's liability.
1. Existing fire alarm systems in building must be protected by covering sensors that may cause activation by dirt, dust, smoke, heat or fumes generated by the Contractor's work.
2. "Hot" work requires special attention to ensure safe working conditions and protection to both facilities and workers.

a. Fire Extinguisher.
b. Fire Watch.

3. Failure to adhere to these procedures may result in a "stop work" order and/or being assessed a fire run fee by the local Fire Department for each emergency response the Fire Department makes as a result of the Contractor's work activating the fire alarm system.

1.18 EROSION CONTROL

A. Proper precautions shall be taken by the General Contractor to prevent erosion of the job site and run off from the job site. Precautions shall be taken during construction to prevent mud and debris being transported off the site onto the streets and drives. The Contractor shall repair any eroded areas at the end of the job, and wash streets and parking lots as needed, during the job, to keep them clear of soil, gravel or other material.

B. Contractor shall provide, install and maintain erosion control methods to insure compliance with Mississippi Department of Environmental Quality (MDEQ) requirements. Contractor is responsible for application and approval of MDEQ.

1.19 USE OF PEMISES

A. The Contractor expressly undertakes at his own expense:

1. To store his apparatus, materials, supplies, and equipment in such orderly fashion at the site of the work as will not unduly interfere with the progress of his work or the work of any other contractors.
2. To place upon the work, or any part thereof, only such loads as are consistent with the safety of that portion of the work.
3. To affect all cutting, fitting, or patching of his work required to make the same conform to the plans and specifications, and except with the consent of the Professional not to cut or otherwise alter the work of any other contractor.
4. Before final payment to remove all surplus material, false-work, construction sign, temporary structures, including foundations thereof, plant of any description and debris of every nature resulting from his operations and to put the site in a neat, orderly condition, to thoroughly clean and leave reasonable dust free all finished surfaces on the interior of the building included in the contract; and to wash and polish all glass installed under the contract including the removal of all paint spatters and other defacement.

B. All materials and equipment shall be brought onto the site by making use of such roadways and drives as designated by the Owner and across the grounds along routes established by the Owner. Access shall be confirmed in the pre-construction meeting.

C. Any streets, roadways, sidewalks, grounds, plantings, trees or other property that may be damaged as a result of the contract work shall be properly repaired or fully replaced by the Contractor to the full satisfaction of all interests involved. Trenches cut across roads, streets, drives, and parking lots shall be back-filled, compacted and topped with an acceptable assembly of paving material to match existing paving material. The Owner must approve final paving patch assemblies. Patching asphalt and brick surfaces with concrete is not acceptable.

1.20 TRASH DISPOSAL AND BURNING

A. From the very start of the work, until its entire completion, the Contractor shall keep on hand an adequate crew of laborers, or others to keep the entire building and surrounding street, sidewalks, alleys, etc. free from any dirt, rubbish and debris resulting from the execution of the contract. The Contractor is responsible for keeping the project site clean and litter-free on a daily basis. It shall be the responsibility of each individual prime contractor to provide dumpsters to collect and remove all of their related debris from the building and the sites. Contractor must take necessary precautions to protect asphalt surfaces and concrete surfaces from damage caused by dumpster placement, storage, and retrieval. Contractor will be required to replace all damaged surfaces.

B. Contractor’s use of the Owner's dumpsters, trash cans and other construction dumpsters is strictly prohibited.

C. There shall be no burning on properties of the Owner. All clearing and grubbing, debris, rubbish, trash and any other material which is subject to burning shall be removed and disposed of outside the limits of the Owner's property. It shall be the responsibility of the Contractor to acquire, maintain and pay for, if necessary, a disposal area.

D. No materials of any sort shall be buried on the Owner's property.

1.21 DESIGNATION OF STORAGE AND WORKING AREA

A. The exact boundaries of the area which may be used by the Contractor and subcontractors for the storage of materials and as a working area will be clearly defined in the contract documents. The contract will include the development of the complete work area and both the design and construction operations will be confined to this area.

B. The Contractor shall confine his operations, and provide within the designated storage and work areas any required space for all Sub-Contractors. Any damage to the grounds and irrigation systems within the designated working area or storage area shall be repaired by the Contractor, and left at the completion of the Project, either in the same state as found to exist at the start of the work, or as shown on the Contract Documents. Such damage shall include repairs or replacement of turf, shrubs, trees, sidewalks, parking lots, existing drains, street surfaces, curbs, gutters, irrigation systems, and other property and building systems. Existing structures, plantings and trees within the work area which are to be retained unchanged shall be protected. The Contractor shall repair all rutted and disturbed ground areas with solid sod to match existing ground cover. Contractor shall water and maintain sod until final acceptance of the project. An inspection of grounds by the Owner shall be included in the final punch list to determine if the site has been properly restored.

1.22 DESIGNATION OF PARKING AREA

A. Parking for the Contractor's and Sub-Contractors' employees shall be close distance to the Project site. If sufficient parking area is not available within the designated storage and working area for the vehicles of workmen employed on the building, the Contractor shall require workmen to park their vehicles in areas designated by the Owner and instructed through the Owner's Representative.

1.23 TREES AND PLANTING

A. Trees and plantings within the work area shall be protected by a 6 feet high (minimum) chain-linked construction fence located 15 feet beyond the drip line of the trees or plantings, at all times. Plastic construction fencing is not acceptable.

B. Compaction equipment, vehicle parking, and storage of materials shall not be allowed beneath the drip line, in order to prevent damage to existing planting. Special exceptions must be approved by the Owner.

C. The Contractor shall refer to the Mississippi Extension Service's publication, "Tree Protection Standards in Construction Sites" for further information and requirements not noted in this document.

1.24 WORK HOURS AND NON-INTERFERENCE OF OWNER'S OPERATIONS

A. As a result of the Work involved, it is understood that the Contractor shall schedule and perform the Work in such a manner as to not unnecessarily interfere with the Owner's normal operations, including the interruption of utilities, without a minimum of ten (10) calendar days prior notice to the Design Professional and the Owner's Representatives.

B. The Contractor expressly undertakes, at his own expense, to comply with the regulations governing the operations of the premises which are occupied by the Project, and to perform his contract in such a manner as not to interrupt or interfere with the operations of the Owner and to

perform any Work after normal working hours, or on Saturday, or on regular holidays without additional expense to the Owner.

C. Construction is not permitted on Sundays, except by specific permission from the Owner.

1.25 IDENTIFICATION OF CONSTRUCTION WORKERS

A. All construction workers and vendors shall wear, at all times, on their upper torso an identification badge, with their photograph, as issued by either their company or as acceptable to the Owner. The ID badge shall identify the name of the worker and the company by which the worker is employed.

1.26 WORKER CONDUCT – OBJECTIONABLE WORKMEN

A. Any workman who may, because of improper conduct, become objectionable to the Owner will be promptly removed by the Contractor at the request of the proper Owner's officials. In addition, the following work requirements shall be met at all times:

1. No firearms of any kind shall be allowed at the building. Possession of a firearm on the site shall be considered improper conduct.
2. The possession or consumption of alcoholic beverages is forbidden on the Owner's properties, and shall be considered improper conduct.
3. The use of tobacco products is prohibited in the renovated building. Smoking is prohibited at all times and at all locations in the building; including all Owner's facilities, properties and grounds. All violators will be subject to a fine in an amount set at the current rate according to Owner's Policy at the time of the offence. Fines will be assessed to the workers' company. Multiple violations shall be considered improper conduct.
4. Clothing for construction workers shall conform to the accepted standards within the construction industry. This includes appropriate footwear, shirts, and pants. The provision of protective clothing shall be the responsibility of the General Contractor.
5. Shirts and pants will be worn by all workers at all times. Non-compliance shall be considered improper conduct.
6. Use of offensive language or gestures to any persons, or facility member, shall be considered improper conduct.
7. Non-compliance with wearing of a company issued identification badge, with the worker's photograph, as noted under Identification of Construction Workers shall be considered improper conduct.

1.27 EXCAVATION

A. Contractors shall follow all current conditions and procedures required by Mississippi One Call prior to and during excavations. No person shall make any excavation in any of the grounds without first obtaining a confirmation number from Mississippi One Call, Inc. calling 1-800-227-6477.

B. The project site grounds as used herein include, but not limited to, the streets, sidewalks, parking areas, and all other public and private areas of the building, whether covered or uncovered.

C. Safety dictates that Contractor be familiar with the color coding scheme used to mark the various utilities (blue – water; orange – gas, etc.).

D. A copy of the Mississippi law Regulation of Excavations near underground utility facilities, and the uniform color code for marking underground utility lines are in Addendum D.

E. Markings made by utility owners are valid for a period of ten (10) days from the proposed starting date provided to the Mississippi One Call, Inc. The person responsible for the excavation shall renew the notification with Mississippi One Call, Inc. at least two (2) days prior to the expiration and continue to renew notification throughout the duration of the excavation. By calling Mississippi One Call, Inc. on the eighth (8^{th}) day, the utility owners can remark utilities so excavation projects can go longer than ten (10) days without requiring the excavator to stop work.

F. Damage to utilities by excavators will be reported to Mississippi One Call, Inc. and the Owner immediately, especially damage to underground utilities permitting escape of any hazardous, flammable, toxic or corrosive gas or liquid. Additionally, those excavating shall take action as reasonably necessary to protect persons and property and to minimize hazards until arrival of the owner's personnel, police and/or fire department.

G. Repairs to utilities are the responsibility of the excavator except where the excavator has fully complied with these procedures. The excavator shall be responsible for any costs and expenses incurred by the owner of the utilities in restoring, correcting, repairing, and replacing the damaged line or facility.

H. Utility owners shall mark utilities within two (2) working days from the time Mississippi One Call, Inc. receives the notification.

1. Unmarked locations – when an excavator sees evidence that utilities are unmarked, or encounters an unmarked utility, the excavator must immediately contact Mississippi One Call, Inc. and owners. All owners must contact the excavator within four (4) hours of any known underground utilities at the excavation site.

a. Group Identifying Colors for Utilities:

Color	Utility
Safety Red	Electrical
High Visibility Safety Yellow	Petroleum products: natural gas, oil, steam, gaseous materials
Safety Precaution Blue	Potable water, irrigation lines
Safety Green	Sewers and drain lines
High Visibility Pink	Temporary survey markings
White	Proposed excavation

I. Procedures.

1. Excavator calls Mississippi One Call, Inc. requesting utility locates and provides information requested.
2. Mississippi One Call, Inc. notifies Owner's (Facilities Management, Telecommunication, Landscaping, etc.) and local providers. Each organization is responsible for marking their utilities.

J. Excess Excavation: Any excess excavation shall be trucked to dumping points off the Project site, as directed by the Professional, or shown on drawings.

1.28 HARDWARE

A. All finish hardware schedules are to be coordinated with the Owner for contact and procedures.

B. The hardware schedule will be noted with sequential numbering system that is compatible with the existing sequence of doors in the facility. The sequence will be provided by the Owner prior to the submission of the hardware schedule.

C. Door hardware shall be compatible with the existing Owner's systems. Keying and hardware schedules should be coordinated with the Owner's locksmith and with the building's manager.

D. Construction cores shall be ordered and installed by the General Contractor to the extent required to secure the building. Final cores shall be provided by the Owner for installation by the General Contractor.

E. The Owner may extend the times that Contractors may keep issued keys. If issued keys are returned within the specified time period, the key deposit will be refunded. If issued keys are not returned within the specified time period, the deposit will be forfeited.

F. Any expenses that occur due to a Contractor losing a key will be borne by the Contractor. The contractor's Final Pay Request may be held until resolution of lost keys is reached.

G. All building re-keying due to lost keys by Contractors will be performed and/or authorized by the Owner. Any duplication of Owner's keys is prohibited.

H. For all questions regarding Owner's Hardware, Cores, and Keys, please contact the Owner.

1.29 CONSTRUCTION SIGN

A. The Contractor shall not install any construction signs on the construction site.

1.30 FIRE ALARM SYSTEM RECORD OF COMPLETION

A. A copy of the Fire Alarm System Record of Completion is to be completed and submitted to the Owner upon completion.

1.31 CONSTRUCTION CHANGE ORDERS

A. See Supplementary Conditions Section of the Specifications, Article 7 – Changes in the Work for required procedures and allowable mark-ups.

1.32 NOTICE OF REVIEW TO THE OWNER

A. The Owner must be notified minimum of (7) days prior to the need to review/approve any on-site mock-ups for color and/or details.

B. The Owner shall require fourteen (14) calendar days to issue approvals of shop drawings, submittals, color schedules, sample selection, keying schedules, etc.; therefore, all such data should be submitted as soon as possible after a construction contract has been awarded. The designated review period shall be considered in the construction schedule.

1.33 SCHEDULING TESTING

A. A representative of the Owner may wish to be present during periods of major testing: i.e., systems tests, performance tests, load tests, etc. The Owner must be notified a minimum of seven (7) days prior to the time when such tests are to be performed. Failure to issue such notice may result in repetition of the testing at the Contractor's expense. The presence of a representative of the Owner at such a test shall not preclude the Design Professional of his Owner review.

1.34 WITHHOLDING OF FINAL PAYMENT TO THE CONTRACTOR

A. The Owner will withhold final payment of the Retainage to the Contractor until ALL project closeouts and as-builts are received in an acceptable manner per the Project Specifications.

1.35 COLOR SCHEDULE

A. The Contractor shall furnish the necessary samples and chips from the actual suppliers or subcontractors for approval and color selection by the Architect. All colors available from the manufacturer shall be available for selection regardless of price codes or categories. (Actual color charts or physical samples shall be submitted for all color/finish selections. Scans or copies of color charts will not be accepted. Provide all information/color selection submittals at one time for finishes (interior & exterior) to be selected and coordinated with all finishes to be selected.)

1.36 CONTINUED OPERATION OF THE FACILITY

A. All other existing spaces and utilities in and around the existing building must remain in operation during the construction period. In the event that utilities and/or heating/air conditioning systems must be disrupted, the Contractor shall provide prior notice of the time and duration of the cut-off to be approved by the Professional and Owner.

B. Time and date of disruption of utilities and heating and air conditioning systems shall be agreed upon in advance by the Owner and the Professional in writing.

C. The Contractor shall maintain and limit access to only those areas as indicated in the drawings and that have been designated by the Owner in advance and as per phasing indicated in the drawings. Use and access to other areas of these buildings is strictly prohibited.

D. The Contractor shall notify the Professional of schedule for any work to occur outside of the established construction area. The Contractor will coordinate all access to other area in advance with the Owner's event schedule.

E. The contractor shall maintain a clear path for exit and entrance to the existing facilities at all times during the project construction. Strictly follow the phasing schedule as indicated in the drawings. There shall not be additional cost to the contract for phases of work to be performed after normal working hours and on weekends.

1.37 PROJECT SCHEDULE/CONSTRUCTION NOTES

A. The project schedule as described in Section Progress Schedules shall be detailed and shall delineate each phase of the work as indicated in the drawings. (See Drawings for detailed phasing requirements.)

B. During all phases of the work, the Contractor shall provide access to the Owner, staff and visitors at all times as coordinated with the Professional. The job superintendent must be in the construction area at all times in which work is being performed in this project. (The project manager and superintendent for the project shall be approved by the Professional/Owner before the beginning of construction.)

C. Any changes to the work schedule, phasing, or scope of work shall be approved by the Owner in advance.

D. It is the Contractor's responsibility to log in, document, and record the exact locations of all utilities as a part of the record documents and to document existing conditions uncovered during construction.

E. During all roofing renovation work, the contractor shall provide protection against water, moisture, and dust infiltration on all interior spaces at all times during construction. Protect all interior finishes and furniture with plastic sheathing (40 mil min thickness) with taped joints. The contractor shall provide for a water- tight condition at the end of each working day. Any damage to interior finishes or building systems/enclosure due to water infiltration during construction shall be replaced/repaired to match specified finish at no cost to the Owner.

F. The contractor shall pressure clean-out all roof drains in project areas to verify they are working properly prior to starting the project work.

END OF SECTION 007314

DIVISION 01

GENERAL REQUIREMENTS

SECTION 010200 – ALLOWANCES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Related Work Specified Elsewhere: Sections of Specifications as listed under Schedule of Allowances.

B. Allowances for Products:

1. Purchase products under each allowance as directed by the Professional.
2. Amount of each allowance includes:

a. Net cost of product.
b. Delivery and unloading at site.
c. Applicable taxes.

3. In addition to amounts of allowances, include in bid, for inclusion in Contract sum, Contractor's costs for:

a. Handling at site, including uncrating and storage.
b. Protection from elements and damage.
c. Labor, installation and finishing.
d. Other expenses required to complete installation.
e. Overhead and profit.

C. Selection of Products:

1. Architect's Duties: Consult with Contractor in consideration of products and Suppliers; make selections, designate products to be used; and, notify Contractor in writing.
2. Contractor's Duties: Assist Professional in determining qualified Suppliers; obtain proposals from Suppliers when requested by the Professional; and, make appropriate recommendations for consideration of the Professional. Upon notification of selection, enter into Purchase Agreement with designated Supplier.

D. Delivery: The Contractor is responsible for arranging all delivery and unloading and should promptly inspect products for damage or defects and submit claims for transportation damage.

E. Installation: Comply with requirements of referenced specification section.

F. Adjustment of Costs: Should actual purchase cost be more, or less, than the specified allowance amount, the Contract Sum will be adjusted by Change Order equal to the amount of the difference.

1.2 SCHEDULE OF ALLOWANCES

A. Refer to Section 019000 – Division One Supplement for Project specific Schedule of Allowances.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 010200

SECTION 010250 – SCHEDULE OF VALUES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope: Submit a Schedule of Values to the Professional at least ten (10) days prior to submitting the first Application for Payment. Upon the Professional's request, the Contractor will provide supportive data substantiating their correctness. Use Schedule of Values only as basis for Contractor's Application for Payment.

B. Form of Submittal: Submit Schedule of Values on AIA Document G703, or computer generated form containing similar style, using Table of Contents of these Specifications as basis for format for listing costs of work for sections under Divisions 2-33. Identify each line item with number and title as listed in Table of Contents in these Specifications.

1. Organize Schedule of Values as follows:

a. (Description of Organized Schedule of Values, as applicable).

C. Preparing Schedule of Values:

1. Itemize separate line item cost for each of the following general cost items: Performance and Payment Bonds, field supervision and layout, temporary facilities and controls.
2. Itemize separate line item cost for work required by each Section of these Specifications. Break down installed cost with overhead and profit.
3. For each line item which has installed value of more than $20,000, break down costs to list major products for operations under each item, rounding figures to nearest dollar. Make sum of total costs of all items listed in Schedule equal to total Contract sum.

D. Preparing Schedule of Unit Material Values:

1. Submit separate Schedule of unit prices for materials to be stored on which progress payments will be made. Make form of submittal parallel to Schedule of Values with each line item identified same as line item in Schedule of Values. Include in unit prices only: cost of material, delivery, unloading at site, and sales tax.
2. Make sure unit prices multiplied by quantities equal material cost of that item in Schedule of Values.

E. Review and Resubmittal: After the Professional's review and approval, the Schedule of Values shall be reviewed and approved by the bonding company. A letter of approval from the bonding company approving the Schedule of Values shall accompany the final submittal of the Schedule of Values to the professional. Payment based on the Schedule of Values shall not be until all approvals are obtained. If requested, revise and resubmit Schedule of Values until approvals are obtained.

F. Bonding Company Approval: The contractor must submittal the initial Schedule of Values to their bonding company for approval prior to submitting to the architect. A letter of approval from the bonding company must accompany the initial schedule of values.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 010250

SECTION 010270 – APPLICATION FOR PAYMENT

PART 1 - GENERAL

1.1 SCOPE

A. This Section describes procedures for preparing and submitting Applications for Payment by the Contractor.

1.2 APPLICATIONS FOR PAYMENT

A. Format: Applications for Payments will be prepared on AIA forms G702 - Application and Certificate for Payment and G703 - Continuation Sheet; or, a computer generated form containing similar data may be used.

B. Preparation of Application:

1. Present required information in typewritten form.
2. Execute certification by signature of authorized officer.
3. Use data from approved Schedule of Values. Provide dollar value in each column for each line item for portion of work performed and for stored products.
4. List each authorized Change Order as an extension on continuation sheet, listing Change Order number and dollar amount as for an original Item of Work.
5. Prepare Application for Final Payment as specified in Section 017200 – Contract Closeout & Record Documents.

C. Submittal Procedures:

1. Submit five (5) copies of each Application for Payment
2. Submit an updated construction schedule with each Application for Payment as described in Section 013100 – Progress Schedules.
3. Submit requests for payment at intervals agreed upon by the Professional, Owner and Contractor.
4. Submit requests to the Professional at agreed upon times, or as may be directed otherwise.

D. Substantiating Data:

1. Submit data justifying dollar amounts in question when such information is needed.
2. Provide one (1) copy of the data with a cover letter for each submittal.
3. Indicate the Application number, date and line item number and description.

E. Waivers of Mechanic's Lien: With each Application for Payment, submit waivers of mechanic's lien from entities lawfully entitled to file a mechanic's lien arising out of the Contract and related to the Work covered by the payment.

1. Submit partial waivers on each item for amount requested in previous application, after deduction for retainage, on each item.
2. When an application shows completion of an item, submit conditional final or full waivers.
3. Owner reserves the right to designate which entities involved in the Work must submit waivers.
4. Waiver Forms: Submit executed waivers of lien on forms acceptable to Owner.

F. Initial Application for Payment: Administrative actions and submittals that must precede or coincide with submittal of first Application for Payment include the following:

1. List of subcontractors.
2. Schedule of values.
3. Contractor's construction schedule (preliminary if not final).
4. Products list (preliminary if not final).
5. Submittal schedule (preliminary if not final).
6. List of Contractor's staff assignments.
7. List of Contractor's principal consultants.
8. Report of preconstruction conference.
9. Certificates of insurance and insurance policies.
10. Performance and payment bonds.
11. Copies of building permits.

G. Application for Payment at Substantial Completion: After Architect issues the Certificate of Substantial Completion, submit an Application for Payment showing 100 percent completion for portion of the Work claimed as substantially complete.

1. Include documentation supporting claim that the Work is substantially complete and a statement showing an accounting of changes to the Contract Sum.
2. This application shall reflect Certificate(s) of Substantial Completion issued previously for Owner occupancy of designated portions of the Work.

H. Final Payment Application: After completing Project closeout requirements, submit final Application for Payment with releases and supporting documentation not previously submitted and accepted, including, but not limited, to the following:

1. Evidence of completion of Project closeout requirements.
2. Insurance certificates for products and completed operations where required and proof that taxes, fees, and similar obligations were paid.
3. Updated final statement, accounting for final changes to the Contract Sum.
4. AIA Document G706, "Contractor's Affidavit of Payment of Debts and Claims."
5. AIA Document G706A, "Contractor's Affidavit of Release of Liens."
6. AIA Document G707, "Consent of Surety to Final Payment."
7. Evidence that claims have been settled.
8. Final meter readings for utilities, a measured record of stored fuel, and similar data as of date of Substantial Completion or when Owner took possession of and assumed responsibility for corresponding elements of the Work.
9. Final liquidated damages settlement statement.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 010270

SECTION 012800 – CHANGE ORDER PROCEDURES

PART 1 - GENERAL

1.1 SCOPE

A. This Section describes the procedures for processing Change Orders by the Professional and the Contractor.

1.2 CHANGE ORDER PROCEDURES

A. Change Proposed by Professional: The Professional may issue a Proposal Request to the Contractor which includes a detailed description of a proposed change with supplementary or revised Drawings and Specifications and a change in Contract Time for executing the change. The Contractor will prepare and submit an estimate within ten (10) days.

B. Change Proposed by Contractor: The Contractor may propose a change by submitting a request for change to the Professional, describing the proposed change and its full effect on the Work, with a statement describing the reason for the change, and the effect on the Contract Sum and Contract Time with full documentation and a statement describing the effect on Work by separate or other Contractors. Document any requested substitutions in accordance with Section 01630 entitled Substitutions and Product Options.

C. Contractor's Documentation:

1. Maintain detailed records of Work completed on a time and material basis. Provide full information required for evaluation of proposed changes, and substantiate costs of changes in the Work.
2. Document each quotation for a change in cost or time with sufficient data allowing evaluation of the quotation.
3. Provide additional data to support computations:

    a. Quantities of products, labor, and equipment
    b. Taxes, insurance and bonds
    c. Overhead and profit
    d. Justification for any change in Contract Time
    e. Credit for deletions from Contract, similarly documented

4. Support each claim for additional costs, and for Work completed on a time and material basis, with additional information:

    a. Origin and date of claim
    b. Dates and times work was performed and by whom
    c. Time records and wage rates paid
    d. Invoices and receipts for products, equipment, and subcontracts, similarly documented.

D. Construction Change Directive: The Professional may issue a document, approved by the Owner, instructing the Contractor to proceed with a change in the Work, for subsequent inclusion in a Change Order. The document will describe changes in the Work, and will

designate method of determining any change in Contract Sum or Contract Time. The change in Work will be promptly executed.

E. Format: The Professional will prepare three (3) originals of the Change Order.

F. Types of Change Orders:

1. Stipulated Sum Change Order: Based on Proposal Request and Contractor's fixed price quotation, or Contractor's request for a Change Order as approved by the Professional.
2. Unit Price Change Order: For predetermined unit prices and quantities, the Change Order will be executed on a fixed unit price basis. For unit costs or quantities of units of work which are not predetermined, execute Work under a Construction Change Directive. Changes in Contract Sum or Contract Time will be computed as specified for Time and Material Change Order.
3. Time and Material Change Order: Submit itemized account and supporting data after completion of change, within time limits indicated in the Standard Form of Agreement Between the Owner and the Contractor. The Professional will determine the change allowable in Contract Sum and Contract Time as provided in the Contract Documents. The Contractor shall maintain detailed records of Work accomplished on Time and Material basis and shall provide full information required for evaluation of proposed changes, and to substantiate costs for changes in the Work.

G. Execution of Change Order: The Professional will issue Change Orders for signatures of parties as provided in the Standard Form of Agreement Between the Owner and the Contractor. Final execution of all Change Orders requires approval by the Owner.

H. Correlation of Contractor Submittals: The Contract shall promptly revise Schedule of Values and the Application for Payment forms to record each authorized Change Order as a separate line item and adjust the Contract Sum. Promptly revise progress schedules to reflect any change in Contract Time, revise sub-schedules to adjust time for other items of Work affected by the change and resubmit. Promptly enter changes in Project Record Documents.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 012800

SECTION 010300 – ALTERNATES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope: This section describes the changes to be made under each alternate.

B. General: The referenced Specification sections contain the pertinent requirements for materials and methods to achieve the work described herein. Coordinate related work and modify surrounding work, as required, to complete the Project under each alternate designated in the Contract.

1.2 DESCRIPTION OF ALTERNATES

A. Refer to Section 019000 – Division One Supplement, for Project specific description of project Alternates.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 010300

SECTION 010410 – PROJECT COORDINATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope: To set forth procedures, conditions and responsibility for coordination of the total project.

B. Project Coordinator: The General Contractor will designate one (1) Individual as Project Coordinator or Superintendent, as referred to in the General Conditions. Prior to beginning the Work, the name and qualifications will be submitted, in writing, to the Professional. Upon the approval of the Professional and the Owner, the Project Coordinator will remain until the Project is completed and cannot be removed during construction without the written consent of the Owner and the Professional.

1.2 DEFINITIONS

A. RFI: Request from Owner, Architect, or Contractor seeking information required by or clarifications of the Contract Documents.

1.3 DUTIES OF PROJECT COORDINATION

A. General.

1. Coordination: Coordinate the work of all Subcontractors and Material Suppliers.
2. Supervision: Supervise the activities of every phase of work taking place on the Project.
3. Mechanical/Electrical: Take special care to coordinate and supervise the work of the plumbing, heating and cooling and electrical Subcontractors.
4. Communication: Establish lines of authority and communication at the job site.
5. Location: The Project Coordinator must be present on the job all of the time.
6. Permits: Assist in obtaining building and special permits required for construction.

B. Interpretations of Contract Documents.

1. Consultation: Consult with Architects and Engineers to obtain interpretations.
2. Assistance: Assist in resolution of any questions.
3. Transmission: Transmit written interpretations to concerned parties.

C. Cessation of Work: Stop all work not in accordance with the requirements of the Contract Documents.

D. Division 01: Coordinate and assist in the preparation of all requirements of Division 01 and specifically as follows:

1. Cutting and Patching: Supervise and control all cutting and patching of other trades' work.
2. Project Meetings: Schedule and preside at all project meetings.
3. Progress Schedules: Prepare and submit all construction schedules; supervise work to monitor compliance with schedules.

4. Shop Drawings, Product Data and Samples: Administer the processing of all submittals required by the Project Manual.
5. Schedule of Values: Assist in preparation and be knowledgeable of each entry in the Schedule of Values.
6. Testing Laboratory Services: Coordinate all required testing.
7. Construction Facilities and Temporary Controls: Allocate, maintain and monitor all temporary facilities.
8. Substitutions and Product Options: Administer the processing of all substitutions.
9. Project Closeout: Conduct final inspections and assist in collection and preparation of closeout documents.
10. Cleaning: Direct and execute a continuing cleaning program Throughout construction, requiring each trade to dispose their own debris.
11. Project Record Documents: Maintain up-to-date project record documents.
12. Safety Measures: Plan and enforce all safety requirements.

E. Changes: Recommend and assist in the preparation of requests to the Professional for any changes in the Contract.

F. Application for Payment: Assist in the preparation and be knowledgeable of each entry in the Application and Certificate for Payment.

1.4 SUBCONTRACTOR'S DUTIES

A. General: The Subcontractor is responsible for coordinating and supervising employees in the work to be accomplished under their part of the Contract.

B. Schedules: Conduct work to assure compliance with construction schedules.

C. Suppliers: Transmit all instructions to Material Suppliers.

D. Cooperation: Cooperate with the Project Coordinator and other Subcontractors.

1.5 OWNER-PURCHASED PRODUCTS

A. General: Cooperate, accept delivery, arrange storage and protect Owner-purchased products until installation, or final acceptance.

1.6 SUBMITTALS

A. Subcontract List: Prepare a written summary identifying individuals or firms proposed for each portion of the Work, including those who are to furnish products or equipment fabricated to a special design. Include the following information in tabular form:

1. Name, address, and telephone number of entity performing subcontract or supplying products.
2. Number and title of related Specification Section(s) covered by subcontract.

B. Key Personnel Names: Within 10 days of starting construction operations, submit a list of key personnel assignments, including superintendent and other personnel in attendance at Project site. Identify individuals and their duties and responsibilities; list addresses and telephone numbers, including home, office, and cellular telephone numbers and e-mail addresses.

Provide names, addresses, and telephone numbers of individuals assigned as alternates in the absence of individuals assigned to Project.

1. Post copies of list in project meeting room, in temporary field office, and by each temporary telephone. Keep list current at all times.

1.7 GENERAL COORDINATION PROCEDURES

A. Coordination: Coordinate construction operations included in different Sections of the Specifications to ensure efficient and orderly installation of each part of the Work. Coordinate construction operations, included in different Sections, that depend on each other for proper installation, connection, and operation.

1. Schedule construction operations in sequence required to obtain the best results where installation of one part of the Work depends on installation of other components, before or after its own installation.
2. Coordinate installation of different components to ensure maximum performance and accessibility for required maintenance, service, and repair.
3. Make adequate provisions to accommodate items scheduled for later installation.

B. Coordination: Each contractor shall coordinate its construction operations with those of other contractors and entities to ensure efficient and orderly installation of each part of the Work. Each contractor shall coordinate its operations with operations, included in different Sections, that depend on each other for proper installation, connection, and operation.

1. Schedule construction operations in sequence required to obtain the best results where installation of one part of the Work depends on installation of other components, before or after its own installation.
2. Coordinate installation of different components with other contractors to ensure maximum performance and accessibility for required maintenance, service, and repair.
3. Make adequate provisions to accommodate items scheduled for later installation.

C. Prepare memoranda for distribution to each party involved, outlining special procedures required for coordination. Include such items as required notices, reports, and list of attendees at meetings.

1. Prepare similar memoranda for Owner and separate contractors if coordination of their Work is required.

D. Administrative Procedures: Coordinate scheduling and timing of required administrative procedures with other construction activities to avoid conflicts and to ensure orderly progress of the Work. Such administrative activities include, but are not limited to, the following:

1. Preparation of Contractor's construction schedule.
2. Preparation of the schedule of values.
3. Installation and removal of temporary facilities and controls.
4. Delivery and processing of submittals.
5. Progress meetings.
6. Preinstallation conferences.
7. Project closeout activities.
8. Startup and adjustment of systems.

1.8 COORDINATION DRAWINGS

A. Coordination Drawings, General: Prepare coordination drawings according to requirements in individual Sections, and additionally where installation is not completely shown on Shop Drawings, where limited space availability necessitates coordination, or if coordination is required to facilitate integration of products and materials fabricated or installed by more than one entity.

1. Content: Project-specific information, drawn accurately to a scale large enough to indicate and resolve conflicts. Do not base coordination drawings on standard printed data. Include the following information, as applicable:

a. Use applicable Drawings as a basis for preparation of coordination drawings. Prepare sections, elevations, and details as needed to describe relationship of various systems and components.
b. Coordinate the addition of trade-specific information to the coordination drawings by multiple contractors in a sequence that best provides for coordination of the information and resolution of conflicts between installed components before submitting for review.
c. Indicate functional and spatial relationships of components of architectural, structural, civil, mechanical, and electrical systems.
d. Indicate space requirements for routine maintenance and for anticipated replacement of components during the life of the installation.
e. Show location and size of access doors required for access to concealed dampers, valves, and other controls.
f. Indicate required installation sequences.
g. Indicate dimensions shown on the Drawings. Specifically note dimensions that appear to be in conflict with submitted equipment and minimum clearance requirements. Provide alternate sketches to Architect indicating proposed resolution of such conflicts. Minor dimension changes and difficult installations will not be considered changes to the Contract.

B. Coordination Drawing Organization: Organize coordination drawings as follows:

1. Floor Plans and Reflected Ceiling Plans: Show architectural and structural elements, and mechanical, plumbing, fire-protection, fire-alarm, and electrical Work. Show locations of visible ceiling-mounted devices relative to acoustical ceiling grid. Supplement plan drawings with section drawings where required to adequately represent the Work.
2. Mechanical Rooms: Provide coordination drawings for mechanical rooms showing plans and elevations of mechanical, plumbing, fire-protection, fire-alarm, and electrical equipment.
3. Structural Penetrations: Indicate penetrations and openings required for all disciplines.
4. Slab Edge and Embedded Items: Indicate slab edge locations and sizes and locations of embedded items for metal fabrications, sleeves, anchor bolts, bearing plates, angles, door floor closers, slab depressions for floor finishes, curbs and housekeeping pads, and similar items.
5. Mechanical and Plumbing Work: Show the following:

a. Sizes and bottom elevations of ductwork, piping, and conduit runs, including insulation, bracing, flanges, and support systems.
b. Dimensions of major components, such as dampers, valves, diffusers, access doors, cleanouts and electrical distribution equipment.
c. Fire-rated enclosures around ductwork.
d. Fan coil units and all associated components within mechanical closets.
e. See Mechanical & Plumbing specifications for other requirements.

6. Electrical Work: Show the following:

    a. Runs of vertical and horizontal conduit 1-1/4 inches in diameter and larger.
    b. Light fixture, exit light, emergency battery pack, smoke detector, and other fire-alarm locations.
    c. Panel board, switch board, switchgear, transformer, busway, generator, and motor control center locations.
    d. See Electrical specifications for other requirements.

7. Fire-Protection System: Show the following:

    a. Locations of standpipes, mains piping, branch lines, pipe drops, and sprinkler heads.

8. Review: Architect will review coordination drawings to confirm that the Work is being coordinated, but not for the details of the coordination, which are Contractor's responsibility. If Architect determines that coordination drawings are not being prepared in sufficient scope or detail, or are otherwise deficient, Architect will so inform Contractor, who shall make changes as directed and resubmit.

C. Coordination Digital Data Files: Prepare coordination digital data files according to the following requirements:

1. File Preparation Format: DWG, Version 2018, operating in Microsoft Windows operating system.

1.9 REQUESTS FOR INFORMATION (RFIs)

A. General: Immediately on discovery of the need for additional information or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified.

1. Architect will return RFIs submitted to Architect by other entities controlled by Contractor with no response.
2. Coordinate and submit RFIs in a prompt manner so as to avoid delays in Contractor's work or work of subcontractors.

B. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:

1. Project name.
2. Project number.
3. Date.
4. Name of Contractor.
5. Name of Architect.
6. RFI number, numbered sequentially.
7. RFI subject.
8. Specification Section number and title and related paragraphs, as appropriate.
9. Drawing number and detail references, as appropriate.
10. Field dimensions and conditions, as appropriate.
11. Contractor's suggested resolution. If Contractor's suggested resolution impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
12. Contractor's signature.

13. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.

    a. Include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments on attached sketches.

C. RFI Forms: AIA Document G716.

1. Attachments shall be electronic files in Adobe Acrobat PDF format.

D. Architect's Action: Architect will review each RFI, determine action required, and respond. Allow seven working days for Architect's response for each RFI. RFIs received by Architect after 1:00 p.m. will be considered as received the following working day.

1. The following Contractor-generated RFIs will be returned without action:

    a. Requests for approval of submittals.
    b. Requests for approval of substitutions.
    c. Requests for approval of Contractor's means and methods.
    d. Requests for coordination information already indicated in the Contract Documents.
    e. Requests for adjustments in the Contract Time or the Contract Sum.
    f. Requests for interpretation of Architect's actions on submittals.
    g. Incomplete RFIs or inaccurately prepared RFIs.

2. Architect's action may include a request for additional information, in which case Architect's time for response will date from time of receipt of additional information.
3. Architect's action on RFIs that may result in a change to the Contract Time or the Contract Sum may be eligible for Contractor to submit Change Proposal according to Section 012800 – Change Order Procedures.

    a. If Contractor believes the RFI response warrants change in the Contract Time or the Contract Sum, notify Architect in writing within 10 days of receipt of the RFI response.

E. RFI Log: Prepare, maintain, and submit a tabular log of RFIs organized by the RFI number. Submit log monthly. Software log with not less than the following:

1. Project name.
2. Name and address of Contractor.
3. Name and address of Architect.
4. RFI number including RFIs that were returned without action or withdrawn.
5. RFI description.
6. Date the RFI was submitted.
7. Date Architect's response was received.

F. On receipt of Architect's action, update the RFI log and immediately distribute the RFI response to affected parties. Review response and notify Architect within seven days if Contractor disagrees with response.

1. Identification of related Minor Change in the Work, Construction Change Directive, and Proposal Request, as appropriate.
2. Identification of related Field Order, Work Change Directive, and Proposal Request, as appropriate.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 010410

SECTION 010450 – CUTTING AND PATCHING

PART 1 - GENERAL

1.1 GENERAL DESCRIPTION

A. Scope: To set forth broad, general conditions covering cutting and patching that applies to everyone and everything on the job.

B. Execute cutting including excavating, fitting, or patching of work required to:

1. Make several parts fit properly.
2. Uncover work to provide for installation of ill-timed work.
3. Remove and replace defective work.
4. Remove and replace work not conforming to Contract requirements.
5. Install specified work in existing construction.

C. In addition to Contract requirements, upon Professional's written instructions:

1. Uncover work for observation of covered work.
2. Remove samples of installed materials for testing.
3. Remove work to provide alteration of existing work.

D. Do not cut or alter work of another Contractor without permission.

E. Payment of Costs: Costs caused by ill-timed, or defective work, or work not conforming to Contract Documents will be borne by party responsible for ill-timed, defective work, or non-conforming work.

1.2 MATERIALS/PRODUCTS

A. Materials for Replacement or Work Removed: Comply with Specifications for type of work to be accomplished.

1.3 EXECUTION

A. Inspection: Inspect existing conditions of work, including elements subject to movement, or damage during cutting and patching.

B. Preparation Prior to Cutting: Provide shoring, bracing and support, as required, to maintain structural integrity of the building. Provide protection for other portions of work and protection from the elements.

C. Performance:

1. Execute cutting and demolition by methods which prevent damage to other work and will provide surfaces to receive installation of repairs and new work.
2. Execute excavating and backfilling by methods which prevent damage to other work and prevent settlement.

3. Restore work which has been cut or removed; install new products to provide completed work in accordance with requirements of Contract Documents.
4. Refinish entire surfaces, as necessary, to provide an even finish. Refinish continuous surfaces to the nearest intersection and assemblies entirely.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 010450

SECTION 010500 – CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope: Work required under this section consists of all temporary construction facilities, services and related items to complete the work indicated on the drawings and described in the Project Manual.

B. Standards:

1. Conform to or exceed all temporary construction requirements stated in the current edition of the International Building Code.
2. Refer to Article 10.1.1 in Section 007213 – General Conditions.

C. Materials: All materials required by the Work of this section shall be as specified in the respective sections.

1.2 SUBMITTALS

A. Site Plan: Show temporary facilities, utility hookups, staging areas, and parking areas for construction personnel.

B. Erosion- and Sedimentation-Control Plan: Show compliance with requirements of EPA Construction General Permit or authorities having jurisdiction, whichever is more stringent.

C. Moisture-Protection Plan: Describe procedures and controls for protecting materials and construction from water absorption and damage.

1. Describe delivery, handling, and storage provisions for materials subject to water absorption or water damage.
2. Indicate procedures for discarding water-damaged materials, protocols for mitigating water intrusion into completed Work, and replacing water-damaged Work.
3. Indicate sequencing of work that requires water, such as sprayed fire-resistive materials, plastering, and terrazzo grinding, and describe plans for dealing with water from these operations. Show procedures for verifying that wet construction has dried sufficiently to permit installation of finish materials.

1.3 QUALITY ASSURANCE

A. Electric Service: Comply with NECA, NEMA, and UL standards and regulations for temporary electric service. Install service to comply with NFPA 70.

B. Tests and Inspections: Arrange for authorities having jurisdiction to test and inspect each temporary utility before use. Obtain required certifications and permits.

PART 2 - PRODUCTS

2.1 FACILITIES AND CONTROLS

A. Access: The Prime General Contractor shall provide an adequate access and/or roads to the site of the structure, if required for the prosecution of work; and, should also provide and maintain at least one (1) temporary, or permanent, access to each working elevation to be permanently occupied.

B. Hoisting Facilities: The Prime General Contractor shall be responsible for providing suitable capacity and hoisting facilities for all people and materials. The use of the hoisting facilities shall be by mutual agreement of the Prime General Contractor and the individual Contractor.

C. Sanitation Facilities: The Prime General Contractor is responsible for furnishing adequate temporary toilet facilities on the job site.

D. Drinking Water: The Prime General Contractor shall provide at all times sanitary drinking water facilities for all workmen on the job including ice, when required, and paper cups, etc..

E. Fire Protection: The Prime General Contractor shall provide general temporary fire protection. Subcontractors will be responsible for their own.

F. Storage: The Prime General Contractor shall coordinate the allocation of storage areas to the various Sub-contractors.

G. Temporary Heat: The Prime General Contractor shall provide heat, fuel and services, as necessary, to protect all work from dampness and cold until final acceptance. If in the late stages of the construction, mechanical and electrical installations will permit, the mechanical and electrical facilities may be used to provide heat and ventilation. However, the Owner is saved harmless of any costs of operation or responsibility as to acceptance of mechanical and/or electrical installations.

H. Utilities: The Prime General Contractor shall make arrangements for and furnish all water, electricity (lighting and power) and other utilities necessary for construction purposes. A written agreement must be reached on how all utilities (water and electricity) will be furnished and the rates the Contractor will be charged. A copy of the final agreement signed by the Contractor and MSU must be forwarded to MSU. If the written agreement is not filed with MSU, the Contractor waives all rights as to the rates charged. MSU will then determine all utility rates and assess the charges before final payment is rendered.

I. Construction Site Fence:

1. General

a. Site Enclosure Fence: The contractor is required to install a construction fence, as shown in the plans, to be maintained, as needed, throughout the duration of the project. The site enclosure fence should be kept in a manner that will prevent people and animals from easily entering the site except by entrance gates.

1) Extent of Fence: As indicated on Drawings.
2) Maintain security by limiting number of keys and restricting distribution to authorized personnel. Allow owner to interlock their lock as necessary.
3) The Contractor shall call Mississippi One-Call System, Inc., before driving any posts for the fencing.

4) Signs shall not be posted on the fence system except: “Caution: Construction Area Authorized Personnel Only” signs may be installed at 50 foot intervals; safety related signs required by OSHA; and visitor site entry rules as required by the Contractor. Advertising signage is strictly prohibited.
5) The Contractor shall keep plant growth from around the base of the fence by either trimming or chemical treatment.
6) Fence shall be maintained for the duration of the project, and shall not be removed without the Owner’s permission.

2. Fence Design and Materials

a. The minimum height for all temporary fencing shall be 8 feet.
b. The fencing shall be of galvanized 11-1/2 ga. chain-link construction with a minimum of 1-5/8” O.D. tubular steel posts and top rails, and bottom tension wire.
c. Privacy netting to screen construction activities shall be used on all projects unless specified otherwise in the contract documents.
d. Privacy screen material shall be vinyl coated polyester or polypropylene, 6’ tall, green, seamed reinforced hems at all edges, and grommets a maximum of 24” on center, equal to U.S. Fence’s Privacy/Windscreen netting.

3. Gates

a. Limit entrance/exit to no more than two locations, unless otherwise approved by the Owner.
b. Gates shall be a minimum of 12 feet in width to allow access for emergency vehicles.
c. Where other transportation authorities need to review gate locations and operation, communication with those authorities will be coordinated through the Owner.
d. Gates shall be closed and locked at all times the site is not occupied, unless otherwise directed by the Owner where emergency vehicle passage through the site is needed to access existing occupied buildings.

2.2 TEMPORARY FACILITIES

A. Field Offices, General: Prefabricated or mobile units with serviceable finishes, temperature controls, and foundations adequate for normal loading.

B. Common-Use Field Office: Of sufficient size to accommodate needs of Owner, Architect, and construction personnel office activities and to accommodate Project meetings specified in other Division 01 Sections. Keep office clean and orderly. Furnish and equip offices as follows:

1. Furniture required for Project-site documents including file cabinets, plan tables, plan racks, and bookcases.
2. Conference room of sufficient size to accommodate meetings of 10 individuals. Provide electrical power service and 120-V ac duplex receptacles, with no fewer than one receptacle on each wall. Furnish room with conference table, chairs, and 4-foot- square tack and marker boards.
3. Drinking water and private toilet.
4. Coffee machine and supplies.
5. Heating and cooling equipment necessary to maintain a uniform indoor temperature of 68 to 72 deg F.
6. Lighting fixtures capable of maintaining average illumination of 20 fc at desk height.

C. Storage and Fabrication Sheds: Provide sheds sized, furnished, and equipped to accommodate materials and equipment for construction operations.

1. Store combustible materials apart from building.

2.3 EQUIPMENT

A. Fire Extinguishers: Portable, UL rated; with class and extinguishing agent as required by locations and classes of fire exposures.

PART 3 - EXECUTION

3.1 SUPPORT FACILITIES INSTALLATION

A. General: Comply with the following:

1. Provide construction for temporary offices, shops, and sheds located within construction area or within 30 feet of building lines that is noncombustible according to ASTM E 136. Comply with NFPA 241.
2. Maintain support facilities until Architect schedules Substantial Completion inspection. Remove before Substantial Completion. Personnel remaining after Substantial Completion will be permitted to use permanent facilities, under conditions acceptable to Owner.

B. Traffic Controls: Comply with requirements of authorities having jurisdiction.

1. Protect existing site improvements to remain including curbs, pavement, and utilities.
2. Maintain access for fire-fighting equipment and access to fire hydrants.

C. Parking: Provide temporary parking areas for construction personnel.

D. Dewatering Facilities and Drains: Comply with requirements of authorities having jurisdiction. Maintain Project site, excavations, and construction free of water.

1. Dispose of rainwater in a lawful manner that will not result in flooding Project or adjoining properties or endanger permanent Work or temporary facilities.
2. Remove snow and ice as required to minimize accumulations.

E. Waste Disposal Facilities: Provide waste-collection containers in sizes adequate to handle waste from construction operations. Comply with requirements of authorities having jurisdiction. Comply with progress cleaning requirements in Section 010640 – Execution.

F. Temporary Stairs: Until permanent stairs are available, provide temporary stairs where ladders are not adequate.

G. Temporary Use of Permanent Stairs: Use of new stairs for construction traffic will be permitted, provided stairs are protected and finishes restored to new condition at time of Substantial Completion.

3.2 SECURITY AND PROTECTION FACILITIES INSTALLATION

A. Protection of Existing Facilities: Protect existing vegetation, equipment, structures, utilities, and other improvements at Project site and on adjacent properties, except those indicated to be removed or altered. Repair damage to existing facilities.

B. Environmental Protection: Provide protection, operate temporary facilities, and conduct construction as required to comply with environmental regulations and that minimize possible air, waterway, and subsoil contamination or pollution or other undesirable effects.

1. Comply with work restrictions specified in Section 010100 – Summary of Work.

C. Temporary Egress: Maintain temporary egress from existing occupied facilities as indicated and as required by authorities having jurisdiction.

D. Temporary Erosion and Sedimentation Control: Provide measures to prevent soil erosion and discharge of soil-bearing water runoff and airborne dust to undisturbed areas and to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings.

1. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross tree- or plant- protection zones.
2. Inspect, repair, and maintain erosion- and sedimentation-control measures during construction until permanent vegetation has been established.
3. Clean, repair, and restore adjoining properties and roads affected by erosion and sedimentation from Project site during the course of Project.
4. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

E. Storm water Control: Comply with requirements of authorities having jurisdiction. Provide barriers in and around excavations and subgrade construction to prevent flooding by runoff of storm water from heavy rains.

F. Pest Control: Engage pest-control service to recommend practices to minimize attraction and harboring of rodents, roaches, and other pests and to perform extermination and control procedures at regular intervals so Project will be free of pests and their residues at Substantial Completion. Perform control operations lawfully, using environmentally safe materials.

G. Barricades, Warning Signs, and Lights: Provide as indicated in the Contract Documents and comply with requirements of authorities having jurisdiction for erecting structurally adequate barricades, including warning signs and lighting.

3.3 MOISTURE AND MOLD CONTROL

A. Contractor's Moisture-Protection Plan: Avoid trapping water in finished work. Document visible signs of mold that may appear during construction.

B. Exposed Construction Phase: Before installation of weather barriers, when materials are subject to wetting and exposure and to airborne mold spores, protect as follows:

1. Protect porous materials from water damage.
2. Protect stored and installed material from flowing or standing water.
3. Keep porous and organic materials from coming into prolonged contact with concrete.
4. Remove standing water from decks.
5. Keep deck openings covered or dammed.

C. Partially Enclosed Construction Phase: After installation of weather barriers but before full enclosure and conditioning of building, when installed materials are still subject to infiltration of moisture and ambient mold spores, protect as follows:

1. Do not load or install drywall or other porous materials or components, or items with high organic content, into partially enclosed building.
2. Keep interior spaces reasonably clean and protected from water damage.
3. Periodically collect and remove waste containing cellulose or other organic matter.
4. Discard or replace water-damaged material.
5. Do not install material that is wet.
6. Discard, replace, or clean stored or installed material that begins to grow mold.
7. Perform work in a sequence that allows any wet materials adequate time to dry before enclosing the material in drywall or other interior finishes.

D. Controlled Construction Phase of Construction: After completing and sealing of the building enclosure but prior to the full operation of permanent HVAC systems, maintain as follows:

1. Control moisture and humidity inside building by maintaining effective dry-in conditions.
2. Use permanent HVAC system to control humidity.
3. Comply with manufacturer's written instructions for temperature, relative humidity, and exposure to water limits.

    a. Hygroscopic materials that may support mold growth, including wood and gypsum-based products, that become wet during the course of construction and remain wet for 48 hours are considered defective.
    b. Measure moisture content of materials that have been exposed to moisture during construction operations or after installation. Record readings beginning at time of exposure and continuing daily for 48 hours. Identify materials containing moisture levels higher than allowed. Report findings in writing to Architect.
    c. Remove materials that cannot be completely restored to their manufactured moisture level within 48 hours.

3.4 OPERATION, TERMINATION, AND REMOVAL

A. Supervision: Enforce strict discipline in use of temporary facilities. To minimize waste and abuse, limit availability of temporary facilities to essential and intended uses.

B. Maintenance: Maintain facilities in good operating condition until removal.

1. Maintain operation of temporary enclosures, heating, cooling, humidity control, ventilation, and similar facilities on a 24-hour basis where required to achieve indicated results and to avoid possibility of damage.

C. Temporary Facility Changeover: Do not change over from using temporary security and protection facilities to permanent facilities until Substantial Completion.

D. Termination and Removal: Remove each temporary facility when need for its service has ended, when it has been replaced by authorized use of a permanent facility, or no later than Substantial Completion. Complete or, if necessary, restore permanent construction that may have been delayed because of interference with temporary facility. Repair damaged Work, clean exposed surfaces, and replace construction that cannot be satisfactorily repaired.

1. Materials and facilities that constitute temporary facilities are property of Contractor. Owner reserves right to take possession of Project identification signs.

2. Remove temporary roads and paved areas not intended for or acceptable for integration into permanent construction. Where area is intended for landscape development, remove soil and aggregate fill that do not comply with requirements for fill or subsoil. Remove materials contaminated with road oil, asphalt and other petrochemical compounds, and other substances that might impair growth of plant materials or lawns. Repair or replace street paving, curbs, and sidewalks at temporary entrances, as required by authorities having jurisdiction.
3. At Substantial Completion, repair, renovate, and clean permanent facilities used during construction period. Comply with final cleaning requirements specified in Section 017100 – Cleaning.

END OF SECTION 010500

SECTION 010630 – SUBSTITUTIONS AND PRODUCT OPTIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope: To set forth the procedure and conditions for substitutions and to give the product options available to the Contractor.

1.2 PRODUCTS LIST

A. Within thirty (30) days after the Contract has been signed, the Contractor will submit to the Professional five (5) copies of a complete list of all products proposed for installation.

B. Tabulate the list by Specification sections.

C. For products specified under reference standards, include with listing of each product:

1. Name and address of Manufacturer.
2. Trade name.
3. Model, or catalog designation.
4. Manufacturer's data.
5. Performance and test data.
6. Reference standards.

1.3 CONTRACTOR'S OPTIONS

A. For products specified only by reference standards, select any product meeting product standards by any Manufacturer.

B. For products specified by naming a minimum of three (3) products or Manufacturers, select any product and Manufacturer named.

C. For product specified by naming one (1) or more products, but indicating the option of selecting equivalent products by stating "or equal" after specified product, Contractor must submit request, as required for substitution, for any product not specifically named.

D. For products specified by naming only one (1) product and Manufacturer, an equivalent product will always be accepted if it is equal in all respects. The Contractor must submit a request for substitution as set forth in this Section.

1.4 SUBSTITUTIONS

A. Professional will not consider requests for substitutions during bidding.

B. Within thirty (30) days after the Contract has been signed, the Professional will consider formal requests from the Contractor for substitution of products in place of those specified. Submit five (5) copies of the request for substitutions. Include in the request:

1. Complete data substantiating compliance of proposed substitutions with Contract Documents.
2. For products:

    a. Product identification including Manufacturer's name and address.
    b. Manufacturer's literature: Product description, performance and test data and reference standards.
    c. Samples.
    d. Name and address of similar products on which product was used and date of installation.

3. For construction methods:

    a. Detailed description of proposed method.
    b. Drawings illustrating methods.

4. Itemized comparison of proposed substitutions with product or method specified.
5. Data relating to changes in construction schedule.
6. Accurate cost data on proposed substitution in comparison with product or method specified.

C. In making request for substitution, Contractor represents:

1. Proposed product, or method, has been investigated and determined that it is equal or superior in all respects to that specified.
2. The same guarantee will be provided for substitutions as for product or method specified.
3. Installation of accepted substitutions will be coordinated into the Work, making such changes required of work to be compete in all respects.
4. All claims for additional costs related to substitution which consequently become apparent will be waived.
5. Cost data is complete and includes all related costs under the Contract.

D. Substitutions will not be considered if:

1. Indicated, or implied, on shop drawings or product data submittals without formal request submitted in accordance with this Section.
2. Acceptance will require substantial revision of Contract Documents.
3. In the Professional's judgment, the product, or material, is not equal.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 010630

SECTION 010635 - PRODUCT REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes administrative and procedural requirements for selection of products for use in Project; product delivery, storage, and handling; manufacturers' standard warranties on products; special warranties; and comparable products.

1.3 DEFINITIONS

A. Products: Items obtained for incorporating into the Work, whether purchased for Project or taken from previously purchased stock. The term "product" includes the terms "material," "equipment," "system," and terms of similar intent.

1. Named Products: Items identified by manufacturer's product name, including make or model number or other designation shown or listed in manufacturer's published product literature, that is current as of date of the Contract Documents.
2. New Products: Items that have not previously been incorporated into another project or facility. Products salvaged or recycled from other projects are not considered new products.
3. Comparable Product: Product that is demonstrated and approved through submittal process to have the indicated qualities related to type, function, dimension, in-service performance, physical properties, appearance, and other characteristics that equal or exceed those of specified product.

B. Basis-of-Design Product Specification: A specification in which a specific manufacturer's product is named and accompanied by the words "basis-of-design product," including make or model number or other designation, to establish the significant qualities related to type, function, dimension, in-service performance, physical properties, appearance, and other characteristics for purposes of evaluating comparable products of additional manufacturers named in the specification.

1.4 SUBMITTALS

A. Comparable Product Requests: Submit request for consideration of each comparable product. Identify product or fabrication or installation method to be replaced. Include Specification Section number and title and Drawing numbers and titles.

1. Include data to indicate compliance with the requirements specified in "Comparable Products" Article.
2. Architect's Action: If necessary, Architect will request additional information or documentation for evaluation within one week of receipt of a comparable product request. Architect will notify Contractor of approval or rejection of proposed comparable product

request within 15 days of receipt of request, or seven days of receipt of additional information or documentation, whichever is later.

a. Form of Approval: As specified in Section 01340 "Shop Drawings, Products Data and Samples."
b. Use product specified if Architect does not issue a decision on use of a comparable product request within time allocated.

B. Basis-of-Design Product Specification Submittal: Comply with requirements in Section 01340 "Shop Drawings, Products Data and Samples." Show compliance with requirements.

1.5 QUALITY ASSURANCE

A. Compatibility of Options: If Contractor is given option of selecting between two or more products for use on Project, select product compatible with products previously selected, even if previously selected products were also options.

1. Each contractor is responsible for providing products and construction methods compatible with products and construction methods of other contractors.
2. If a dispute arises between contractors over concurrently selectable but incompatible products, Architect will determine which products shall be used.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products using means and methods that will prevent damage, deterioration, and loss, including theft and vandalism. Comply with manufacturer's written instructions.

B. Delivery and Handling:

1. Schedule delivery to minimize long-term storage at Project site and to prevent overcrowding of construction spaces.
2. Coordinate delivery with installation time to ensure minimum holding time for items that are flammable, hazardous, easily damaged, or sensitive to deterioration, theft, and other losses.
3. Deliver products to Project site in an undamaged condition in manufacturer's original sealed container or other packaging system, complete with labels and instructions for handling, storing, unpacking, protecting, and installing.
4. Inspect products on delivery to determine compliance with the Contract Documents and to determine that products are undamaged and properly protected.

C. Storage:

1. Store products to allow for inspection and measurement of quantity or counting of units.
2. Store materials in a manner that will not endanger Project structure.
3. Store products that are subject to damage by the elements, under cover in a weathertight enclosure above ground, with ventilation adequate to prevent condensation.
4. Protect foam plastic from exposure to sunlight, except to extent necessary for period of installation and concealment.
5. Comply with product manufacturer's written instructions for temperature, humidity, ventilation, and weather-protection requirements for storage.
6. Protect stored products from damage and liquids from freezing.
7. Provide a secure location and enclosure at Project site for storage of materials and equipment by Owner's construction forces. Coordinate location with Owner.

1.7 PRODUCT WARRANTIES

A. Warranties specified in other Sections shall be in addition to, and run concurrent with, other warranties required by the Contract Documents. Manufacturer's disclaimers and limitations on product warranties do not relieve Contractor of obligations under requirements of the Contract Documents.

1. Manufacturer's Warranty: Written warranty furnished by individual manufacturer for a particular product and specifically endorsed by manufacturer to Owner.
2. Special Warranty: Written warranty required by the Contract Documents to provide specific rights for Owner.

B. Special Warranties: Prepare a written document that contains appropriate terms and identification, ready for execution.

1. Manufacturer's Standard Form: Modified to include Project-specific information and properly executed.
2. Specified Form: When specified forms are included with the Specifications, prepare a written document using indicated form properly executed.
3. See other Sections for specific content requirements and particular requirements for submitting special warranties.

C. Submittal Time: Comply with requirements in Section 017200 – Contract Closeout & Record Documents.

PART 2 - PRODUCTS

2.1 PRODUCT SELECTION PROCEDURES

A. General Product Requirements: Provide products that comply with the Contract Documents, are undamaged and, unless otherwise indicated, are new at time of installation.

1. Provide products complete with accessories, trim, finish, fasteners, and other items needed for a complete installation and indicated use and effect.
2. Standard Products: If available, and unless custom products or nonstandard options are specified, provide standard products of types that have been produced and used successfully in similar situations on other projects.
3. Owner reserves the right to limit selection to products with warranties not in conflict with requirements of the Contract Documents.
4. Where products are accompanied by the term "as selected," Architect will make selection.
5. Descriptive, performance, and reference standard requirements in the Specifications establish salient characteristics of products.
6. Or Equal: For products specified by name and accompanied by the term "or equal," or "or approved equal," or "or approved," comply with requirements in "Comparable Products" Article to obtain approval for use of an unnamed product.

B. Product Selection Procedures:

1. Product: Where Specifications name a single manufacturer and product, provide the named product that complies with requirements. Comparable products or substitutions for Contractor's convenience will not be considered.

2. Manufacturer/Source: Where Specifications name a single manufacturer or source, provide a product by the named manufacturer or source that complies with requirements. Comparable products or substitutions for Contractor's convenience will not be considered.
3. Products:

    a. Restricted List: Where Specifications include a list of names of both manufacturers and products, provide one of the products listed that complies with requirements. Comparable products or substitutions for Contractor's convenience will not be considered.
    b. Nonrestricted List: Where Specifications include a list of names of both available manufacturers and products, provide one of the products listed, or an unnamed product, that complies with requirements. Comply with requirements in "Comparable Products" Article for consideration of an unnamed product.

4. Manufacturers:

    a. Restricted List: Where Specifications include a list of manufacturers' names, provide a product by one of the manufacturers listed that complies with requirements. Comparable products or substitutions for Contractor's convenience will not be considered.
    b. Nonrestricted List: Where Specifications include a list of available manufacturers, provide a product by one of the manufacturers listed, or a product by an unnamed manufacturer, that complies with requirements. Comply with requirements in "Comparable Products" Article for consideration of an unnamed manufacturer's product.

5. Basis-of-Design Product: Where Specifications name a product, or refer to a product indicated on Drawings, and include a list of manufacturers, provide the specified or indicated product or a comparable product by one of the other named manufacturers. Drawings and Specifications indicate sizes, profiles, dimensions, and other characteristics that are based on the product named. Comply with requirements in "Comparable Products" Article for consideration of an unnamed product by one of the other named manufacturers.

C. Visual Matching Specification: Where Specifications require "match Architect's sample", provide a product that complies with requirements and matches Architect's sample. Architect's decision will be final on whether a proposed product matches.

1. If no product available within specified category matches and complies with other specified requirements, comply with requirements in Section 01630 "Substitution and Product Options" for proposal of product.

D. Visual Selection Specification: Where Specifications include the phrase "as selected by Architect from manufacturer's full range" or similar phrase, select a product that complies with requirements. Architect will select color, gloss, pattern, density, or texture from manufacturer's product line that includes both standard and premium items.

2.2 COMPARABLE PRODUCTS

A. Conditions for Consideration: Architect will consider Contractor's request for comparable product when the following conditions are satisfied. If the following conditions are not satisfied, Architect may return requests without action, except to record noncompliance with these requirements:

1. Evidence that the proposed product does not require revisions to the Contract Documents, that it is consistent with the Contract Documents and will produce the indicated results, and that it is compatible with other portions of the Work.
2. Detailed comparison of significant qualities of proposed product with those named in the Specifications. Significant qualities include attributes such as performance, weight, size, durability, visual effect, and specific features and requirements indicated.
3. Evidence that proposed product provides specified warranty.
4. List of similar installations for completed projects with project names and addresses and names and addresses of architects and owners, if requested.
5. Samples, if requested.

PART 3 - EXECUTION (Not Used)

END OF SECTION 010635

SECTION 010640 - EXECUTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes general administrative and procedural requirements governing execution of the Work including, but not limited to, the following:

1. Construction layout.
2. Field engineering and surveying.
3. Installation of the Work.
4. Coordination of Owner-installed products.
5. Protection of installed construction.
6. Correction of the Work.

1.3 SUBMITTALS

A. Qualification Data: For land surveyor.

B. Certificates: Submit certificate signed by land surveyor certifying that location and elevation of improvements comply with requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Comply with requirements specified in other Sections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Existing Conditions: The existence and location of underground and other utilities and construction indicated as existing are not guaranteed. Before beginning sitework, investigate and verify the existence and location of underground utilities and other construction affecting the Work.

1. Before construction, verify the location and invert elevation at points of connection of sanitary sewer, storm sewer, and water-service piping; underground electrical services, and other utilities.

2. Furnish location data for work related to Project that must be performed by public utilities serving Project site.

B. Examination and Acceptance of Conditions: Before proceeding with each component of the Work, examine substrates, areas, and conditions, with Installer or Applicator present where indicated, for compliance with requirements for installation tolerances and other conditions affecting performance. Record observations.

1. Examine roughing-in for mechanical and electrical systems to verify actual locations of connections before equipment and fixture installation.
2. Examine walls, floors, and roofs for suitable conditions where products and systems are to be installed.
3. Verify compatibility with and suitability of substrates, including compatibility with existing finishes or primers.

C. Written Report: Where a written report listing conditions detrimental to performance of the Work is required by other Sections, include the following:

1. Description of the Work.
2. List of detrimental conditions, including substrates.
3. List of unacceptable installation tolerances.
4. Recommended corrections.

D. Proceed with installation only after unsatisfactory conditions have been corrected. Proceeding with the Work indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Existing Utility Information: Furnish information to local utility that is necessary to adjust, move, or relocate existing utility structures, utility poles, lines, services, or other utility appurtenances located in or affected by construction. Coordinate with authorities having jurisdiction.

B. Field Measurements: Take field measurements as required to fit the Work properly. Recheck measurements before installing each product. Where portions of the Work are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

C. Space Requirements: Verify space requirements and dimensions of items shown diagrammatically on Drawings.

D. Review of Contract Documents and Field Conditions: Immediately on discovery of the need for clarification of the Contract Documents caused by differing field conditions outside the control of Contractor, submit a request for information to Architect according to requirements in Section 010410 – Project Coordination.

3.3 CONSTRUCTION LAYOUT

A. Verification: Before proceeding to lay out the Work, verify layout information shown on Drawings, in relation to the property survey and existing benchmarks. If discrepancies are discovered, notify Architect promptly.

B. General: Engage a land surveyor to lay out the Work using accepted surveying practices.

1. Establish benchmarks and control points to set lines and levels at each story of construction and elsewhere as needed to locate each element of Project.
2. Establish limits on use of Project site.
3. Establish dimensions within tolerances indicated. Do not scale Drawings to obtain required dimensions.
4. Inform installers of lines and levels to which they must comply.
5. Check the location, level and plumb, of every major element as the Work progresses.
6. Notify Architect when deviations from required lines and levels exceed allowable tolerances.
7. Close site surveys with an error of closure equal to or less than the standard established by authorities having jurisdiction.

C. Site Improvements: Locate and lay out site improvements, including pavements, grading, fill and topsoil placement, utility slopes, and rim and invert elevations.

D. Building Lines and Levels: Locate and lay out control lines and levels for structures, building foundations, column grids, and floor levels, including those required for mechanical and electrical work. Transfer survey markings and elevations for use with control lines and levels. Level foundations and piers from two or more locations.

E. Record Log: Maintain a log of layout control work. Record deviations from required lines and levels. Include beginning and ending dates and times of surveys, weather conditions, name and duty of each survey party member, and types of instruments and tapes used. Make the log available for reference by Architect.

3.4 FIELD ENGINEERING

A. Identification: Owner will identify existing benchmarks, control points, and property corners.

B. Reference Points: Locate existing permanent benchmarks, control points, and similar reference points before beginning the Work. Preserve and protect permanent benchmarks and control points during construction operations.

1. Do not change or relocate existing benchmarks or control points without prior written approval of Architect. Report lost or destroyed permanent benchmarks or control points promptly. Report the need to relocate permanent benchmarks or control points to Architect before proceeding.
2. Replace lost or destroyed permanent benchmarks and control points promptly. Base replacements on the original survey control points.

C. Benchmarks: Establish and maintain a minimum of two permanent benchmarks on Project site, referenced to data established by survey control points. Comply with authorities having jurisdiction for type and size of benchmark.

1. Record benchmark locations, with horizontal and vertical data, on Project Record Documents.
2. Where the actual location or elevation of layout points cannot be marked, provide temporary reference points sufficient to locate the Work.
3. Remove temporary reference points when no longer needed. Restore marked construction to its original condition.

3.5 INSTALLATION

A. General: Locate the Work and components of the Work accurately, in correct alignment and elevation, as indicated.

1. Make vertical work plumb and make horizontal work level.
2. Where space is limited, install components to maximize space available for maintenance and ease of removal for replacement.
3. Conceal pipes, ducts, and wiring in finished areas unless otherwise indicated.

B. Comply with manufacturer's written instructions and recommendations for installing products in applications indicated.

C. Install products at the time and under conditions that will ensure the best possible results. Maintain conditions required for product performance until Substantial Completion.

D. Conduct construction operations so no part of the Work is subjected to damaging operations or loading in excess of that expected during normal conditions of occupancy.

E. Sequence the Work and allow adequate clearances to accommodate movement of construction items on site and placement in permanent locations.

F. Tools and Equipment: Do not use tools or equipment that produce harmful noise levels.

G. Templates: Obtain and distribute to the parties involved templates for work specified to be factory prepared and field installed. Check Shop Drawings of other work to confirm that adequate provisions are made for locating and installing products to comply with indicated requirements.

H. Attachment: Provide blocking and attachment plates and anchors and fasteners of adequate size and number to securely anchor each component in place, accurately located and aligned with other portions of the Work. Where size and type of attachments are not indicated, verify size and type required for load conditions.

1. Mounting Heights: Where mounting heights are not indicated, mount components at heights directed by Architect.
2. Allow for building movement, including thermal expansion and contraction.
3. Coordinate installation of anchorages. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

I. Joints: Make joints of uniform width. Where joint locations in exposed work are not indicated, arrange joints for the best visual effect. Fit exposed connections together to form hairline joints.

J. Hazardous Materials: Use products, cleaners, and installation materials that are not considered hazardous.

3.6 OWNER-INSTALLED PRODUCTS

A. Site Access: Provide access to Project site for Owner's construction personnel.

B. Coordination: Coordinate construction and operations of the Work with work performed by Owner's construction personnel.

1. Construction Schedule: Inform Owner of Contractor's preferred construction schedule for Owner's portion of the Work. Adjust construction schedule based on a mutually agreeable timetable. Notify Owner if changes to schedule are required due to differences in actual construction progress.
2. Preinstallation Conferences: Include Owner's construction personnel at preinstallation conferences covering portions of the Work that are to receive Owner's work. Attend preinstallation conferences conducted by Owner's construction personnel if portions of the Work depend on Owner's construction.

3.7 PROTECTION OF INSTALLED CONSTRUCTION

A. Provide final protection and maintain conditions that ensure installed Work is without damage or deterioration at time of Substantial Completion.

B. Comply with manufacturer's written instructions for temperature and relative humidity.

END OF SECTION 010640

SECTION 010650 – STARTING OF SYSTEMS

PART 1 - GENERAL

1.1 GENERAL

A. Scope: This Section describes the procedures for start up of all building equipment and systems including necessary demonstration and instructions.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for instructing Owner's personnel, including the following:

1. Demonstration of operation of systems, subsystems, and equipment.
2. Training in operation and maintenance of systems, subsystems, and equipment.
3. Demonstration and training video recordings.

1.3 STARTING SYSTEMS

A. Coordinate Schedule for start-up of various equipment and systems.

B. Notify Professional and Owner seven (7) days prior to start-up of each system.

C. Verify 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 wiring and support components for equipment are complete and tested.

F. Execute start-up under supervision of responsible Contractors' personnel in accordance with manufacturers' 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.

1.4 DEMONSTRATION AND INSTRUCTIONS

A. Demonstrate operation and maintenance of Products to Owner's personnel prior to date of Substantial Completion.

B. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with Owner's personnel in detail to explain all aspects of operation and maintenance.

C. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shut- down of each item of equipment at agreed-upon times, at designated location.

D. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instruction.

1.5 INFORMATIONAL SUBMITTALS

A. Instruction Program: Submit outline of instructional program for demonstration and training, including a list of training modules and a schedule of proposed dates, times, length of instruction time, and instructors' names for each training module. Include learning objective and outline for each training module.

1. Indicate proposed training modules using manufacturer-produced demonstration and training video recordings for systems, equipment, and products in lieu of video recording of live instructional module.

B. Qualification Data: For instructor.

C. Attendance Record: For each training module, submit list of participants and length of instruction time.

D. Evaluations: For each participant and for each training module, submit results and documentation of performance-based test.

1.6 CLOSEOUT SUBMITTALS

A. Demonstration and Training Video Recordings: Submit two copies within seven days of end of each training module.

1. Identification: On each copy, provide an applied label with the following information:

a. Name of Project.
b. Name and address of videographer.
c. Name of Architect.
d. Name of Construction Manager.
e. Name of Contractor.
f. Date of video recording.

2. Transcript: Prepared and bound in format matching operation and maintenance manuals. Mark appropriate identification on front and spine of each binder. Include a cover sheet with same label information as the corresponding video recording. Include name of Project and date of video recording on each page.
3. Transcript: Prepared in PDF electronic format. Include a cover sheet with same label information as the corresponding video recording and a table of contents with links to corresponding training components. Include name of Project and date of video recording on each page.
4. At completion of training, submit complete training manual(s) for Owner's use prepared and bound in format matching operation and maintenance manuals and in PDF electronic file format on compact disc.

1.7 QUALITY ASSURANCE

A. Instructor Qualifications: A factory-authorized service representative, complying with requirements in Section 014000 "Quality Requirements," experienced in operation and maintenance procedures and training.

B. Videographer Qualifications: A professional videographer who is experienced photographing demonstration and training events similar to those required.

C. Pre-instruction Conference: Conduct conference at Project site to comply with requirements in Section 013100 "Project Management and Coordination." Review methods and procedures related to demonstration and training including, but not limited to, the following:

1. Inspect and discuss locations and other facilities required for instruction.
2. Review and finalize instruction schedule and verify availability of educational materials, instructors' personnel, audiovisual equipment, and facilities needed to avoid delays.
3. Review required content of instruction.
4. For instruction that must occur outside, review weather and forecasted weather conditions and procedures to follow if conditions are unfavorable.

1.8 COORDINATION

A. Coordinate instruction schedule with Owner's operations. Adjust schedule as required to minimize disrupting Owner's operations and to ensure availability of Owner's personnel.

B. Coordinate instructors, including providing notification of dates, times, length of instruction time, and course content.

C. Coordinate content of training modules with content of approved emergency, operation, and maintenance manuals. Do not submit instruction program until operation and maintenance data has been reviewed and approved by Architect.

PART 2 - PRODUCTS

2.1 INSTRUCTION PROGRAM

A. Program Structure: Develop an instruction program that includes individual training modules for each system and for equipment not part of a system, as required by individual Specification Sections.

B. Training Modules: Develop a learning objective and teaching outline for each module. Include a description of specific skills and knowledge that participant is expected to master. For each module, include instruction for the following as applicable to the system, equipment, or component:

1. Basis of System Design, Operational Requirements, and Criteria: Include the following:

a. System, subsystem, and equipment descriptions.
b. Performance and design criteria if Contractor is delegated design responsibility.
c. Operating standards.
d. Regulatory requirements.
e. Equipment function.

f. Operating characteristics.
g. Limiting conditions.
h. Performance curves.

2. Documentation: Review the following items in detail:

a. Emergency manuals.
b. Operations manuals.
c. Maintenance manuals.
d. Project record documents.
e. Identification systems.
f. Warranties and bonds.
g. Maintenance service agreements and similar continuing commitments.

3. Emergencies: Include the following, as applicable:

a. Instructions on meaning of warnings, trouble indications, and error messages.
b. Instructions on stopping.
c. Shutdown instructions for each type of emergency.
d. Operating instructions for conditions outside of normal operating limits.
e. Sequences for electric or electronic systems.
f. Special operating instructions and procedures.

4. Operations: Include the following, as applicable:

a. Startup procedures.
b. Equipment or system break-in procedures.
c. Routine and normal operating instructions.
d. Regulation and control procedures.
e. Control sequences.
f. Safety procedures.
g. Instructions on stopping.
h. Normal shutdown instructions.
i. Operating procedures for emergencies.
j. Operating procedures for system, subsystem, or equipment failure.
k. Seasonal and weekend operating instructions.
l. Required sequences for electric or electronic systems.
m. Special operating instructions and procedures.

5. Adjustments: Include the following:

a. Alignments.
b. Checking adjustments.
c. Noise and vibration adjustments.
d. Economy and efficiency adjustments.

6. Troubleshooting: Include the following:

a. Diagnostic instructions.
b. Test and inspection procedures.

7. Maintenance: Include the following:

a. Inspection procedures.
b. Types of cleaning agents to be used and methods of cleaning.

c. List of cleaning agents and methods of cleaning detrimental to product.
d. Procedures for routine cleaning
e. Procedures for preventive maintenance.
f. Procedures for routine maintenance.
g. Instruction on use of special tools.

8. Repairs: Include the following:

a. Diagnosis instructions.
b. Repair instructions.
c. Disassembly; component removal, repair, and replacement; and reassembly instructions.
d. Instructions for identifying parts and components.
e. Review of spare parts needed for operation and maintenance.

PART 3 - EXECUTION

3.1 PREPARATION

A. Assemble educational materials necessary for instruction, including documentation and training module.

B. Set up instructional equipment at instruction location.

3.2 INSTRUCTION

A. Facilitator: Engage a qualified facilitator to prepare instruction program and training modules, to coordinate instructors, and to coordinate between Contractor and Owner for number of participants, instruction times, and location.

B. Engage qualified instructors to instruct Owner's personnel to adjust, operate, and maintain systems, subsystems, and equipment not part of a system.

1. Owner will furnish an instructor to describe Owner's operational philosophy.
2. Owner will furnish Contractor with names and positions of participants.

C. Scheduling: Provide instruction at mutually agreed on times. For equipment that requires seasonal operation, provide similar instruction at start of each season.

1. Schedule training with Owner, through Architect, with at least seven days advance notice.

D. Training Location and Reference Material: Conduct training on-site in the completed and fully operational facility using the actual equipment in-place. Conduct training using final operation and maintenance data submittals.

E. Evaluation: At conclusion of each training module, assess and document each participant's mastery of module by use of a demonstration performance-based test.

F. Cleanup: Collect used and leftover educational materials and remove from Project site. Remove instructional equipment. Restore systems and equipment to condition existing before initial training use.

3.3 DEMONSTRATION AND TRAINING VIDEO RECORDINGS

A. General: Engage a qualified commercial videographer to record demonstration and training video recordings. Record each training module separately. Include classroom instructions and demonstrations, board diagrams, and other visual aids, but not student practice.

1. At beginning of each training module, record each chart containing learning objective and lesson outline.

B. Video: Provide minimum 640 x 480 video resolution converted to format file type acceptable to Owner, on electronic media.

1. Electronic Media: Read-only format compact disc acceptable to Owner, with commercial-grade graphic label.
2. File Hierarchy: Organize folder structure and file locations according to project manual table of contents. Provide complete screen-based menu.
3. File Names: Utilize file names based upon name of equipment generally described in video segment, as identified in Project specifications.
4. Contractor and Installer Contact File: Using appropriate software, create a file for inclusion on the Equipment Demonstration and Training DVD that describes the following for each Contractor involved on the Project, arranged according to Project table of contents:

a. Name of Contractor/Installer.
b. Business address.
c. Business phone number.
d. Point of contact.
e. E-mail address.

C. Recording: Mount camera on tripod before starting recording, unless otherwise necessary to adequately cover area of demonstration and training. Display continuous running time.

1. Film training session(s) in segments not to exceed 15 minutes.

a. Produce segments to present a single significant piece of equipment per segment.
b. Organize segments with multiple pieces of equipment to follow order of Project Manual table of contents.
c. Where a training session on a particular piece of equipment exceeds 15 minutes, stop filming and pause training session. Begin training session again upon commencement of new filming segment.

D. Light Levels: Verify light levels are adequate to properly light equipment. Verify equipment markings are clearly visible prior to recording.

1. Furnish additional portable lighting as required.

E. Narration: Describe scenes on video recording by audio narration by microphone while or dubbing audio narration off-site after video recording is recorded. Include description of items being viewed.

F. Transcript: Provide a transcript of the narration. Display images and running time captured from videotape opposite the corresponding narration segment.

END OF SECTION 010650

SECTION 010710 – CLEANING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Scope: Maintain premises and public properties from accumulations of waste, debris and rubbish caused by operations. At completion of work, remove waste materials, rubbish, tools, equipment, machinery and surplus materials and clean all sight-exposed surfaces; leave Project clean and ready for occupancy.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Use only cleaning materials recommended by Manufacturer of surface to be cleaned. Use cleaning materials only on surfaces recommended by the cleaning materials Manufacturer.

PART 3 - EXECUTION

3.1 EXECUTION

A. During Construction: Execute cleaning to Ensure that building, grounds and public properties are maintained free from accumulations of waste materials and rubbish. Wet down dry materials and rubbish to lay dust and prevent blowing dust. At reasonable intervals during progress of work, clean site and public properties and dispose of waste materials, debris and rubbish. Remove waste materials, debris and rubbish from site and legally dispose of at public or private dumping areas off Owner's property. Vacuum clean interior building areas when ready to receive finish painting and continue vacuum cleaning on an as-needed basis until building is ready for substantial completion or occupancy. Handle materials in a controlled manner with as few handlings as possible; do not drop or throw materials from heights. Schedule cleaning operations so that dust or other contaminants resulting from cleaning process will not fall on wet or newly painted surfaces.

B. Final Cleaning: Employ experienced workmen, or professional cleaners, for final cleaning. In preparation for substantial completion or occupancy, conduct final inspection of sight-exposed interior and exterior surfaces and concealed spaces. Remove grease, dust, dirt, stains, labels, fingerprints and other foreign materials from sight-exposed finishes. Repair, patch and touch up marred surfaces to specified finish to match adjacent surfaces. Broom clean paved surfaces; rake clean other surfaces of grounds. Replace air conditioning filters if units were operated during construction. Clean ducts, blowers and coils if air conditioning units were operated without filters during construction. Maintain cleaning until Project, or respective portions thereof, is occupied by Owner.

1. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion for entire Project or for a designated portion of Project:

a. Clean Project site, yard, and grounds, in areas disturbed by construction activities, including landscape development areas, of rubbish, waste material, litter, and other foreign substances.
b. Sweep paved areas broom clean. Remove petrochemical spills, stains, and other foreign deposits.
c. Rake grounds that are neither planted nor paved to a smooth, even-textured surface.
d. Remove tools, construction equipment, machinery, and surplus material from Project site.
e. Remove snow and ice to provide safe access to building.
f. Clean exposed exterior and interior hard-surfaced finishes to a dirt-free condition, free of stains, films, and similar foreign substances. Avoid disturbing natural weathering of exterior surfaces. Restore reflective surfaces to their original condition.
g. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, attics, and similar spaces.
h. Sweep concrete floors broom clean in unoccupied spaces.
i. Vacuum carpet and similar soft surfaces, removing debris and excess nap; clean according to manufacturer's recommendations if visible soil or stains remain.
j. Clean transparent materials, including mirrors and glass in doors and windows. Remove glazing compounds and other noticeable, vision-obscuring materials. Polish mirrors and glass, taking care not to scratch surfaces.
k. Remove labels that are not permanent.
l. Wipe surfaces of mechanical and electrical equipment, elevator equipment, and similar equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.
m. Clean plumbing fixtures to a sanitary condition, free of stains, including stains resulting from water exposure.
n. Replace disposable air filters and clean permanent air filters. Clean exposed surfaces of diffusers, registers, and grills.
o. Clean ducts, blowers, and coils if units were operated without filters during construction or that display contamination with particulate matter on inspection.
p. Clean light fixtures, lamps, globes, and reflectors to function with full efficiency.
q. Leave Project clean and ready for occupancy.

END OF SECTION 010710

SECTION 012000 – PROJECT MEETINGS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Contractor's Responsibilities: The General Contractor will administer all progress meetings which include the following:

1. Prepare agenda
2. Distribute written notice of meetings seven (7) days in advance
3. Make physical arrangements for and presiding at the meetings
4. Record minutes
5. Distribute copies of the minutes to participants within four (4) days

B. Pre-Construction Meeting: Owner will schedule a pre-construction meeting as soon as possible after the award of Contract and the issuance of a Notice to Proceed.

1. Attendance:

a. Owner
b. Professional and Consultants
c. General Contractor
d. Major Subcontractors, including mechanical and electrical
e. Representatives of governmental, or other regulatory agencies

2. Minimum Agenda: (prepared by the General Contractor)

a. Distribute and discuss list of major Subcontractors and construction schedule
b. Critical work sequencing
c. Designation of responsible personnel
d. Procedures for maintaining record documents
e. Use of premises, including office and storage areas
f. Owner's requirements
g. Security procedures
h. Housekeeping procedures

3. Utilities: A written agreement must be reached on how all utilities will be furnished and the rates the Contractor will be charged. This agreement should be resolved at this meeting. Refer to Section 010500 entitled Construction Facilities and Temporary Controls of this Project Manual for additional utility requirements.

C. Preinstallation Conferences: Conduct a preinstallation conference at Project site before each construction activity that requires coordination with other construction.

1. Attendees: Installer and representatives of manufacturers and fabricators involved in or affected by the installation and its coordination or integration with other materials and installations that have preceded or will follow, shall attend the meeting. Advise Architect of scheduled meeting dates.
2. Agenda: Review progress of other construction activities and preparations for the particular activity under consideration, including requirements for the following:

a. Contract Documents.

b. Options.
c. Related RFIs.
d. Related Change Orders.
e. Purchases.
f. Deliveries.
g. Submittals.
h. Review of mockups.
i. Possible conflicts.
j. Compatibility requirements.
k. Time schedules.
l. Weather limitations.
m. Manufacturer's written instructions.
n. Warranty requirements.
o. Compatibility of materials.
p. Acceptability of substrates.
q. Temporary facilities and controls.
r. Space and access limitations.
s. Regulations of authorities having jurisdiction.
t. Testing and inspecting requirements.
u. Installation procedures.
v. Coordination with other work.
w. Required performance results.
x. Protection of adjacent work.
y. Protection of construction and personnel.

3. Record significant conference discussions, agreements, and disagreements, including required corrective measures and actions.
4. Reporting: Distribute minutes of the meeting to each party present and to other parties requiring information.
5. Do not proceed with installation if the conference cannot be successfully concluded. Initiate whatever actions are necessary to resolve impediments to performance of the Work and reconvene the conference at earliest feasible date.
6. Minutes: Entity conducting meeting will record and distribute meeting minutes.

D. Progress Meetings: Owner will schedule regular meetings at the time of the pre-construction conference Hold all meetings as progress of work dictates.

1. Attendance:

a. Owner
b. Professional and Consultants
c. General Contractor
d. Subcontractors, as pertinent to the agenda

2. Minimum Agenda:

a. Review, approve minutes of the previous meeting
b. Review work progress since last meeting
c. Note field inspections, problems and decisions
d. Identify problems which impede planned progress
e. Review off-site fabrication problems
f. f. Revise construction schedule, as indicated
g. Plan progress during the next work period
h. Review proposed changes
i. Complete other current business

E. Project Closeout Conference: Schedule and conduct a project closeout conference, at a time convenient to Owner and Architect, but no later than 90 days prior to the scheduled date of Substantial Completion.

1. Conduct the conference to review requirements and responsibilities related to Project closeout.
2. Attendees: Authorized representatives of Owner, Owner's Commissioning Authority, Architect, and their consultants; Contractor and its superintendent; major subcontractors; suppliers; and other concerned parties shall attend the meeting. Participants at the meeting shall be familiar with Project and authorized to conclude matters relating to the Work.
3. Agenda: Discuss items of significance that could affect or delay Project closeout, including the following:

    a. Preparation of record documents.
    b. Procedures required prior to inspection for Substantial Completion and for final inspection for acceptance.
    c. Submittal of written warranties.
    d. Requirements for preparing operations and maintenance data.
    e. Requirements for delivery of material samples, attic stock, and spare parts.
    f. Requirements for demonstration and training.
    g. Preparation of Contractor's punch list.
    h. Procedures for processing Applications for Payment at Substantial Completion and for final payment.
    i. Submittal procedures.
    j. Coordination of separate contracts.
    k. Owner's partial occupancy requirements.
    l. Installation of Owner's furniture, fixtures, and equipment.
    m. Responsibility for removing temporary facilities and controls.

4. Minutes: Entity conducting meeting will record and distribute meeting minutes.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 012000

SECTION 013100 – PROGRESS SCHEDULE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes administrative and procedural requirements for documenting the progress of construction during performance of the Work, including the following:

1. Startup construction schedule.
2. Contractor's construction schedule.
3. Construction schedule updating reports.
4. Daily construction reports.
5. Material location reports.
6. Site condition reports.
7. Special reports.

1.3 DEFINITIONS

A. Activity: A discrete part of a project that can be identified for planning, scheduling, monitoring, and controlling the construction project. Activities included in a construction schedule consume time and resources.

1. Critical Activity: An activity on the critical path that must start and finish on the planned early start and finish times.
2. Predecessor Activity: An activity that precedes another activity in the network.
3. Successor Activity: An activity that follows another activity in the network.

B. CPM: Critical path method, which is a method of planning and scheduling a construction project where activities are arranged based on activity relationships. Network calculations determine when activities can be performed and the critical path of Project.

C. Critical Path: The longest connected chain of interdependent activities through the network schedule that establishes the minimum overall Project duration and contains no float.

D. Event: The starting or ending point of an activity.

E. Float: The measure of leeway in starting and completing an activity.

1. Float time is not for the exclusive use or benefit of either Owner or Contractor, but is a jointly owned, expiring Project resource available to both parties as needed to meet schedule milestones and Contract completion date.
2. Free float is the amount of time an activity can be delayed without adversely affecting the early start of the successor activity.

3. Total float is the measure of leeway in starting or completing an activity without adversely affecting the planned Project completion date.

F. Resource Loading: The allocation of manpower and equipment necessary for the completion of an activity as scheduled.

1.4 SUBMITTALS

A. Format for Submittals: Submit required submittals in the following format:

1. Working electronic copy of schedule file, where indicated.
2. PDF electronic file.
3. Eight paper copies.

B. Contractor's Construction Schedule: Initial schedule, of size required to display entire schedule for entire construction period.

1. Submit a working electronic copy of schedule, using software indicated, and labeled to comply with requirements for submittals. Include type of schedule (initial or updated) and date on label.

C. Construction Schedule Updating Reports: Submit with Applications for Payment.

D. Site Condition Reports: Submit at time of discovery of differing conditions.

E. Special Reports: Submit at time of unusual event.

1.5 QUALITY ASSURANCE

A. Prescheduling Conference: Conduct conference at Project site to comply with requirements in Section 01200 "Project Meetings." Review methods and procedures related to the preliminary construction schedule and Contractor's construction schedule, including, but not limited to, the following:

1. Review software limitations and content and format for reports.
2. Verify availability of qualified personnel needed to develop and update schedule.
3. Discuss constraints, including work stages and interim milestones.
4. Review delivery dates for Owner-furnished products.
5. Review schedule for work of Owner's separate contracts.
6. Review submittal requirements and procedures.
7. Review time required for review of submittals and resubmittals.
8. Review requirements for tests and inspections by independent testing and inspecting agencies.
9. Review time required for Project closeout and Owner startup procedures.
10. Review and finalize list of construction activities to be included in schedule.
11. Review procedures for updating schedule.

1.6 COORDINATION

A. Coordinate Contractor's construction schedule with the schedule of values, submittal schedule, progress reports, payment requests, and other required schedules and reports.

1. Secure time commitments for performing critical elements of the Work from entities involved.
2. Coordinate each construction activity in the network with other activities and schedule them in proper sequence.

PART 2 - PRODUCTS

2.1 CONTRACTOR'S CONSTRUCTION SCHEDULE, GENERAL

A. Time Frame: Extend schedule from date established for the Notice to Proceed to date of Substantial Completion.

1. Contract completion date shall not be changed by submission of a schedule that shows an early completion date, unless specifically authorized by Change Order.

B. Activities: Treat each story or separate area as a separate numbered activity for each main element of the Work. Comply with the following:

1. Activity Duration: Define activities so no activity is longer than 20 days, unless specifically allowed by Architect.
2. Procurement Activities: Include procurement process activities for the following long lead items and major items, requiring a cycle of more than 60 days, as separate activities in schedule. Procurement cycle activities include, but are not limited to, submittals, approvals, purchasing, fabrication, and delivery.
3. Submittal Review Time: Include review and resubmittal times indicated in Section 013300 "Submittal Procedures" in schedule. Coordinate submittal review times in Contractor's construction schedule with submittal schedule.
4. Startup and Testing Time: Include no fewer than 21 days for startup and testing.
5. Substantial Completion: Indicate completion in advance of date established for Substantial Completion and allow time for Architect's administrative procedures necessary for certification of Substantial Completion.
6. Punch List and Final Completion: Include not more than 15 days for completion of punch list items and final completion.

C. Milestones: Include milestones indicated in the Contract Documents in schedule, including, but not limited to, the Notice to Proceed, Substantial Completion, and final completion.

D. Upcoming Work Summary: Prepare summary report indicating activities scheduled to occur or commence prior to submittal of next schedule update. Summarize the following issues:

1. Unresolved issues.
2. Unanswered Requests for Information.
3. Rejected or unreturned submittals.
4. Notations on returned submittals.
5. Pending modifications affecting the Work and Contract Time.

E. Recovery Schedule: When periodic update indicates the Work is 14 or more calendar days behind the current approved schedule, submit a separate recovery schedule indicating means by which Contractor intends to regain compliance with the schedule. Indicate changes to working hours, working days, crew sizes, and equipment required to achieve compliance, and date by which recovery will be accomplished.

F. Computer Scheduling Software: Prepare schedules using current version of a program that has been developed specifically to manage construction schedules.

2.2 CONTRACTOR'S CONSTRUCTION SCHEDULE (CPM SCHEDULE)

A. General: Prepare network diagrams using AON (activity-on-node) format.

B. Startup Network Diagram: Submit diagram within 14 days of date established for the Notice to Proceed. Outline significant construction activities for the first 90 days of construction. Include skeleton diagram for the remainder of the Work and a cash requirement prediction based on indicated activities.

C. CPM Schedule: Prepare Contractor's construction schedule using a time-scaled CPM network analysis diagram for the Work.

1. Develop network diagram in sufficient time to submit CPM schedule so it can be accepted for use no later than 30 days after date established for Notice to Proceed.

    a. Failure to include any work item required for performance of this Contract shall not excuse Contractor from completing all work within applicable completion dates, regardless of Architect's approval of the schedule.

2. Conduct educational workshops to train and inform key Project personnel, including subcontractors' personnel, in proper methods of providing data and using CPM schedule information.
3. Establish procedures for monitoring and updating CPM schedule and for reporting progress. Coordinate procedures with progress meeting and payment request dates.
4. Use "one workday" as the unit of time for individual activities. Indicate nonworking days and holidays incorporated into the schedule in order to coordinate with the Contract Time.

D. CPM Schedule Preparation: Prepare a list of all activities required to complete the Work. Using the startup network diagram, prepare a skeleton network to identify probable critical paths.

1. Activities: Indicate the estimated time duration, sequence requirements, and relationship of each activity in relation to other activities. Include estimated time frames for the following activities:

    a. Preparation and processing of submittals.
    b. Mobilization and demobilization.
    c. Purchase of materials.
    d. Delivery.
    e. Fabrication.
    f. Utility interruptions.
    g. Installation.
    h. Work by Owner that may affect or be affected by Contractor's activities.
    i. Testing.
    j. Punch list and final completion.
    k. Activities occurring following final completion.

2. Critical Path Activities: Identify critical path activities, including those for interim completion dates. Scheduled start and completion dates shall be consistent with Contract milestone dates.

3. Processing: Process data to produce output data on a computer-drawn, time-scaled network. Revise data, reorganize activity sequences, and reproduce as often as necessary to produce the CPM schedule within the limitations of the Contract Time.
4. Format: Mark the critical path. Locate the critical path near center of network; locate paths with most float near the edges.

    a. Subnetworks on separate sheets are permissible for activities clearly off the critical path.

E. Contract Modifications: For each proposed contract modification and concurrent with its submission, prepare a time-impact analysis using a network fragment to demonstrate the effect of the proposed change on the overall project schedule.

F. Initial Issue of Schedule: Prepare initial network diagram from a sorted activity list indicating straight "early start-total float." Identify critical activities. Prepare tabulated reports showing the following:

1. Contractor or subcontractor and the Work or activity.
2. Description of activity.
3. Main events of activity.
4. Immediate preceding and succeeding activities.
5. Early and late start dates.
6. Early and late finish dates.
7. Activity duration in workdays.
8. Total float or slack time.
9. Average size of workforce.
10. Dollar value of activity (coordinated with the schedule of values).

G. Schedule Updating: Concurrent with making revisions to schedule, prepare tabulated reports showing the following:

1. Identification of activities that have changed.
2. Changes in early and late start dates.
3. Changes in early and late finish dates.
4. Changes in activity durations in workdays.
5. Changes in the critical path.
6. Changes in total float or slack time.
7. Changes in the Contract Time.

2.3 REPORTS

A. Daily Construction Reports: Prepare a daily construction report recording the following information concerning events at Project site:

1. List of subcontractors at Project site.
2. Approximate count of personnel at Project site.
3. Equipment at Project site.
4. Material deliveries.
5. High and low temperatures and general weather conditions, including presence of rain or snow.
6. Accidents.
7. Meetings and significant decisions.
8. Unusual events (see special reports).
9. Stoppages, delays, shortages, and losses.

10. Emergency procedures.
11. Change Orders received and implemented.
12. Construction Change Directives received and implemented.
13. Services connected and disconnected.
14. Equipment or system tests and startups.
15. Partial completions and occupancies.

B. Site Condition Reports: Immediately on discovery of a difference between site conditions and the Contract Documents, prepare and submit a detailed report. Submit with a Request for Information. Include a detailed description of the differing conditions, together with recommendations for changing the Contract Documents.

2.4 SPECIAL REPORTS

A. General: Submit special reports directly to Owner within seven day(s) of an occurrence. Distribute copies of report to parties affected by the occurrence.

B. Reporting Unusual Events: When an event of an unusual and significant nature occurs at Project site, whether or not related directly to the Work, prepare and submit a special report. List chain of events, persons participating, response by Contractor's personnel, evaluation of results or effects, and similar pertinent information. Advise Owner in advance when these events are known or predictable.

PART 3 - EXECUTION

3.1 CONTRACTOR'S CONSTRUCTION SCHEDULE

A. Contractor's Construction Schedule Updating: At monthly intervals, update schedule to reflect actual construction progress and activities. Issue schedule one week before each regularly scheduled progress meeting.

1. Revise schedule immediately after each meeting or other activity where revisions have been recognized or made. Issue updated schedule concurrently with the report of each such meeting.
2. Include a report with updated schedule that indicates every change, including, but not limited to, changes in logic, durations, actual starts and finishes, and activity durations.
3. As the Work progresses, indicate final completion percentage for each activity.

B. Distribution: Distribute copies of approved schedule to Architect, Owner, separate contractors, testing and inspecting agencies, and other parties identified by Contractor with a need-to-know schedule responsibility.

1. Post copies in Project meeting rooms and temporary field offices.
2. When revisions are made, distribute updated schedules to the same parties and post in the same locations. Delete parties from distribution when they have completed their assigned portion of the Work and are no longer involved in performance of construction activities.

END OF SECTION 013100

SECTION 013400 - SHOP DRAWINGS, PRODUCT DATA AND SAMPLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes requirements for the submittal schedule and administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals.

1.3 DEFINITIONS

A. Action Submittals: Written and graphic information and physical samples that require Architect's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

B. Informational Submittals: Written and graphic information and physical samples that do not require Architect's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

C. Submittal Exchange: A collaborative, secure online system for electronically exchanging, reviewing, and archiving construction submittals, RFIs, and other construction communications.

D. Portable Document Format (PDF): An open standard file format licensed by Adobe Systems used for representing documents in a device-independent and display resolution-independent fixed-layout document format.

1.4 SUBMITTALS

A. Submittal Schedule: Submit a schedule of submittals, arranged in chronological order by dates required by construction schedule. Include time required for review, ordering, manufacturing, fabrication, and delivery when establishing dates. Include additional time required for making corrections or revisions to submittals noted by Architect and additional time for handling and reviewing submittals required by those corrections.

1. Coordinate submittal schedule with list of subcontracts, the schedule of values, and Contractor's construction schedule.
2. Initial Submittal: Submit concurrently with startup construction schedule. Include submittals required during the first 60 days of construction. List those submittals required to maintain orderly progress of the Work and those required early because of long lead time for manufacture or fabrication.
3. Final Submittal: Submit concurrently with the first complete submittal of Contractor's construction schedule.

a. Submit revised submittal schedule to reflect changes in current status and timing for submittals.

4. Format: Arrange the following information in a tabular format:

a. Scheduled date for first submittal.
b. Specification Section number and title.
c. Submittal category: Action; informational.
d. Name of subcontractor.
e. Description of the Work covered.
f. Scheduled date for Architect's final release or approval.
g. Scheduled date of fabrication.
h. Scheduled dates for purchasing.
i. Scheduled dates for installation.
j. Activity or event number.

1.5 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

A. Architect's Digital Data Files: Electronic digital data files of the Contract Drawings will not be provided by Architect for Contractor's use in preparing submittals.

B. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.

a. Architect reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

C. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.

1. Initial Review: Allow 10 days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required. Architect will advise Contractor when a submittal being processed must be delayed for coordination.
2. Intermediate Review: If intermediate submittal is necessary, process it in same manner as initial submittal.
3. Resubmittal Review: Allow 10 days for review of each resubmittal.
4. Sequential Review: Where sequential review of submittals by Architect's consultants, Owner, or other parties is indicated, allow 10 days for initial review of each submittal.

D. Electronic Submittal Procedures

1. Summary:

a. Shop drawing and product data submittals shall be transmitted to Architect in electronic (PDF) format using Submittal Exchange, a website service designed specifically for transmitting submittals between construction team members.
b. The intent of electronic submittals is to expedite the construction process by reducing paperwork, improving information flow, and decreasing turnaround time.
c. The electronic submittal process is not intended for color samples, color charts, or physical material samples.

2. Procedures:

a. Submittal Preparation - Contractor may use any or all of the following options:

1) Subcontractors and Suppliers provide electronic (PDF) submittals to Contractor via the Submittal Exchange website.
2) Subcontractors and Suppliers provide paper submittals to General Contractor who electronically scans and converts to PDF format.
3) Subcontractors and Suppliers provide paper submittals to Scanning Service which electronically scans and converts to PDF format.

b. Contractor shall review and apply electronic stamp certifying that the submittal complies with the requirements of the Contract Documents including verification of manufacturer / product, dimensions and coordination of information with other parts of the work.
c. Contractor shall transmit each submittal to Architect using the Submittal Exchange website, www.submittalexchange.com.
d. Architect / Engineer review comments will be made available on the Submittal Exchange website for downloading. Contractor will receive email notice of completed review.
e. Distribution of reviewed submittals to subcontractors and suppliers is the responsibility of the Contractor.

3. Costs:

a. General Contractor shall include the full cost of Submittal Exchange project subscription in their proposal. This cost is included in the Contract Amount. Contact Submittal Exchange at 515-393-2245 to verify cost prior to bid.
b. At Contractor's option, training is available from Submittal Exchange regarding use of website and PDF submittals. Contact Submittal Exchange at 515-393-2245.
c. Internet Service and Equipment Requirements:

1) Email address and Internet access at Contractor's main office.
2) Adobe Acrobat (www.adobe.com), Bluebeam PDF Revu (www.bluebeam.com), or other similar PDF review software for applying electronic stamps and comments.

E. Deviations and Additional Information: On an attached separate sheet, prepared on Contractor's letterhead, record relevant information, requests for data, revisions other than those requested by Architect on previous submittals, and deviations from requirements in the Contract Documents, including minor variations and limitations. Include same identification information as related submittal.

F. Resubmittals: Make resubmittals in same form and number of copies as initial submittal.

1. Note date and content of previous submittal.
2. Note date and content of revision in label or title block and clearly indicate extent of revision.
3. Resubmit submittals until they are marked with approval notation from Architect's action stamp.

G. Distribution: Furnish copies of final submittals to manufacturers, subcontractors, suppliers, fabricators, installers, authorities having jurisdiction, and others as necessary for performance of construction activities. Show distribution on transmittal forms.

H. Use for Construction: Retain complete copies of submittals on Project site. Use only final action submittals that are marked with approval notation from Architect's action stamp.

PART 2 - PRODUCTS

2.1 SUBMITTAL PROCEDURES

A. General Submittal Procedure Requirements: Prepare and submit submittals required by individual Specification Sections. Types of submittals are indicated in individual Specification Sections.

1. All submittals will be processed using the online services of Submittal Exchange.
2. Retain one of first two subparagraphs below if required.
3. Electronic submittals will be uploaded to Submittal Exchange as PDF electronic files.

    a. Architect will upload annotated files to Submittal Exchange for action by the Contractor.
    b. Contractor to coordinate filing and assembly of project Close Out Documents using Submittal Exchange Protocols and filing retrieval methods.
    c. Access permission, file interface and naming protocols using Submittal Exchange will be established in the Pre-Construction Meeting.

4. Certificates and Certifications Submittals: Provide a statement that includes signature of entity responsible for preparing certification. Certificates and certifications shall be signed by an officer or other individual authorized to sign documents on behalf of that entity.

    a. Provide a digital signature with digital certificate on electronically submitted certificates and certifications where indicated.
    b. Provide a notarized statement on original paper copy certificates and certifications where indicated.

B. Product Data: Collect information into a single submittal for each element of construction and type of product or equipment.

1. If information must be specially prepared for submittal because standard published data are not suitable for use, submit as Shop Drawings, not as Product Data.
2. Mark each copy of each submittal to show which products and options are applicable.
3. Include the following information, as applicable:

    a. Manufacturer's catalog cuts.
    b. Manufacturer's product specifications.
    c. Standard color charts.
    d. Statement of compliance with specified referenced standards.
    e. Testing by recognized testing agency.
    f. Application of testing agency labels and seals.
    g. Notation of coordination requirements.
    h. Availability and delivery time information.

4. For equipment, include the following in addition to the above, as applicable:

a. Wiring diagrams showing factory-installed wiring.
b. Printed performance curves.
c. Operational range diagrams.
d. Clearances required to other construction, if not indicated on accompanying Shop Drawings.

5. Submit Product Data before or concurrent with Samples.
6. Submit Product Data in the following format:

a. PDF electronic file.

C. Shop Drawings: Prepare Project-specific information, drawn accurately to scale. Do not base Shop Drawings on reproductions of the Contract Documents or standard printed data.

1. Preparation: Fully illustrate requirements in the Contract Documents. Include the following information, as applicable:

a. Identification of products.
b. Schedules.
c. Compliance with specified standards.
d. Notation of coordination requirements.
e. Notation of dimensions established by field measurement.
f. Relationship and attachment to adjoining construction clearly indicated.
g. Seal and signature of professional engineer if specified.

2. Sheet Size: Except for templates, patterns, and similar full-size drawings, submit Shop Drawings on sheets at least 8-1/2 by 11 inches, but no larger than 30 by 42 inches.
3. Submit Shop Drawings in the following format:

a. PDF electronic file.

D. Samples: Submit Samples for review of kind, color, pattern, and texture for a check of these characteristics with other elements and for a comparison of these characteristics between submittal and actual component as delivered and installed.

1. Transmit Samples that contain multiple, related components such as accessories together in one submittal package.
2. Identification: Attach label on unexposed side of Samples that includes the following:

a. Generic description of Sample.
b. Product name and name of manufacturer.
c. Sample source.
d. Number and title of applicable Specification Section.
e. Specification paragraph number and generic name of each item.

3. For projects where electronic submittals are required, provide corresponding electronic submittal of sample transmittal, digital image file illustrating sample characteristics and identification information to be included as part of Record Documents.
4. Disposition: Maintain sets of approved Samples at Project site, available for quality-control comparisons throughout the course of construction activity. Sample sets may be used to determine final acceptance of construction associated with each set.

a. Samples not designated as Owner's property are the property of Contractor.

E. Coordination Drawing Submittals: Comply with requirements specified in Section 010410 – Project Coordination.

F. Contractor's Construction Schedule: Comply with requirements specified in Section 013100 – Progress Schedule.

G. Application for Payment and Schedule of Values: Comply with requirements specified in Section 010250 – Schedule of Values and Section 010270 – Applications for Payment.

H. Closeout Submittals and Maintenance Material Submittals: Comply with requirements specified in Section 017200 – Contract Closeout & Record Documents.

I. Maintenance Data: Comply with requirements specified herein.

J. Qualification Data: Prepare written information that demonstrates capabilities and experience of firm or person. Include lists of completed projects with project names and addresses, contact information of architects and owners, and other information specified.

K. Welding Certificates: Prepare written certification that welding procedures and personnel comply with requirements in the Contract Documents. Submit record of Welding Procedure Specification and Procedure Qualification Record on AWS forms. Include names of firms and personnel certified.

L. Installer Certificates: Submit written statements on manufacturer's letterhead certifying that Installer complies with requirements in the Contract Documents and, where required, is authorized by manufacturer for this specific Project.

M. Manufacturer Certificates: Submit written statements on manufacturer's letterhead certifying that manufacturer complies with requirements in the Contract Documents. Include evidence of manufacturing experience where required.

N. Product Certificates: Submit written statements on manufacturer's letterhead certifying that product complies with requirements in the Contract Documents.

O. Material Certificates: Submit written statements on manufacturer's letterhead certifying that material complies with requirements in the Contract Documents.

P. Material Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting test results of material for compliance with requirements in the Contract Documents.

Q. Product Test Reports: Submit written reports indicating that current product produced by manufacturer complies with requirements in the Contract Documents. Base reports on evaluation of tests performed by manufacturer and witnessed by a qualified testing agency, or on comprehensive tests performed by a qualified testing agency.

R. Preconstruction Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of tests performed before installation of product, for compliance with performance requirements in the Contract Documents.

S. Compatibility Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of compatibility tests performed before installation of product. Include written recommendations for primers and substrate preparation needed for adhesion.

T. Field Test Reports: Submit written reports indicating and interpreting results of field tests performed either during installation of product or after product is installed in its final location, for compliance with requirements in the Contract Documents.

U. Design Data: Prepare and submit written and graphic information, including, but not limited to, performance and design criteria, list of applicable codes and regulations, and calculations. Include list of assumptions and other performance and design criteria and a summary of loads. Include load diagrams if applicable. Provide name and version of software, if any, used for calculations. Include page numbers.

2.2 DELEGATED-DESIGN SERVICES

A. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.

1. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to Architect.

B. Delegated-Design Services Certification: In addition to Shop Drawings, Product Data, and other required submittals, submit digitally signed PDF electronic file and three paper copies of certificate, signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional.

1. Indicate that products and systems comply with performance and design criteria in the Contract Documents. Include list of codes, loads, and other factors used in performing these services.

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

A. Submittals: Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents. Note corrections and field dimensions. Mark with approval stamp before submitting to Architect.

B. Project Closeout and Maintenance Material Submittals: See requirements in Section 017200 – Contract Closeout & Record Documents.

C. Approval Stamp: Stamp each submittal with a uniform, approval stamp. Include Project name and location, submittal number, Specification Section title and number, name of reviewer, date of Contractor's approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Contract Documents.

3.2 ARCHITECT'S ACTION

A. Action Submittals: Architect will review each submittal, make marks to indicate corrections or revisions required, and return it. Architect will stamp each submittal with an action stamp and will mark stamp appropriately to indicate action.

B. Informational Submittals: Architect will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect will forward each submittal to appropriate party.

C. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.

D. Incomplete submittals are unacceptable, will be considered nonresponsive, and will be returned for resubmittal without review.

E. Submittals not required by the Contract Documents may be returned by the Architect without action.

END OF SECTION 013400

SECTION 017200 – CONTRACT CLOSEOUT & RECORD DOCUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Scope: The work required in this Section consists of the final inspections and the submission of all closeout documents and related items to complete the Work indicated on the Drawings and described in the Project Manual.

B. All items required in subsequent Specifications Sections shall also be required in addition to all items described within this section.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specifications Sections apply to this section.

1.3 SUBMITTALS

A. the Contractor shall submit, through the Professional, the following copies of items required before final payment is made.

B. Contract Closeout Documents: Submit two (2) hard copies and two (2) electronic copies.

C. Project As-built Drawings: Submit one (1) hard copy and two (2) electronic copies.

D. Project Record Documents: Submit two (2) electronic copies.

PART 2 - PRODUCTS

2.1 FINAL INSPECTIONS

A. Contractor’s Inspection: The Contractor shall perform a punch list of all work and confirm that all items have been corrected prior to requesting the Professional’s inspection. When the Contractor considers the Work, or a portion thereof is substantially complete, the Contractor shall prepare and submit to the Professional a comprehensive list of items to be completed or corrected prior to final payment. All startup testing of systems; testing, adjusting, and balancing of systems; Owner training sessions, final cleaning and touchup painting must be complete prior to requesting the Professional’s Inspection.

B. Professional's Inspection: The Contractor shall make a written request for a final inspection to the Professional ten (10) days prior to the inspection. A list of any deficiencies, compiled by the Professional, will be corrected by the Contractor. If, in the Professional's judgment, the Project is not ready for a final inspection, the Professional may schedule another inspection and submit re-inspection cost to the Contractor. The Contractor shall complete the final punch list provided by the Professionals.

C. Owner's Inspection: After the Professional has ascertained the Project to be ready, an Owner's inspection will be scheduled within ten (10) days thereafter. The Owner's punch list shall be included with the Professional's punch list in the Substantial Completion Certificate and completed within ten (10) days after the Owner's acceptance.

D. Correction of Work Before Final Payment:

1. The Contractor shall promptly remove from the Owner's premises all materials condemned for failure to conform to the Contract, whether incorporated in the Work or not, and the Contractor shall, at his own expense, replace such condemned materials with those conforming to the requirements of the Contract. Failure to remedy such defects after ten (10) days written notice will allow the Owner to make good such defects and such costs shall be deducted from the balance due the Contractor, or charged to the Contractor in the event no payment is due.

2.2 CONTRACT CLOSEOUT DOCUMENTS

A. The Contractor shall facilitate a review meeting with the Owner and Professional prior to assembling the close-out documents for submission to review the content and organizational format. The Contractor shall submit the following:

1. Request for Final Payment: AIA Document G702, current edition, completed in full or a computer generated form having similar data; with notary seal and signature.
2. Consent of Surety Company to Final Payment: AIA Document G707, current edition, completed in full by the Bonding Company; with correct contract dates, notary seal and signature.
3. Power of Attorney: Closeout documents should be accompanied by an appropriate Power of Attorney; with notary seal and signature.
4. Release of Liens and Certification that All Bills Have Been Paid: AIA Document G706A, current edition, completed in full or a sworn statement and affidavit from the Contractor to the Owner stating that all bills for this job have been paid and that the Owner is released from any and all claims and/or damages; with notary seal and signature.
5. Contractor's Affidavit of Payment of Debts and Claims: AIA Document G706, current edition, completed in full; with notary seal and signature.
6. Affidavit Certifying Payment to All Subcontractors with notary seal and signature.
7. Guarantee of Work: Sworn statement that all work is guaranteed against defects in materials and workmanship for one (1) year from date of Owner's Substantial Completion acceptance, except where specified for longer periods.

    a. Provide a Guarantee from the General Contractor for the Project.
    b. Provide a Guarantee from each Subcontractor for their scope of work.
    c. Provide a comprehensive Warranties Reference List listing for each warranty the following information:

        1) Subcontractor name and contract information.
        2) Manufacturer name and contact information.
        3) Product description.
        4) Length of time for each warranty.

    d. Provide the Warranties from each manufacturer.
    e. Word the Guarantee as directed by the Professional and as acceptable to the Owner.
    f. All guarantees and warranties shall be obtained in the Owner's name.

g. Within the Guaranty period, if repairs or changes are requested in connection with guaranteed work which, in the opinion of the Owner, are 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, the Contractor shall promptly, upon receipt of notice from and without expense to the Owner, place in satisfactory condition building, site, equipment or contents thereof. The Contractor shall make good any work, materials, equipment or contents of said buildings or site that may be disturbed by fulfilling any such Guaranty.

h. If, after notice, the Contractor fails to proceed promptly to comply with the terms of the Guaranty, the Owner may have the defects corrected and the Contractor and his Sureties shall be liable for all expense incurred.

i. All special guarantees applicable to definite parts of the work stipulated in the Project Manual or other documents forming part of the Contract shall be subject to the terms of this paragraph during the first year of the life of such special guaranty.

2.3 PROJECT AS-BUILT DOCUMENTS

A. Project AS-BUILT Drawings: Submit as-builts of all contract documents red-lined reflecting actual installation. The Contractor shall assemble all subcontractor as-builts and submit one complete set of documents with no duplication of Project Document pages. The Contractor shall submit one as-built page for each page of the Contract Documents including plans and specifications. The documents shall be updated with all RFI's, ASI's and modifications to the drawings. Each change shall be clouded and the corresponding RFI or ASI number provided. The electronic copies shall have a separate file for each page labeled as defined in this section.

1. Provide As-built Log referenced herein.
2. Provide list of each RFI and the corresponding page and specification section that was modified.
3. Provide list of each ASI and the corresponding page and specification section that was modified.
4. Submit plan sheets on full size sheets at original drawing scale. All sheets must be the same size.
5. Mark the Contract Documents or Shop Drawings, whichever is most capable of showing actual physical conditions, completely and accurately. If Shop Drawings are marked, show cross-reference on the Contract Drawings.
6. Note Construction Change Directive, RFI, ASI numbers, alternate numbers, Change Order numbers and similar identification, where applicable.
7. Identify and date each Record Drawing, including the designation "PROJECT AS-BUILT" in the same prominent location on each sheet.
8. Types of items requiring red-lined marks include, but are not limited to, the following:

    a. Dimensional changes to the Drawings.
    b. Revisions to details shown on the Drawings.
    c. Depths of foundations below first floor.
    d. Locations and depths of underground utilities.
    e. Revisions to routing of piping.
    f. Revisions to electrical circuitry.
    g. Actual equipment locations.
    h. Duct size and routing.
    i. Locations of concealed internal utilities.
    j. Changes made following Professional's written orders.
    k. Details not on the original Contract Drawings.
    l. Field records for variable and concealed conditions.
    m. Record information on the Work that is shown only schematically.
    n. Changes made by Change Order and/or Construction Change Directive.

B. AS-BUILT Site Drawings: The Contractor shall provide GPS coordinates on the final As-Built documents, and shall provide CADD files to the Owner as follows:

1. Locate ALL abandoned underground valve, terminus points/junctions, junction boxes, changes in direction, manholes, fittings, tie-ins, switches, terminus points/junctions, etc. for all utilities known to be abandoned.
2. Locate ALL uncovered, existing underground valve, terminus points/junctions, junction boxes, changes in direction, manholes, fittings, tie-ins, switches, terminus points/junctions, etc. for all utilities known to be abandoned.
3. Locate ALL new underground valves, terminus points/junctions, junction boxes, changes in direction, manholes, fittings, tie-ins, switches, terminus points/junctions, etc. for all new utilities.
4. Projected Coordinate System: State Plane Coordinate System, Mississippi East FIPS 2301, Linear units in Feet, North American Datum 1983.

   Projection Details.
   Projection: Transverse Mercator.
   False_Eastling: 984250.00000000.
   False_Northing: 0.00000000.
   Central_Meridian: -88.83333333.
   Scale Factor: 0.99995000.
   Latitude of Origin: 29.50000000.
   Linear Unit: Foot_US.

5. Geographic Coordinate System: GCS_North_American_1983.
   Datum: D_North_American_1983.
   Prime Meridian: Greenwich.
   Angular Unit: Degree.
   Accuracy: Certified within 6”.

2.4 PROJECT RECORD DOCUMENTS

A. Furnish all Project Record Documents as defined here-in.

B. Submittals: Provide a copy of all approved submittals and shop drawings for the project. Submittals shall be organized by specification section. Shop drawings shall be labeled with the specification section, project name, Professional's project number and description of shop drawing. Provide a table of contents for the submittals and shop drawings. The electronic file copies shall have a separate file for each specification section.

C. Operations and Maintenance Manuals: Provide Operations and Maintenance Manuals as required in Contract Documents.

D. Owner Training Videos: Provide video copies of the owner training videos performed. Provide a separate file for each training session and for each type of system or equipment. Do not submit combined video files. The intent is for the Owner to easily reference the files to find the training video for each system and equipment separately. Clearly identify each file with system and equipment type using format defined in this specification section.

1. Attendance Record: For each training module, submit a list of participants and length of instruction time.

E. Attic Stock Inventory: Provide an inventory of attic stock and all transmittals signed by Owner. Organize inventory list by specification section. Clearly identify each material, type, color, etc.

F. Certificates: Provide a copy of all equipment start-up certificates, system certificates, inspection reports, factory start-up reports.

G. Test & Balance Reports: Provide a copy of the final test and balance report with letter from Contractor certifying that all items have been completed and verified.

H. Change Orders: Provide a copy of all change orders for the project.

I. Change Directives Provide a copy of all Change Directives for the project.

J. Substantial Completion Documents: Provide a copy of the Substantial Completion Certificate and the referenced punch list(s).

K. Additional Documents Specified Within the Project Manual: Provide all additional certificates, warranties, guarantees, bonds or documents as called for in the individual sections of the Project Manual. The Contractor is responsible for examining the Project Manual for these requirements.

PART 3 - EXECUTION

3.1 ORGANIZATION OF DOCUMENTS

A. Prior to submission of final pay application, submit 2 hard copies and two electronic copy of each close out document.

B. Close-out Document Table of Contents and Organization: Organize close-out documents and provide one compete Table of Contents that contains the following format. Organize hard bound sets into manageable three ring binders with clearly defined cover pages and table of contents for each. Organize hard and electronic files in the following format.

1. Cover Page: list project title, Professional, Contractor, Professional's project number, substantial completion date.
2. Substantial Completion Certification and Punch List.
3. Application for Final Payment.

    a. Consent of Surety.
    b. Power of Attorney.
    c. Release of Liens.
    d. Contractor's Affidavit of Payment of Debts and Claims.

4. Guaranty of Work.

    a. Contractor’s Guaranty.
    b. Subcontractor’s Guaranties.
    c. Manufacturer’s Guaranties.
    d. Warranty Reference List.

5. As-built Documents.

    a. Table of Contents of all documents.
    b. RFI and ASI as-built update log.

c. RFI and ASI plan change log.

6. Submittals.

a. Table of Contents of submittals by specification section.

7. Owner's and Operating Manuals.

a. Table of Contents of all manuals by Specification Section.

8. Owner Training Videos.

a. Table of Contents of all owner training by Specification Section.

9. Attic Stock Inventory.

a. Table of Contents of all attic stock transmitted to owner.

10. Certifications.

a. Table of Contents of all certifications.

11. Test and Balance Report.
12. Copy of Contract with Owner.
13. Change Orders.
14. Change Directives.

C. Provide a separate labeled tab / file for each of the following:

1. Warranty.
2. Certificate.
3. Test Report.
4. RFI.
5. ASI.
6. Change Order.
7. Change Directive.
8. Submittal.
9. Owners & Operating Manual.

a. Specification Section.

1) Equipment.

10. As-built Drawing Section.

D. All the documents are to be submitted in 3 ring binders, with the ability to lock the rings closed, of the appropriate sizes and quantities. No binder will be over 4" thick. All binders will be the same color. Contact the Professional for the color of binders for each project.

E. Use binders with clear plastic covers over the front/back covers and the edge spline. Insert typed/printed labels on each cover and spline with the following:

1. Project name and numbers.
2. Nature of work (trade package definition).
3. Nature of documents (paragraph 2, above) and book number in the set.

4. Name and telephone number of Contractor.
5. Name and telephone number of Professional.

F. Save the electronic copies of all of the above items with each section of work in a separate file that is labeled according to the spec section associated with document.

G. The first inclusion in every book regardless of the balance of the documents is to be a complete project call list. Include Contractor and every subcontractor and vendor including mailing address, physical address, for the principal office and any branch office who worked on the project, phone and fax numbers for each office listed, primary and secondary contacts, e-mail, addresses, cell phone numbers, pager numbers and home telephone numbers for each contact.

H. Electronic Filing Format: Label each electronic file in the following manner. Review with Professionals prior to compiling the files to ensure that the desired format is being utilized.
1. General Files:

a. *Project # _ Specification Section _ File Description*

2. Warranty Files:

a. *Project # _ Specification Section _ File Description*

3. As-Built Files: Assign a SHT number for each As-built sheet starting with the cover page of the Contract Documents and ending with the last page on the Table of Contents of the Project Plans. The order of the electronic files should be in the same order as shown on the Table of Contents of the Project Plans.

a. *Project # _*SHT *Assigned Number _ Sheet ID per Table of Contents*

4. RFI Files:

a. *Project # _ RFI # _ RFI Description*

5. Submittal Files:

a. *Project # _ Specification Section _ Submittal ID _ Submittal Name*

3.2 CONTRACT CLOSEOUT DOCUMENT

END OF SECTION 017200

DIVISION 02

EXISTING CONDITIONS

SECTION 024119 – SELECTIVE DEMOLITION

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. Demolition and removal of selected portions of building or structure.
2. Demolition and removal of selected site elements.
3. Salvage of existing items to be reused or recycled.
4. Saw cutting/core drilling.
5. Patching and repairs.

B. Related Sections:

1. Division 00 – General Requirements.

1.3 DEFINIITONS

A. Remove: Detach items from existing construction and dispose of them off-site unless indicated to be salvaged or reinstalled.

B. Remove and Salvage: Detach items from existing construction, in a manner to prevent damage, and deliver to Owner ready for storage.

C. Remove and Reinstall: Detach items from existing construction, in a manner to prevent damage, prepare for reuse, and reinstall where indicated.

D. Existing to Remain: Leave existing items that are not to be removed and that are not otherwise indicated to be salvaged or reinstalled.

1.4 MATERIALS OWNERSHIP

A. Unless otherwise indicated, demolition waste becomes property of Contractor.

B. Historic items, relics, antiques, and similar objects including, but not limited to, cornerstones and their contents, commemorative plaques and tablets, and other items of interest or value to Owner that may be uncovered during demolition remain the property of Owner.

1. Carefully salvage in a manner to prevent damage and promptly return to Owner.

1.5 PREINSTALLATION MEETINGS

A. Pre-demolition Conference: Conduct conference at location coordinated with Architect.

1. Inspect and discuss condition of construction to be selectively demolished.
2. Review structural load limitations of existing structure.
3. Review and finalize selective demolition schedule and verify availability of materials, demolition personnel, equipment, and facilities needed to make progress and avoid delays.
4. Review requirements of work performed by other trades that rely on substrates exposed by selective demolition operations.
5. Review areas where existing construction is to remain and requires protection.

1.6 QUALITY ASSURANCE AND PROTECTION

A. Regulatory Requirements: Comply with governing EPA notification regulations before starting selective demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.

B. Coordinate all hazardous material demolition with the Department of Environmental Quality (DEQ) with their mandatory prior notice requirement (minimum 10 days).

C. The Contractor shall provide for a safe and secure healthy working environment at all times per OSHA, local code and safe practice.

D. Temporary barrier, railing fencing, etc. shall be provided and a safely installed to limit access to unauthorized personnel to work areas, limit the spread of construction duct/debris to User occupied spaces, and security for construction trailers, equipment and supplies.

E. Any Owner furniture, especially cloth materials, shall be substantially protected. Contractor shall cover all furniture and protect blinds, curtains, etc. in demolition and other areas where demolition occurs or where construction routes and/or dust may be interactive.

1.7 SUBMITTALS

A. See Section 230010 Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop and coordination drawings according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Proposed protective measures report				R
Schedule of selective demolition activities				R
Pre-work / pre-demolition photos				R
Statement of refrigerant recovery per EPA regulations				R
Warranties (documentation indicating existing warranties are in effect after completion of selective demolition				R

1.8 PROJECT CONDITIONS

A. Owner will occupy portions of building immediately adjacent to selective demolition area. Conduct selective demolition so Owner's operations will not be disrupted.

B. Owner will occupy all buildings and grounds immediately adjacent to this building and some selective demolition areas. Conduct selective demolition so that Owner's operations will not be disrupted. Provide not less than 72 hours' prior notice to Owner of activities that will affect Owner's operations, including traffic dust, noise, etc.

C. Owner assumes no responsibility for actual condition of buildings or systems to be selectively demolished.

D. Asbestos and Lead Based Paint: If any materials suspected of containing asbestos are encountered, do not disturb the materials. Immediately notify the Professional and the Owner.

E. Storage or sale of removed items or materials on-site will not be permitted.

F. Removal, relocation of some of the furniture in construction areas shall be by the Owner. The remainder of furniture, fixtures and built-ins shall be protected by the Contractor during all construction. All areas, furniture and fixtures left in the construction area shall be daily cleaned and thereafter comprehensively cleaned after construction is complete in each space or room, at the Contractor's expense.

G. Utility Service: Maintain existing utilities indicated to remain in service and protect them against damage during selective demolition operations.

1. Maintain fire-protection facilities in service during selective demolition operations.

1.9 WARRANTY

A. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during selective demolition, by methods and with materials and using approved contractors so as not to void existing warranties. Notify warrantor before proceeding.

B. Notify warrantor on completion of selective demolition, and obtain documentation verifying that existing system has been inspected and warranty remains in effect. Submit documentation at Project closeout.

1.10 COORDINATION

A. Arrange selective demolition schedule so as not to interfere with Owner's operations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Comply with governing EPA notification regulations before beginning selective demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.

B. Standards: Comply with ASSE A10.6 and NFPA 241.

2.2 REPAIR MATERIALS

A. Use repair materials identical to existing materials.

1. Where identical materials are unavailable or cannot be used for exposed surfaces, use materials that visually match existing adjacent surfaces to the fullest extent possible as approved by Architect.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that utilities have been disconnected and capped, as appropriate, to safety protect occupants and the facilities.

B. Survey existing conditions and correlate with requirements indicated to determine extent of selective demolition required. Minimally demolish to match the extent to adequately access for repair or replacement work necessary.

C. When unanticipated mechanical, electrical, or structural elements that conflict with the intended function or design are encountered, investigate and measure the nature and extent of the conflict. Promptly submit a written report to the Professional and provide suggested remedial action and cost estimate(s).

D. Survey the condition of the building to determine whether removing any element might result in structural deficiency or unplanned collapse of any portion of the structure or adjacent structures during selective demolition. Contact the Professional immediately if an unsafe condition is noted. Protect people first and foremost.

E. Survey Existing Conditions: Record existing pre-demolition conditions by use of photographs and/or video. Inventory and record the condition of items to be removed and salvaged. Provide photographs or video of conditions that might be misconstrued as damage caused by salvage operations.

3.2 SCOPE

A. Remove portions of walls and devices systems including, but not limited to ceiling tiles, ceiling grid, gypsum board ceilings, devices, piping, cabling, conduit, ductwork, exterior wall systems (including brick, concrete block, flashing, masonry ties,etc.), lights, and existing HVAC equipment indicated to be removed, and all part/accessories as noted in the Construction Specifications and Drawings in order to provide, install, and seal all fire and smoke rated partitions.

B. Remove other items indicated, for salvage and relocation.

C. Removal of all hazardous materials found/uncovered during demolition and renovations shall be removed and disposed of as per all local, state, and federal requirements. The contractor shall provide all dump tickets, chain of custody documents, clearances/testing, and all disposal documents to the professional within 72 hours of disposal.

D. All demolition procedures shall be done in a manner that will protect the existing walls, flooring, base, ceilings, doors, devices; mechanical, electrical, and life-safety systems; and all devices and elements on the interior surfaces of the building. All building surfaces shall be protected from adhesives, fire-caulking, scratches, stains, dents, and any damage during renovations. (Any damage to the building surface or systems shall be repaired at the Contractor's expense and to meet all requirements as specified here-in, to match existing adjacent surfaces/finishes, and as indicated in the drawings.)

3.3 GENERAL PROCEDURES AND PROJECT CONDIITONS

A. Comply with applicable codes and regulations for demolition operations and safety of adjacent structures and the public.

1. Obtain required permits.
2. Comply with applicable requirements of NFPA 241.
3. Use of explosives is not permitted.
4. Provide all shoring, bracing, supports, and take precautions to prevent catastrophic or uncontrolled collapse and cracking of structures and wall systems to be removed; do not allow worker or public access within range of potential collapse of unstable structures.
5. Provide, erect, and maintain temporary barriers and security devices.
6. Use physical barriers to prevent access to areas that could be hazardous to workers or the public.
7. Conduct operations to minimize effects on and interference with adjacent structures and occupants.
8. Do not close or obstruct roadways, corridors, or sidewalks without permit or permissions.
9. Conduct operations to prevent obstruction of public and private entrances, corridors, and exits; do not obstruct required exits at any time; protect persons using entrances and exits from removal operations.
10. Obtain written permission from owners of adjacent properties when demolition equipment will traverse, infringe upon or limit access to their property.

B. Do not begin removal until receipt of notification to proceed from Owner

C. Protect existing structures and other elements that are not to be removed.

1. Provide bracing and shoring.
2. Prevent movement or settlement of adjacent structures.
3. Stop work immediately if adjacent structures appear to be in danger.

D. Minimize production of dust due to demolition operations; do not use water if that will result in ice, flooding, sedimentation of public waterways or storm sewers, or other pollution.

E. Hazardous Materials: Comply with 29 CFR 1926 and state and local regulations.

F. Perform demolition in a manner that maximizes salvage and recycling of materials.

1. Dismantle existing construction and separate materials.
2. Set aside reusable, recyclable, and salvageable materials; store and deliver to collection point or point of reuse.

3.4 PREPARATION

A. Conduct demolition operations to prevent injury to people and damage to adjacent buildings and facilities to remain. Ensure safe passage of unauthorized non construction personnel around selective demolition area(s).

1. Erect temporary protection, such as walks, fences railings, canopies, temporary construction barriers, and covered passageways, where required by authorities having jurisdiction.
2. Provide temporary weather protection, during interval between demolition and removal of existing construction, on exterior surfaces and new construction to ensure that no water leakage or damage occurs to structure or interior areas.

3.5 UTILITY SERVICES AND MECHANICAL/ELECTRICAL SYSTEMS

A. Maintain existing utilities indicated to remain in service and protect them against damage during selective demolition operations.

1. Do not interrupt existing utilities serving occupied or operating facilities, except when authorized in writing by Owner and authorities having jurisdiction. Provide temporary services during interruptions to existing utilities, as acceptable to Owner and to governing authorities.

    a. Provide not less than seven (7) days written prior notice to Owner if shutdown of service is required during any changeover, replacement, repair, etc.
    b. Utility Requirements: Refer to requirements outlined herein and in Divisions 21, 22, 23 and 26 for shutting off, disconnecting, removing, and sealing or capping utility services. Do not start selective demolition work until utility disconnecting and sealing have been completed and verified in writing.

B. Existing Services/Systems to Be Removed, Relocated, or Abandoned: Locate, identify, disconnect, and seal or cap off utility services and mechanical/electrical systems serving areas to be selectively demolished.

1. Arrange to shut off utilities with Owner and/or utility companies.
2. If services/systems are required to be removed, relocated, or abandoned, provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.
3. Disconnect, demolish, and remove fire-suppression systems, plumbing, and HVAC systems, equipment, and components indicated on Drawings to be removed.

    a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping at the main from which it is served with same or compatible piping material.
    b. Equipment to Be Removed: Disconnect and cap services and remove equipment.
    c. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
    d. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
    e. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts at the main from which it is served with same or compatible ductwork material.

3.6 PROTECTION

A. Temporary Protection: Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.

1. Provide protection to ensure safe passage of people around selective demolition area and to and from occupied portions of building.
2. Provide temporary weather protection, during interval between selective demolition of existing construction on exterior surfaces and new construction, to prevent water leakage and damage to structure and interior areas.
3. Protect walls, ceilings, floors, and other existing finish work that are to remain or that are exposed during selective demolition operations.
4. Cover and protect furniture, furnishings, and equipment that have not been removed.
5. Provide temporary enclosures, dust control, heating, and cooling as required.

B. Temporary Shoring: Design, provide, and maintain shoring, bracing, and structural supports as required to preserve stability and prevent movement, settlement, or collapse of construction and finishes to remain, and to prevent unexpected or uncontrolled movement or collapse of construction being demolished.

1. Strengthen or add new supports when required during progress of selective demolition.

C. Remove temporary barricades and protections where hazards no longer exist.

3.7 SELECTIVE DEMOLITION – GENERAL

A. General: Demolish and remove existing construction only to the extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations and as follows:

1. Proceed with selective demolition systematically, from higher to lower level. Complete selective demolition operations above each floor or tier before disturbing supporting members on the next lower level.
2. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction. Use hand tools or small power tools designed for sawing or grinding, not hammering and chopping. Temporarily cover openings to remain.
3. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.
4. Do not use cutting torches until work area is cleared of flammable materials. At concealed spaces, such as duct and pipe interiors, verify condition and contents of hidden space before starting flame-cutting operations. Maintain portable fire-suppression devices during flame-cutting operations.
5. Maintain fire watch during and for at least four hours after flame-cutting operations.
6. Maintain adequate ventilation when using cutting torches.
7. Remove decayed, vermin-infested, or otherwise dangerous or unsuitable materials and promptly dispose of off-site.
8. Remove structural framing members and lower to ground by method suitable to avoid free fall and to prevent ground impact or dust generation.
9. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.
10. Dispose of demolished items and materials promptly. On-site storage or sale of removed items is prohibited.

11. Return elements of construction and surfaces to remain to condition existing before start of selective demolition operations.

B. Site Access and Temporary Controls: Conduct selective demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.

C. Removed and Reinstalled Items:

1. Clean and repair items to functional condition adequate for intended reuse.
2. Pack or crate items after cleaning and repairing. Identify contents of containers.
3. Protect items from damage during transport and storage.
4. Reinstall items in locations indicated. Comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make item functional for use indicated.

D. Existing Items to Remain: Protect construction indicated to remain against damage and soiling during selective demolition. When permitted by Architect, items may be removed to a suitable, protected storage location during selective demolition and cleaned and reinstalled in their original locations after selective demolition operations are complete.

3.8 SELECTIVE DEMOLIITON – SPECIFIC MATERIALS

A. Concrete: Demolish in sections. Cut concrete full depth at junctures with construction to remain and at regular intervals using power-driven saw, and then remove concrete between saw cuts. Do not use power-driven impact tools during Owner's normal occupied periods.

B. Masonry: Demolish in small sections. Cut masonry at junctures with construction to remain, using power-driven saw, and then remove masonry between saw cuts.

C. Concrete Slabs-on-Grade: Saw-cut perimeter of area to be demolished, and then break up and remove.

D. Remove resilient floor coverings and adhesive according to recommendations of the Resilient Floor Covering Institute's (RFCI) "Recommended Work Practices for the Removal of Resilient Floor Coverings" and Addendum.

1. Remove residual adhesive and prepare substrate for new floor coverings by one of the methods recommended by RFCI.

E. Remove no more existing walls or roofing than can be promptly covered and interior areas protected.

F. Remove HVAC equipment without releasing refrigerants. Recover all refrigerants and oils per governing codes.

G. Provide temporary walls and seal air tight between construction areas and Owner occupied spaces. Construction barriers shall be provided where shown and as required, per Architect's directive.

3.9 DISPOSAL OF DEMOLISHED MATERIALS

A. General: Promptly dispose of demolished materials to an appropriate disposal site per local code requirements. Do not allow demolished materials to accumulate on-site or in building renovation areas.

B. Promptly haul off debris and demolition and unused construction material and equipment.

3.10 PATCHING AND REPAIRS

A. Restore walls, roofs, floors, ceilings, etc. to like new condition matching the surrounding finishes prior to demolition.

B. See additional requirements in Division 01.

3.11 CLEANING

A. Clean adjacent structures and improvements of dust, dirt, and debris caused by selective demolition operations. Return adjacent areas to condition existing before selective demolition operations began.

B. Clean and sweep the building, equipment room and outdoor concrete spaces, broom clean and provide for a thorough comprehensive vacuuming and dust removal on completion of selective demolition operation, at minimum daily intervals and prior to next day Owner occupancy of premises.

C. All areas affected by construction dust shall be thoroughly cleaned. All furniture, plumbing and light fixtures, wall, ceiling, and floor surfaces shall be cleaned.

END OF SECTION 024119

DIVISION 09

FINISHES

SECTION 095152 – ACOUSTICAL TILE CEILINGS

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. Provide all labor, materials, equipment, and services and perform all operations required for complete installation of Suspended Ceiling Tile and Metal Grid System and related work as indicated on the Drawings and specified herein.

B. Work Included:

1. All materials and required accessories for a complete installation of ceiling systems.

a. Suspended metal grid ceiling system.
b. Non-fire rated assembly.
c. Perimeter trim.

2. Coordination of mechanical and electrical vents, registers, sprinkler heads, fixtures, and other miscellaneous items as required for a completed installation.

1.3 RELATED WORK

A. Gypsum wallboard.

B. Division 23 HVAC: Air outlets and inlets, air diffusion devices in ceiling system and fire protection systems.

C. Division 26 Electrical: Lighting fixtures, communication devices, fire alarm devices, etc.

D. Coordinate exact location of mechanical and electrical devices with new exposed grid with no tile.

1.4 REFERENCE STANDARDS

A. ASTM C635: Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings.

B. ASTM C636: Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels.

1.5 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacture of ceiling suspension system and ceiling panels with five (5) year minimum experience.

B. Installer: Company with three (3) year minimum documented experience and approved by manufacturer.

1.6 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Shop drawings with grid layout and related dimensions, junctions with other work or ceiling finishes and coordination with Division 21 Fire Sprinkler, Division 23 HVAC and Division 26 Electrical items	R	R	R	R
Metal grid	R			R
Ceiling tiles	R			
Manufacturer’s installation instructions	R			

1.7 DELIVERY, HANDLING AND STORAGE

A. Deliver products to job site in manufacturer's original packaging.

B. Protect all materials with resilient packaging, sealed as required to prevent moisture penetration.

C. On exterior packaging each material shall be clearly marked and labeled with manufacturers name.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Maintain uniform temperature of minimum 60 degrees F. and humidity of 20 to 40 percent prior to, curing, and after installation.

1.9 SEQUENCING/SCHEDULING

A. Do not install acoustical ceilings until building is enclosed, sufficient heat is provided, dust generating activities have terminated, and overhead work is completed, tested, and approved.

B. Schedule installation of acoustic units after interior wet work is dry.

1.10 EXTRA STOCK

A. Provide one (1) extra carton of each type of ceiling panel to Owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Suspension System:

1. U.S. Gypsum Company.
2. Donn Corporation.
3. Armstrong Corporation – Prelude Grid System.
4. Or equal.

2.2 SUSPENSION SYSTEM MATERIALS

A. Grid: ASTM C635, non-fire rated exposed T (15/16") and (9/16") widths; components die cut and interlocking, equal to DX Suspension System. (Coordinate w/ ceiling tile types).

B. Accessories: Stabilizer bars and edge moldings required for suspended grid system.

C. Grid Materials: Commercial quality cold-rolled steel with hot-dipped galvanized coating.

D. Support Channels and Hangers: Galvanized steel; size and type to suit application, to rigidly secure acoustic ceiling system including integral mechanical and electrical components with maximum deflection of 1/360.

2.3 ACOUSTIC CEILING TILE MATERIALS

A. Acoustical Ceiling Tiles (ACT).

1. Manufactured by Armstrong, # 589 Cirrus Tegular (medium texture).

a. Size: 24" x 24"X 3/4" thickness.
b. Composition: Wet Formed Mineral Fiber.
c. Light Reflectance: .86.
d. CAC Range: 35.
e. Sag Resistance: Humiguard Plus.
f. Edge: beveled tegular.
g. Flame Spread: 25 or less. Fire Class A.
h. Color: White.

PART 3 - EXECUTION

3.1 INSPECTION

A. Make a thorough examination of all areas receiving the work of this Section before starting the installation.

B. Verify that existing conditions are ready to receive work.

C. Verify that layout of hangers will not interfere with other work.

D. Notify the Architect, in writing, of any defect which affects the satisfactory completion of the work of this Section.

E. Starting of work shall imply installers acceptance of conditions.

3.2 PREPARATION

A. Examine the Drawings and Specifications in order too, ensure the completeness of the work required under this Section.

1. Supplementary parts necessary to complete all work indicated under this Section, though not specifically indicated on Drawings, or specified herein shall be provided for a complete and finished installation.

3.3 INSTALLATION

A. Install system in accordance with ASTM C636 and as supplemented in this Section.

B. Install system capable of supporting imposed loads to a deflection of 1/360 maximum.

C. Install after major above ceiling work is complete.

1. Coordinate the location of hangers with other work.

D. Hang system independent of walls, columns, ducts, pipes, and conduit.

1. Where carrying members are spliced, avoid visible displacement of face plane of adjacent members.

E. Where ducts or other equipment prevent the regular spacing of hangers, reinforce the nearest affected hangers and related carrying channels to span the extra distance.

F. Center system on room axis leaving equal border units.

G. Do not support components on main runners or cross runners if weight causes total dead load to exceed deflection capability.

H. Do not eccentrically load system or produce rotation of runners.

I. Install edge molding at intersection of ceiling and vertical surfaces, using longest practical lengths.

1. Miter corners.
2. Provide edge moldings at junctions with other interruptions.

J. Form expansion joints as required.

1. Form to accommodate plus or minus one (1) inch movements.
2. Maintain visual closure.

K. Fit acoustic units in place, free from damaged edges or other defects detrimental to appearance and function.

L. Lay directional patterned units one way with pattern parallel to longest room axis.

M. Install acoustic unit’s level, in uniform place, and free from twist, warps and dents.

3.4 TOLERANCES

A. Variation from Flat and Level Surface: 1/8" in 10 feet.

B. Variation from Plumb of Grid Members Caused by Eccentric Loads: one (1) degree maximum.

3.5 ADJUSTING AND CLEANING

A. Remove dirt, smudges, or other blemishes from exposed surfaces of metal grid system.

B. Panels that cannot be easily cleaned or have scratches shall be replaced with new panels to match once Substantial Completion walk through has been completed.

C. Remove debris from project site.

3.6 PROTECTION

A. All completed work shall be adequately protected from damage due to subsequent construction operation and effects of weather.

B. Repair or replacement of materials shall be as required for Architect's approval.

END OF SECTION 095123

DIVISION 22

PLUMBING

SECTION 221316 - SANITARY WASTE AND VENT 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. Pipe, tube, and fittings.
2. Specialty pipe fittings.

1.3 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Piping and fitting materials	R			R
Couplings	R			

1.4 FIELD CONDITIONS

A. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. Notify Architect no fewer than two days in advance of proposed interruption of sanitary waste service.
2. Do not proceed with interruption of sanitary waste service without Architect's written permission.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Soil, Waste, and Vent Piping: 10-foot head of water.

2.2 PIPING MATERIALS

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.3 COPPER TUBE AND FITTINGS

A. Copper Type DWV Tube: ASTM B 306, drainage tube, drawn temper.

B. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

C. Hard Copper Tube: ASTM B 88, Type L and Type M, water tube, drawn temper.

D. Copper Pressure Fittings:

1. Copper Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

E. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.

1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

F. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.4 PVC PIPE AND FITTINGS

A. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.

B. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

C. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

D. Adhesive Primer: ASTM F 656.

E. Solvent Cement: ASTM D 2564.

PART 3 - EXECUTION

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Division 31.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.

1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
2. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.

1. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical.
2. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe.

    a. Straight tees, elbows, and crosses may be used on vent lines.

3. Do not change direction of flow more than 90 degrees.
4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.

a. Reducing size of waste piping in direction of flow is prohibited.

K. Lay buried building waste piping beginning at low point of each system.

1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
3. Maintain swab in piping and pull past each joint as completed.

L. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:

1. Building Sanitary Waste: 2 percent downward in direction of flow for piping NPS 3 and smaller; 2 percent downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Sanitary Waste Piping: 2 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

M. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."

N. Install aboveground PVC piping according to ASTM D 2665.

O. Install underground PVC piping according to ASTM D 2321.

P. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

Q. Install sleeves for piping penetrations of walls, ceilings, and floors.

R. Install sleeve seals for piping penetrations of concrete walls and slabs.

S. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.3 JOINT CONSTRUCTION

A. Join copper tube and fittings with soldered joints according to ASTM B 828. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.

B. Plastic, Non-Pressure Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 appendixes.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger and support devices and installation specified in Section 230529 – Hangers and Supports.

1. Install galvanized-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install galvanized-steel pipe support clamps for vertical piping in noncorrosive environments.

3. Vertical Piping: MSS Type 8 or Type 42, clamps.
4. Install individual, straight, horizontal piping runs:

    a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.

5. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
6. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4: 72 inches with 3/8-inch rod.
2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
3. NPS 2-1/2: 108 inches with 1/2-inch rod.
4. NPS 3 and NPS 5: 10 feet with 1/2-inch rod.
5. NPS 6: 10 feet with 5/8-inch rod.
6. NPS 8: 10 feet with 3/4-inch rod.

F. Install supports for vertical copper tubing every 10 feet.

G. Install hangers for PVC, CPVC and polypropylene piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.
2. NPS 3: 48 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
4. NPS 6 and NPS 8: 48 inches with 3/4-inch rod.
5. NPS 10 and NPS 12: 48 inches with 7/8-inch rod.

H. Install supports for vertical PVC, CPVC and polypropylene piping every 48 inches.

I. Support piping and tubing not listed above according to MSS SP-58 and manufacturer's written instructions.

3.5 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect waste piping to the following:

1. HVAC condensate drains from equipment to discharge locations.

C. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

D. Make connections according to the following unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.6 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping.

B. Comply with requirements for identification specified in Section 230553 – Mechanical Identification.

3.7 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

C. Test sanitary waste and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.

    a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced waste and vent piping until it has been tested and approved.

    a. Expose work that was covered or concealed before it was tested.

3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.

    a. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water.
    b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
    c. Inspect joints for leaks.

4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight.

a. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg.
b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
c. Air pressure must remain constant without introducing additional air throughout period of inspection.
d. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.8 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect sanitary waste and vent piping during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

D. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

E. Repair damage to adjacent materials caused by waste and vent piping installation.

3.9 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

Description	Pipe	Fittings	Joints
Condensate drains (interior to building). Insulate per Section 230719 Piping and Equipment Insulation	Copper, Type L	Copper, DWV pattern	Soldered
Condensate drains (exterior to building)	Solid wall PVC	PVC socket fittings, DWV pattern	Solvent-cemented

Sanitary Waste and Vent Piping Test Log						
Date	System	Description of Piping Section Tested	Test Press. (psig)	Test Duration (hours)	Results Pass/ Fail	Witness (Contractor) Initials
This form stall be completed and submitted with the project closeout documents. Contractor shall copy this form if more sheets are required. Piping pressure test log shall be kept at project site and shall be made available to the Architect upon request.						

END OF SECTION 221316

DIVISION 23

HVAC

SECTION 230010 – MECHANICAL GENERAL PROVISIONS

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 DIVISION OF WORK

A. This section delineates the division of work between Divisions.

B. Consult all other Sections, determine the extent and character of related work, and properly coordinate work specified herein with that specified elsewhere to produce a complete and operable installation. This section is provided to assist the Contractor in coordination of work scope but shall not be construed to limit Contractor's scope of work encompassed by the contract documents.

C. Coordination with other Trades: The following table is intended to assist the Contractors in coordinating the scope of work between Division 23 (Indicated as 23 in table), Section 230900 Energy Management & Control System (indicated as 23C), and other Divisions as indicated. However, the General Contractor is ultimately responsible for coordination among his subcontractors regardless of what is listed in this Section.

INTERFACE/RESPONSIBILITY MATRIX						
System		Division under which the following is specified				Remarks
		Equipment	Installation	Power Wiring [1]	Control & Interlock Wiring [1]	
FIRE SPRINKLER SYSTEM						
	Modifications and additions to existing sprinkler systems in accordance with NFPA 13	21	21	-	-	
FIRE & LIFE SAFETY SYSTEMS						
	Fire alarm and smoke control systems	26	26	26	26	
	Duct mounted & in-direct mounted smoke detectors	26	23	26	26/ 23C	[2]
	Other smoke detectors	26	26	26	26	
MECHANICAL EQUIPMENT						
	VRF system	23	23	26	23C	[3]
	Dedicated outdoor air systems	23	23	26	23C	[4]
	Air handling units	23	23	26	23C	
	Computer room units (indoor and outdoor units)	23	23	26	23C	
	VAV boxes	23	23	26	23C	
	Split-system heat pumps	23	23	26	23C	

INTERFACE/RESPONSIBILITY MATRIX						
System		Division under which the following is specified				Remarks
		Equipment	Installation	Power Wiring [1]	Control & Interlock Wiring [1]	
	Ductless split-systems	23	23	26	23C	
	Dehumidifiers	23	23	26	23C	
	Bipolar Ionization (ion generators)	23	23	26	23	
	Fans	23	23	26	23C	
	Motor starters	23	23	26	23C	[5]
	Other powered equipment	23	23	26	23C	
	Disconnects	26/23	26/23	26	26	[6]
	Closed-loop hydronic system water treatment	23	23	-	-	[17]
ENERGY MANAGEMENT & CONTROL SYSTEM						
	Central control workstations & servers	23C	23C	26	23C	
	Control system network backbone	23C	23C	23C	23C	
	Control panels	23C	23C	23C	23C	[7]
	Control devices	23C	23C	23C	23C	
	Network IT WAN/LAN drop	-	23C	23C	23C	[8]
PLUMBING SYSTEMS						
	Condensate drains including traps, primers	22	22	-	-	[9]
HVAC HYDRONIC SYSTEMS						
	Pipe gauges, thermometers, test plugs	23	23	-	-	
	Pressure relief valves	23	23	-	-	
	Relief valve vent piping, equipment drain piping, etc. from equipment to floor drains/sinks	23	23	-	-	
	Automatic isolation and control valves	23C	23	23C	23C	
	Sensor wells, meters, and other pipe-mounted control devices	23C	23	23C	23C	
	Test plugs	23	23			[16]
VAV BOXES						
	Terminal box control transformer panel	23C	23C	26	23C	[7]
	Terminal box with damper	23	23	-	-	
	Digital controller and damper actuator	23C	23	23C	23C	
	Air-flow measurement pickup and piping	23	23	-	-	
	Air-flow measurement transducer and wiring	23C	23C	23C	23C	
	Wall sensor module	23C	23C	23C	23C	
	HW control valve and actuator	23C	23	23C	23C	
HVAC SHEET METAL						
	Duct air leakage testing	23	23	-	-	[10]
	Duct mounted sensors	23C	23	23C	23C	
	Filter gauges	23C	23C	-	-	
	Control dampers	23	23	23C	23C	[11]
	Control damper actuators	23C	23C	23C	23C	[11],[12]
MISCELLANEOUS						
	Trenching, backfilling, boring, soil compaction, saw-cutting, patching and paving for underground piping	23	23	-	-	

INTERFACE/RESPONSIBILITY MATRIX						
	System	Division under which the following is specified				Remarks
		Equipment	Installation	Power Wiring [1]	Control & Interlock Wiring [1]	
	Excavation and dirt work for new concrete equipment pads and walkways.	23	23	-	-	
	Concrete equipment pads for equipment and walkways	23	23	-	-	[13]
	Restoring grass areas disturbed during construction with new sod. Grass type shall match existing	23	23			
	Equipment, ductwork, and piping steel supports and frames	23	23	-	-	
	Painting of exposed piping, HVAC equipment, etc.	23	23	-	-	
	Fire-stopping around pipe and duct penetrations in floor and walls	23	23	-	-	
	Framing of walls and ceilings to accept air outlets, fire dampers, etc.	23	23	-	-	[14]
	Ceiling and wall access doors	23	23	-	-	[15]

NUMBERED REMARKS:

[1] Wiring includes raceway, fittings, wire, boxes and related items, all voltages

[2] Wiring of interlock of duct smoke detectors to shut off supply fans upon detection of smoke is specified under Section 230900 Energy Management & Control System. All other smoke control/fire alarm related control wiring is specified under Division 26 Electrical.

[3] VRF system control & interlock wiring is specified under Division 23 HVAC. The control wiring includes but is not limited to all communication wiring, to all system components, remote controller wiring, branch selectors, system controllers, BACnet interface, etc. VRF control system shall be setup and configured by Division 23 HVAC. VRF system vendor to provide all necessary technical assistance to Division 23C Contractor in mapping across system points to the EMCS.

[4] Factory installed starters and variable speed drives are specified under Division 23 HVAC. Prewired control panel is specified under Division 23 HVAC, single point power connection (unless otherwise noted on drawings) specified by Division 23 HVAC. Packaged mechanical equipment specified with BACnet communication cards/gateways shall be provided by Division 23 HVAC. Packaged mechanical equipment vendor to provide all necessary technical assistance to Division 23C Contractor in mapping across equipment points to the EMCS.

[5] Motor starters are specified under Division 23 HVAC. Incoming power (from source) and outgoing power (to motor) is specified under Division 26 Electrical.

[6] Disconnects are specified under Division 23 HVAC where specifically called for in equipment schedules or specifications to be factory installed with equipment. Otherwise, all disconnects are specified under Division 26 Electrical.

[7] Power to all EMCS control panels is specified under Section 230900 Energy Management & Control Systems, coordinate with Division 26 contractor for available circuits.

[8] Network IT LAN drop at required EMCS location(s) specified under Section 230900 Energy Management & Control Systems. It shall be the responsibility of the Division 23C contractor to coordinate required IT LAN network connection location(s) with the Division 26 contractor or Owner's IT Department. Connection(s) to Owner's IT LAN and termination to wall jack specified under Section 230900 Energy Management and Control System.

[9] Coordinate piping from condensate pans to the sewer system including trap and final connections is specified under Division 22 Plumbing. Piping from auxiliary drain pans where provided at air handling equipment in furred spaces is specified under Division 23 HVAC.

[10] Duct air leakage testing is specified under Division 23 HVAC. Division 23 HVAC contractor shall notify

INTERFACE/RESPONSIBILITY MATRIX					
System	Division under which the following is specified				Remarks
	Equipment	Installation	Power Wiring [1]	Control & Interlock Wiring [1]	
Testing, Adjusting, and Balancing (TAB) Agency once all ductwork has passed the pretests and maximum duct air leakage rates confirmed. TAB Agency shall witness the final duct air leakage tests and initial the Duct Air Leakage Test Log (included in Section 233113 – Metal Ducts) certifying the test passed. [11] Duct access doors required for access to control devices where required specified under Division 23 HVAC. [12] Actuators for motorized dampers supplied with equipment, where scheduled on HVAC drawings are specified under Division 23 HVAC, mounted but not wired. Power and control wiring specified under Section 230900 Energy Management & Control Systems. [13] Shop drawings showing dimensions of all curbs, bases, etc. specified under Division 23 HVAC. [14] Additional T-bar or spline and cut ceiling tile as required to accept air outlets is specified under Division 23. [15] Dimensioning of access doors to all mechanical equipment and coordination with Engineer and Division 23 specified under Division 23. [16] Test plugs mounted adjacent to all temperature well (for calibration) specified under Division 23 [17] Add closed-loop hydronic water treatment chemicals to hydronic systems modified under this contract is specified under Division 23.					

D. HVAC/Electrical Design Coordination

1. The power ratings of motors and other HVAC equipment and the electrical characteristics of electrical systems serving them, as specified herein and indicated on the Drawings, have been established as minimums which will allow that equipment to satisfactorily function while producing the required capacities. These power ratings include a safety factor deemed appropriate to accommodate common differences between design parameters and field construction practices. Under no circumstances shall equipment with power ratings less than those indicated on the Drawings or specified herein be provided.
2. Reasonable efforts have been made to coordinate the electrical requirements of the HVAC equipment with the electrical systems serving that equipment. Differences among manufacturers of HVAC equipment make it impossible to produce a single electrical design which will satisfy the varying electrical requirements of those manufacturers. Consequently, the Contractor shall coordinate the electrical requirements of the HVAC equipment actually furnished on this Project and provide the electrical systems required by that equipment. This coordination effort shall be completed prior to the installation of either the HVAC equipment or the electrical systems serving that equipment. Electrical system revisions required to coordinate with the HVAC equipment actually furnished shall be provided at no additional cost to the Owner.

1.3 REFERENCE STANDARDS

A. Reference to codes, standards, specifications and recommendation of technical societies, trade organizations and governmental agencies shall mean that latest edition of such publications adopted and published prior to submittal of the bid. Such codes or standards shall be considered a part of this Specification as though fully repeated herein.

B. Work shall be performed in accordance with all applicable requirements of the latest edition of all governing codes, rules and regulations including but not limited to the following minimum standards, whether statutory or not.

C. Requirements of Regulatory Agencies

1. In accordance with the requirement of Division 1 General Requirements.
2. Nothing in contract documents shall be construed to permit work not conforming to current and applicable laws, ordinances, rules and regulations.
3. Where contract documents exceed requirements of applicable laws, ordinances, rules and regulations, comply with documents establishing the more stringent requirement.
4. It is not the intent of contract documents to repeat requirements of codes except where necessary for completeness or clarity.
5. Comply with the Safety Orders issued by OSHA and any other safety, State health or environmental regulations and any districts having jurisdictional authority. Where an omission or conflict appears between OSHA requirements and the Drawings and Specifications, OSHA requirements shall take precedence.
6. Applicable codes as listed below, in addition to others specified in individual sections.

    a. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) – Standard 90.1-2010 “Energy Standard for Buildings Except Low-Rise Residential Buildings”.
    b. International Building Code (IBC) – 2018.
    c. International Mechanical Code (IMC) – 2018.
    d. International Plumbing Code (IPC) - 2018.
    e. NFPA 1 – 2018, Fire Code
    f. NFPA 70 - 2017, National Electric Code
    g. NFPA 90A - 2018, Installation of Air Conditioning and Ventilating Systems

D. Published specifications, standards, tests or recommended method of trade, industry or governmental organizations as listed below apply to all work in Division 23 HVAC, in addition to other standards which may be specified in individual sections.

E. All base material shall meet ASTM and ANSI standards.

F. All Gas Fired Devices: Comply with standards and bear label of AGA.

G. All Pressure Vessels, Relief Valves, Safety Relief Valves and Safety Valves: Comply with standards, ASME stamped.

H. All Electrical Devices and Wiring

1. Conform to standards of NEC
2. All devices UL or ETL listed and identified

I. Guidelines and Standards: The latest edition of guidelines and standards published by the following govern the Mechanical Systems and associated support system design. The systems shall be designed to meet or exceed these guidelines and standards.

AABC	Associated Air Balance Council
ADC	Air Diffuser Balance Council

AGA	American Gas Association
AMCA	Air Movement and Control Association, Inc.
ANSI	American National Standards Institute
ARI	Air Conditioning and Refrigeration Institute
ASC	Adhesive and Sealant Council
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASSE	American Society of Sanitary Engineers
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
AWS	American Welding Society
ETL	Interlek Semko (Formerly Electrical Testing Laboratories)
GISO	General Industry Safety Orders
HI	Hydraulic Institute
ICBO	International Conference of Building Officials
IEEE	Institute of Electrical and Electronic Engineers
NBS	National Bureau of Standards
NEBB	National Environmental Balancing Bureau
NEC	National Electrical Code
NEMA	National Electrical Manufacturer's Association
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Act
PDI	Plumbing and Drainage Institute
SMACNA	Sheet Metal and Air Conditioning Contractors National Association, Inc.
UL	Underwriter's Laboratories, Inc.

1.4 QUALITY ASSURANCE

A. Supply all equipment and accessories in compliance with the applicable standards listed herein and with all applicable national, state and local codes.

B. All equipment and accessories shall be new, and the product of a manufacturer regularly engaged in its manufacture.

C. All items of a given type shall be the products of same manufacturer.

D. Workmanship, material and equipment shall be in accordance with Specifications and Drawings and in some instances the requirements exceed those required by codes and standards. Where not exceeded, the codes and standards shall be considered as absolute minimum requirements.

1.5 SUBMITTALS

A. No work may begin on any segment of this Project until the related submittals have been reviewed for conformance with the design intent and the Contractor has responded to all comments to the satisfaction of the Owner.

B. Submit drawings, product data, samples and certificates of compliance required as hereinafter specified. See also Division 01 – General Requirements.

C. Submit no later than 35-days after signing of Contract, or as otherwise indicated by Architect. Submit a schedule indicating the proposed submission date of each submittal specified herein. Schedule shall anticipate the submittal review time, the possible need for resubmittals, and the time required for fabrication, shipping and integration into the construction sequence. Architect will advise of any conflicts in reviewing submittals that the proposed schedule presents.

1. Complete schedule of submittals for equipment and layout shop drawings. Allow 15-working days for review unless Architect agrees to accelerated schedule.
2. List of all proposed substitutions: See requirements herein.
3. Designate in schedule dates for submission and dates that reviewed shop drawings, product data and samples will be needed.
4. Provide submittals promptly in accordance with schedule and in such sequence as to cause no delay in work or in work of any other division.

D. Submit drawings, product data, samples and certificates of compliance required hereinafter specified.

1. See also Division 01 General Requirements.
2. Provide submittals promptly in accordance with schedule and in such sequence as to cause no delay in work or in work of any other division.
3. Submittals for each specification section shall be submitted in a single package. However, it is not required (nor desired) for all products to be submitted concurrently. Rather, submittals may be staggered based on schedule and required equipment release dates.
4. Allow 15-working days for review unless the Architect agrees to accelerated schedule.
5. For substitutions, list any features or characteristics that are not strictly in compliance with specifications. If none are listed with the submittal, Contractor is guaranteeing that substituted product is functionally equivalent to the specified product in accordance with requirements herein.
6. Submittal reviews by the Architect are intended to assist the Contractor in complying with the design intent and requirements of the drawings and specifications. Reviews do not relieve the Contractor from compliance with these requirements and comments or lack thereof does not constitute approval of changes in these requirements.

E. Submission and Resubmission Procedure.

1. Each submittal cover sheet shall contain the Contractor's review statement. The statement shall be worded as follows:

   a. It is hereby certified that the information included in this submittal and approved/proposed to be incorporated into this project (include official project name on Contract Drawings), is in compliance with the Contract Drawings and specifications, the electrical requirements have been coordinated with the Electrical Sub-Contractor, can be installed in the allocated spaces with adequate service space, and is approved for use and is submitted for Architect's review.

   Authorized Reviewer: _____ Date: _____

2. Each submittal shall have a unique serial number that includes the associated specification section followed by a number for each sub-part of the submittal for that specification section, such as "SUBMITTAL 23 xx xx-01".
3. Each resubmittal shall have the original unique serial number plus revision number such as "SUBMITTAL 23 xx xx-01 REVISION 1".
4. Submit in format specified below. Submissions made in wrong format will be returned without action.

   a. Product Submittals: One copy in word-searchable electronic format per requirements herein. Submit each specification section in a separate file named with unique name and number described above.
   b. Shop Drawings:

      1) One copy in electronic format .dwg, .dwf, or .pdf
      2) Two and only two copies on paper; any additional copies will not be returned without review

c. Samples: As indicated in each specification section.

5. Architect will return a memo or mark-up of submittal with comments and corrections noted where required.
6. Make corrections

a. Revise initial submittal to resolve review comments and corrections.
b. Indicate any changes that have been made other than those requested.
c. Clearly identify resubmittal by original submittal number and revision number.

7. Resubmit revised submittals until “No Exceptions” or “Furnish as Corrected” is provided by the Professional.
8. Once submittals are accepted and stamped with “No Exceptions” or “Furnish as Corrected”, provide:

a. Complete submittal of all accepted products in a single electronic file for each specification section.
b. Photocopies for coordination with other trades, if and as required by the Contractor or Architect. Photocopies will serve as submittal for record and coordination.

9. The stipulation included with the Professionals remarks with “Furnish as Corrected” indicate provisional acceptance.

F. Product Data Submittals

1. Contents.

a. Manufacturer’s name and model number.
b. All information required to completely describe materials and equipment and to indicate compliance with drawings and specifications, including, but not limited to:

1) Schedule when more than one of each item is covered by submittal.
2) Physical data, as applicable.

a) Dimensions.
b) Weights.
c) Finishes and colors.
d) Dimensional shop drawings.

3) Performance data, as applicable.

a) Rated capacities.
b) Performance curve.
c) Operating temperature and pressure.
d) Efficiency.

4) Flow and wiring diagrams as applicable.
5) Description of system operation.

c. All other pertinent information requested in individual sections.

2. Format.

a. See Division 01 – General Requirements.
b. Identify clearly if submittal is substitution: See requirements herein.
c. Reference specification Division, Section, Title, Paragraph and Page number or drawing number as applicable

d. Use same nomenclature, legend, symbols, and abbreviations on submittal material as used in contract documents.

1.6 COMPLETION REQUIREMENTS

A. Procedure.

1. Until the documents required in this section are submitted and approved, the system will not be considered “accepted”.
2. Before requesting acceptance of work, submit one set of Completion Documents for review and approval of Architect.
3. After review, furnish quantity of sets indicated below to Owner.
4. Format:

a. See herein for required format of Completion Documents.
b. Paper Copies: Assemble in chronological order following alpha-numeric system used in specification, in heavy three-ring binder.
c. Where electronic copies are called for herein, comply with the following:

1) Provide in word-searchable electronic format; acceptable formats are MS Word, Adobe Acrobat (pdf) and HTML; submit other formats for review and approval prior to submission; scanned paper documents not acceptable.
2) For submittals, provide separate file for each type of equipment.
3) For Test & Balance report, provide separate files for each air handling system.
4) Record drawings shall be in original format.

B. Operating and Maintenance (O&M) Manual.

1. See O&M Manual requirement herein

C. Record Drawings.

1. Keep up-to-date during progress of job one set of Mechanical Drawings indicating the Record installation. In addition to changes made during course of Work, show following by dimension from readily obtained base lines.

a. Fully illustrate all revisions made by all crafts in course of work.
b. Include all field changes, adjustments, variances, substitutions, and deletions, including all Change Orders.
c. Exact location, type and function of concealed valves, dampers, controllers, piping, air vents and piping drains.
d. Exact size, invert elevations and location of underground and under floor piping and ducts.

1) Progress drawing set shall be available for inspection by Architect weekly.
2) Update engineering design drawings and shop drawings to reflect revisions and additional data listed above at completion of Project.

e. Original engineering design drawings will be provided to Contactor in electronic format compatible with AutoCAD version 2010 or later.
f. Both shop and engineering design drawings shall be in format compatible with AutoCAD version 2010 or later.
g. Drawings required to be updated if revisions were made.

1) Floor plans.
2) Shop drawings required herein.
3) Sections.
4) Riser diagrams.

D. Test and Balance Reports.

1. See Section 230593 – Testing, Adjusting, and Balancing for HVAC.

E. Training Materials.

1. See Training Materials requirements herein.

F. Miscellaneous Certificates.

1. Pressure and Leakage Test documentation/certificates.
2. Training/Instruction completion certificates.
3. Fire Marshal and Fire Department approvals of system, as required.
4. Final inspection certificate signed by governing authorities.
5. Warranty period, including start and end period.
6. Field test report, including as applicable.
7. Start-up documents with date and name of technician.
8. Piping pressure tests.
9. Flex coupled pump alignment verification.
10. Duct leakage and pressure tests.
11. Drain pan drainage tests.
12. Letters from manufacturers certifying their supervision of equipment installation and start-up procedures.
13. Machinery vibration test reports.
14. Certificates of sterilization/chlorination of plumbing systems.
15. Others as specified herein and in other Division 23 – Mechanical sections.

G. Format of Completion Documents.

1. Provide the type and quantity of media listed in table below.
2. Optical media shall be readable on a personal computer.
3. Where indicated in table, the electronic files shall be stored on the EMCS systems' Operator Workstation and hyperlinked to the front-end DDC controls graphics so operators can get the details of a certain device or balance reports by clicking on the link: See Section 230900 – Energy Management & Control Systems.

Document	Paper (Binder or bound)	Electronic	
		USB Flash Drive	Loaded Onto Operator Workstation
O&M Manuals	3	1	1
Record Drawings	2 Full sizes 2 Half sizes	1	1
Original issue EMCS software & manuals	1	1	1
Control sequences	1	1	1
Test and Balance Report	5	1	1
Miscellaneous Certificates	1	1	1
Warranty documents	1	1	1
Training materials	1 per trainee	1	1

1.7 SUBSTITUTIONS AND PRODUCT OPTIONS

A. For specific substitution requirements, See Division 00, and Division 01.

B. Where equipment and materials are shown on the drawings and/or specified hereinafter by a manufacturer's name and/or model number, it is the intent of these specifications to set minimum definite standards for equipment and materials to be used on the project. It is not the intent of these specifications to preclude the use of materials and equipment of similar design and quality to manufacturer's name specified. If the Contractor desires to substitute materials and equipment, he shall obtain written approval through the materials submittals process of all such substitutions before such substitutions are made. Unauthorized substitutions of materials and equipment may be ordered removed from the project without further grounds. The Architect will not approve any substitutions for specified materials and equipment unless such substitutions are requested by the Contractor.

C. The products of particular manufacturers have been used as the basis of design in preparation of these documents. It shall be the responsibility of this Contractor to determine if the submitted materials and equipment will fit into the space allotted with all required clearances as the materials and equipment utilized as the basis of design. Furthermore, the Contractor shall verify and maintain adequate access to equipment, valves, filters, lubrication outlets, etc. Any changes to the building or system design necessary shall be arranged for in writing before the materials and equipment is ordered. All costs involved in making such changes shall be borne by the Contractor. If such changes are deemed inadvisable by the Architect, the Contractor shall install items specified even though materials and equipment had been previously approved. Architect's approval of materials and equipment other than the basis of design is for performance only.

D. Contractor shall consider the following parameters (at a minimum) when considering materials and equipment substitutions:

1. Capacities: The capacities included in the Contract Documents are absolute minimum and the substitution shall have equal or greater capacities.
2. Physical size limitations: Substitutes shall fit in the allotted space and shall have the manufacturer's minimum clearances.
3. Installation and operating weights.
4. Structural properties.
5. Noise levels.
6. Vibration.
7. Interchangeability.
8. Accessibility for maintenance, operation, and replacement.
9. Compatibility with other materials and assemblies.
10. Equal quality and style.

1.8 DESCRIPTION OF BID DOCUMENTS

A. The Contractor shall be responsible for becoming thoroughly acquainted with all Contract Document contents that affect his work under this contract. Work required under this section includes, but is not limited to, all material, equipment transportation, services and labor required to complete the entire mechanical system as required by the Contract Documents.

B. The Specifications and the associated Drawings are complimentary, and any portion of the work described in one shall be provided as if described in both.

C. Specifications.

1. Specifications, in general, describe quality and character of materials and equipment.
2. Specifications are of simplified form and include incomplete sentences.
3. Words or phrases such as "The Contractor shall," "shall be," "furnish," "provide," "a," "an," "the," and "all" have often been omitted from specifications for brevity.

D. Drawings.

1. Drawings are diagrammatic in nature and, unless explicitly dimensioned, indicate approximate locations of apparatus, equipment, ductwork, and piping. Changes in the location, and offsets, of same which are not shown on the Drawings but are necessary in order to accommodate building conditions and coordination with the work of other trades, shall be made during the preparation of coordination drawings and prior to initial installation, without additional cost to the Owner. Contractor shall install all system components in such a manner as to conform to the structure, avoid obstructions, preserve headroom, keep openings and passageways clear and maintain required servicing clearances without further instructions or additional cost to the Owner.
2. Scaled and figured dimensions are approximate and are for estimating purposes only. Indicated dimensions are limiting dimensions where noted. Duct and piping elevations are indicated for initial coordination; final requirements shall be determined by the Contractor after final coordination with other trades.
3. Before proceeding with work, check and verify all dimensions in field.
4. Assume all responsibility for fitting of materials and equipment to other parts of equipment and structure.
5. Make adjustments that may be necessary or requested in order to resolve space problems, preserve headroom, and avoid architectural openings, structural members and work of other trades.
6. It is intended that all mechanical, plumbing and fire protection devices, piping, etc. be located symmetrically with all architectural elements. Refer to Architectural, Structural, Plumbing, Fire Protection, Mechanical and Electrical Specifications and Drawings in completing the required coordination.
7. The Contractor shall fully inform himself regarding any and all peculiarities and limitations of the spaces available for the installation of all work and materials furnished and installed under this Contract. He shall exercise due and particular caution to determine that all parts of his work are made readily accessible.
8. The Contractor shall study all drawings and specifications to determine any conflict with all applicable ordinances and statutes. Any discrepancies shall be reported to the Owner and any changes shall be shown on the as-built drawings with the additional work performed at no cost to the Owner.
9. The submittal of his bid shall indicate the Contractor has examined the site, drawings and specifications and has included all required allowances in his bid. No allowance shall be made for any error or omission resulting from the Contractor's failure to visit job site and to review drawings and specifications. The Contractor's bid shall include costs for all required drawings and changes as outlined above at no cost to the Owner.
10. Provide access to equipment and apparatus requiring operation, service or maintenance throughout the life of the system.

E. Do not use equipment exceeding dimensions indicated on drawings or equipment or arrangements that reduce required clearances or exceed specified maximum dimensions.

F. If any part of Specifications or Drawings appears unclear or contradictory, apply to Architect for an interpretation and decision prior to bid and as early as possible.

1. Do not proceed with work without the decision of the Architect.

1.9 DEFINITIONS

A. In addition to those defined in Division 01 – General Requirements, the following additional definitions shall apply. Definitions of term used in Division 23 HVAC may differ from those given in general and supplementary conditions.

B. "Provide": to furnish, supply, install and connect up complete and ready safe and regular operation of particular work referred to unless specifically noted.

C. "Supply": to purchase, procure, acquire, and deliver complete with related accessories.

D. “Work”: includes labor, materials, apparatus, controls, equipment services and all related accessories necessary for the proper and complete installation of complete systems.

E. “Piping”: includes pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation, and all related accessories.

F. “Wiring”: includes raceway, fittings, wire, boxes, and all related accessories.

G. “Concealed”: not in view, installed in masonry or other construction, within furred spaces, double partitions, hung ceiling, trenches, crawl spaces, or enclosures.

H. “Exposed”: in view, not installed underground or “concealed” as defined above. Exposed piping, conduit, or ductwork is that which can be seen when the building is complete without opening or removing access doors or panels or accessible ceiling components.

I. “Control or Actuated Devices”: includes automatic sensing and switching devices such as thermostats, pressure, float, flow, electro-pneumatic switches, and electrodes controlling operation of equipment.

J. “Indicated,” “shown” or “noted”: as indicated, shown, or noted on drawings or specifications.

K. “Reviewed,” “approved,” or “directed”, as reviewed, approved or directed by or to Owner.

L. “Motor Controllers”: starter, variable speed drives and other devices controlling the operation of motors.

1.10 PROJECT CONDITIONS

A. Examine site related work and surfaces before starting work of any Section.

1. In case of conflict, the most stringent takes precedence.
2. For purposes of clarity and legibility, Drawings are essentially diagrammatic to extent that many offsets, bends, unions, special fittings, exact locations of items are not indicated, unless specifically dimensioned. Especially note a number of required duct and pipe offsets to coordinate with structure and not shown. Coordinate dimensioned conditions, including invert elevations, with other trades prior to installation by any trade.
3. Exact routing of piping, ductwork, etc. shall be governed by structural conditions and other obstructions. Not all offsets in ductwork or piping are shown on the Drawings. Determine which item to offset or relocate. Maintain required slope in piping. Make use of data in Contract Documents. In addition, Architect reserves right, at no additional cost to the Owner, to make any reasonable change in location of mechanical items, exposed at ceiling or on walls, to group them into orderly relationships or increase their utility. Verify Owner’s requirements in this regard prior to rough-in.
4. Take dimensions, location of doors, partitions, similar physical features from Architectural Drawings. Verify at Site under this Division. Consult Architectural Drawings for exact location of outlets to center with Architectural features, panels, etc., at the appropriate location shown on Mechanical Drawings.
5. Mounting heights of brackets, outlets, etc., as required.
6. Report to Architect, in writing, conditions which will prevent proper provision of this work.
7. Beginning work of any Section without reporting unsuitable conditions to Architect constitutes acceptance of conditions by Contractor.
8. Perform any required removal, repair or replacement of this work caused by unsuitable conditions at no additional cost to the Owner.

B. Coordination.

1. Work out all “tight” conditions involving Work specified under this Division and work in other Divisions in advance of installation, if necessary, and before Work proceeds in these areas, prepare supplementary Drawings under this Division for review showing all Work in congested

area. Provide supplementary Drawings, additional Work necessary to overcome congested conditions, at no additional cost to the Owner.

2. Conflicts: Difference or disputes concerning coordination, interference, or extent of Work between sections shall be decided as follows:

    a. Install mechanical and electrical systems in the following order of preference (those trades listed below another must reroute to resolve the conflict):

        1) Drain piping required by code to be sloped.
        2) Supply air and exhaust air ductwork connected to fans.
        3) Electrical conduit 4 inches and larger.
        4) Hydronic piping connected to pumps.
        5) Domestic water piping.
        6) Fire sprinkler piping.
        7) Electrical conduit smaller than 4 inches.
        8) Transfer ducts and other ductwork not connected to fans.
        9) Control system piping and wiring.

    b. Continued disputes shall be decided by Contractor and Contractor's decision, if consistent with Contract Document requirements, shall be final.

3. Supervision: Personally, or through an authorized and competent representative, constantly supervise the work from beginning to completion and, within reason, keep the same foreman and workmen on the Project throughout the Project duration.
4. Provide templates, information, and instructions to other Divisions to properly locate hides and openings to be cut or provided.
5. The drawings govern in matters of quantity, and the specifications govern in matters of quality. In the event of conflict within the drawings involving quantities, or within the specifications involving quantities, or within the specifications involving quality, the greater quantity and higher quality shall apply. Such discrepancies shall be noted and clarified in the Bid. No additional allowances will be made because of errors, ambiguities, or omissions that reasonably should have been discovered during the preparation of the Bid.

C. Equipment Rough-in.

1. Rough-in locations shown on Mechanical Drawings for equipment furnished by the Owner and for equipment furnished under other Divisions are approximate only. Obtain exact rough-in locations from following sources.

    a. From Shop Drawings for equipment provided under this contract.
    b. From Architect for Owner Furnished-Contractor installed equipment.
    c. From existing equipment where such equipment is relocated under this Contract.

2. Verify mechanical characteristics of equipment before starting rough-in. Where conflict exists between equipment and rough-in shown on Drawings obtain clarification from Architect and provide as directed by the Architect at no additional cost to the Owner.
3. Make final connections.

1.11 CLEARANCE FROM ELECTRICAL EQUIPMENT

A. Piping, equipment or ductwork.

1. Prohibited, except as noted in:

    a. Electric rooms and closets over equipment, as restricted by NEC.
    b. Telephone rooms and closets.
    c. Elevator machine rooms.

d. Elevator shafts.
e. Electrical switchboard room.
f. Communications room.

2. Prohibited, except as noted, over or within 5 feet of:

a. Transformers.
b. Substations.
c. Switchboards.
d. Motor control centers.
e. Standby power plant.
f. Bus ducts.
g. Electrical panels.
h. Variable frequency drives.
i. Starters.

B. Drip pans under piping.

1. Where piping is located over any electrical equipment listed above; reroute piping, if possible, rather than use drip pan.
2. 28 gage galvanized steel.
3. 18 gage copper.
4. Reinforced and supported.
5. Watertight.
6. With 1-1/4-inch drain outlet piped to floor drain or service sink.

C. Electrical Working Space: Dimensions of the working space shall be a minimum depth of 42" horizontally, the width of the equipment or 30", whichever is greater, and the height of the equipment or 78", whichever is greater. Minimum depth shall be increased to 60" for equipment rated over 600 V.

1.12 PRODUCT DELIVERY, HANDLING AND STORAGE

A. See Division 01 – General Requirements (Product Requirements).

B. Deliver equipment in its original package to prevent damage or entrance of foreign matter. Provide materials on factory provided shipping skids and lifting lugs if required for handling. Provide protective coverings during construction.

C. Handle and ship in accordance with manufacturer's recommendations.

D. Identify materials and equipment delivered to Site to permit check against approved materials list, reviewed with no exceptions taken Shop Drawings.

E. Protect from loss or damage. Replace lost or damaged materials and equipment with new at no additional cost to Owner.

F. Where necessary, ship in crated sections of size to permit passing through available space.

1.13 PROJECT MANAGEMENT AND COORDINATION SERVICES

A. See Division 01 – General Requirements.

B. Overview: Provide a project manager/engineer for the duration of the Project to coordinate the Division 23 HVAC work with all other trades. Coordination services, procedures and documentation responsibility shall include, but shall not be limited to the items listed in this section.

C. Review of shop drawings prepared by other subcontractors

1. Obtain copies of all shop drawings for equipment provided by others that require electrical service connections or interface with Division 23 HVAC work.
2. Perform a thorough review of the shop drawings to confirm compliance with the service requirements contained in the Division 23 HVAC contract documents. Document and discrepancy or deviation as follows:

    a. Prepare memo summarizing the discrepancy.
    b. Provide a copy of the specific shop drawing, indicating via cloud, the discrepancy.

3. Prepare and maintain a shop drawing review log indicating the following information.

    a. Shop drawing number and brief description of the system/material.
    b. Date of review.
    c. Indication if follow-up coordination is required.

D. Request for Information (RFI)

1. See Division 1 Request for Information

1.14 REVIEW OF CONSTRUCTION

A. Work may be reviewed at any time by representatives of the Owner and/or Architect.

B. Advise Owner that work is ready for review at the following times.

1. Prior to backfilling buried work.
2. Prior to concealment of work in walls and above ceilings.
3. When all requirements of Contract have been completed.
4. When testing will be performed.

C. Do not backfill or conceal work without Architect's consent.

D. Maintain on site, one set of Specifications and Drawings for use by Owner and/or Architect.

1. Include all change orders.

E. Contractor is responsible for construction methods, sequences, and safety precautions.

1.15 SCHEDULE OF WORK

A. In accordance with Division 01 – General Requirements and as follows:

1. Arrange work to conform to schedule of construction established or required to comply with Contract Documents.
2. In scheduling, anticipate means of installing equipment through available openings in structure.

B. Confirm in writing to Architect, within 35-days of signing of contract, anticipated number of days required to perform test, balance, acceptance testing and commissioning of mechanical systems. Schedule test balance and acceptance testing of mechanical systems as follows:

1. Submit for review at this time, names and qualifications of test and balancing agencies to be used.

2. Test, Adjusting and Balancing and commissioning must occur after completion of mechanical systems, including all control calibration and adjustment, and requires substantial completion of the building, including closure, ceilings, lighting, partitioning, etc.
3. Allow 21-days after test and balance for system commissioning and life safety testing (where applicable).

1.16 CUTTING AND PATCHING

A. See Division 01 – General Requirements.

1.17 UTILITY CONNECTIONS

A. Utilities include but are not limited to, water, sanitary sewer, storm sewer, natural gas, fire protection water, chilled water, heating water, steam, Energy Management and Control System, etc.

B. Connect to utility company mains as required. Include all meters and other ancillary components required by serving utility company.

C. Connect to on-site piping mains.

D. Contractor shall be responsible for payment of all service charges.

E. Contractor shall be responsible for provisions for temporary utilities.

F. (Others as required).

1.18 WARRANTY

A. In accordance with Division 1 Guarantees, Warranties, Bonds, Service & Maintenance Contracts and as follows.

B. All extended warranties specified herein shall be non-prorated.

C. Warranty all materials, equipment, apparatus, and workmanship to be free of defective materials and faulty workmanship for a period of one year from and after date of acceptance of completed contract.

D. Provide new materials, equipment, apparatus, and labor to replace that determined by Architect to be defective or faulty.

E. This guarantee also applies to services including instructions, adjusting, testing, noise, balancing, etc.

F. Refrigerant compressors to have an additional four-year parts warranty.

G. Nothing herein intends or implies that guarantee shall apply to work which has been abused or neglected by the Owner or the Owner's successor in interest. The Contractor shall clearly identify such work and Owner requirements inside warranty documentation and at Owner training, with forms and checklist.

1.19 PERMITS

A. Obtain all permits, certificates of inspections, patent rights and licenses that are required for the performing of this work by all laws, ordinances, rules and regulations or orders of any officer and/or body. Provide all notices necessary in connection therewith and pay all fees relating thereto and all

costs and expenses incurred on account thereof. No work shall be covered before inspection by the jurisdiction authorities and observation by the Architect.

1.20 CONTINUITY OF EXISTING SERVICE AND SYSTEMS

A. Schedule work so existing systems will not be interrupted. Obtain approval from the Owner and Architect at least 14 days prior to any utility interruption or connection.

B. Perform work at such time and in such a manner as to cause minimum inconvenience to the Owner and as approved by the Architect. No allowance will be made for lack of knowledge of existing conditions.

C. Existing utility service and systems:

1. Protect existing active utilities.
2. Relocate as indicated on Construction Drawings.
3. Existing inactive utilities shall be capped or plugged (below grade).

D. Connections to existing work:

1. Install new work and connect to existing work with minimum interference to existing facilities.
2. Connect new work to existing work in neat and acceptable manner. Restore existing disturbed work to original condition.

E. Removal and relocation of existing work.

1. Disconnect, remove, or relocate piping, ductwork, conduit, and other work noted or required by alterations, modifications or changes in existing construction.
2. Plug or cap affected active lines behind or below finished walls and/or floors.
3. Dispose of removed piping and material.

F. Special Traffic Requirements:

1. Maintain emergency and service entrances so they are usable for pedestrian, truck and emergency vehicles at all times.
2. Where trenches are cut, provide adequate bridging for above-mentioned traffic.

1.21 PROCEDURE OF WORK

A. The Contractor is hereby cautioned that although he will be permitted to conduct his work during regular working hours (see exceptions below), his work shall be performed in such a manner so as not to interfere with the conduct of regular business unless approval for such interference has been obtained from the Owner and Architect. No reimbursement shall be made to the Contractor for losses sustained due to delays and interruptions of his work to accommodate the operation and business of the Owner.

B. Regular working hours exceptions: Extended utilities shutdowns and/or major equipment changeouts.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Listed “Acceptable Manufacturers” are those considered capable of manufacturing products or equipment conforming to detailed Specifications and Schedules, and as such, are invited to compete provided the offering is comparable in every respect to scheduled or specified products and actually

conforms to the detailed Specifications and Schedule requirements. Listing herein as “Acceptable Manufacturers” does not imply “Accepted”, “Approved”, “Prior Approval” or any other connotation. All product offerings must be submitted for approval after Contract Award.

B. Alternate manufacturers as identified in each section will be considered under conditions specified herein.

C. Identify materials, equipment by manufacturer's name, nameplate data. Remove unidentified materials, equipment from Site.

D. Equipment specified by manufacturer's number shall include all accessories, controls, etc., listed in catalog as standard with equipment. Furnish optional or additional accessories as specified.

E. Where no specific make of material or equipment is mentioned, any first-class product of reputable manufacturer may be used, provided it conforms to requirements of system and meets with acceptance.

F. Provide an authorized representative to constantly supervise work of this Division, check all materials prior to installation for conformance with Drawings, Specifications, reviewed Submittals and reviewed Shop Drawings.

G. Conform to conditions shown and specified. Coordinate with other trades for best possible assembly of combined Work. Relocate equipment when necessitated by failures to coordinate Work or to advise Architect of conflicts in writing.

H. Material and Equipment-General Requirements

1. New.
2. Approved for use by State Fire Marshal and local building inspection department when applicable.
3. Testing agency labeled or with other identification wherever standards have been established.
4. Architect reserves right to reject items not in accordance with Specification either before or after installation.
5. Comprised to render complete and operable systems; provide additional items needed to complete installation to realized design.
6. Compatible with space allocated; modifications necessary to adjust items to space limitations at Contractor's expense.
7. Installed fully operating and without objectionable noise or vibration.
8. Design of mechanical systems is generally based on product of the first named manufacturers cited. Where systems for product installed necessitate modification of systems shown on drawings, Contractor is responsible for installation of systems appropriate to product installed.

I. Electrical Requirements

1. Electrical Work performed under Division 23 – Mechanical shall conform to requirements of Division 26 Electrical.
2. Provide weatherproof devices and installation for out-of-doors work.

2.2 PAINTING

A. Finish painting (other than factory applied) of mechanical equipment and associated piping and ductwork shall be as specified in Division 09 “Painting” Section(s). Provide touch up painting of prefinished mechanical products.

1. All equipment, ductwork, piping conduit and associated supports, attachments, hardware, and connectors exposed to the weather shall be properly coated, painted or otherwise protected from corrosion caused by the elements (sun, wind, rain, snow, ice, etc.).

B. Surfaces shall be left clean, debris shall be removed, and equipment shall be furnished in prime coat finish ready for finish coats.

1. Piping, Ductwork and Equipment: Clean exterior of piping, ductwork and equipment removing rust, plaster and dirt by wire brushing. Remove grease, oil and similar materials by wiping with clean rags and suitable solvents.
2. Motors, Pumps and Other Items with Factory Finish: Remove grease and oil and leave surfaces clean and polished.

C. Cleaning operations may be supplemented by more detailed instructions in various other Sections of this Specification.

D. Paint for high temperature piping and equipment shall be high temperature resistant, designed for the temperatures at which the system will operate.

PART 3 - EXECUTION

3.1 INSPECTION

A. Verify that conditions are satisfactory for the installation of materials and equipment. Notify Architect if conditions are not satisfactory and do not commence work until conditions have been corrected.

3.2 INSTALLATION

A. Install materials and equipment in compliance with governing codes.

B. Use printed descriptions, specifications, and recommendations of manufacturers as a guide for installation of Work. Follow in all cases where manufacturers of articles used furnish directions covering points not specified or shown.

C. Equipment.

1. Assemble equipment which is required to be field assembled under the direct supervision of the manufacturers' agent.
2. Prior to the final acceptance submit letters from the manufacturers that equipment has been assembled under the direct supervision of the manufacturers' agent.
3. Accurately set and level equipment with supports neatly placed and properly fastened.
4. Properly fasten equipment in place with bolts to prevent movement.
5. Coordinate the installation of equipment with openings in structure.
6. Coordinate and fully dimension steel supports for mechanical equipment, where shown on drawings with installing contractor.
7. Provide all roof curbs for roof mounted fans, flues, piping and duct penetrations, etc.
8. Concrete.

    a. Concrete work, include forming, steel bar reinforcing, cast-in-place concrete, finishing, and grouting is specified under Division 03 Concrete.
    b. Coordinate and fully dimension concrete housekeeping pads and curbs with installing contractor; dimensions shall be as required for structural requirements.
    c. Coordinate inertia base fill with installing contractor

D. Electrical.

1. See Division 26 Electrical.
2. Install electrical devices with code required clearances and access.

3. Assist the electrical contractor in the proper connecting of all electrical wiring and equipment required for mechanical equipment.

E. Sleeves, Chases and Concrete Inserts.

1. Provide all required sleeves, chases, concrete inserts, anchor bolts, etc.
2. Sleeves, chases are prohibited in structural members, except where shown or as directed by Architect in writing.
3. Embed no piping in concrete or masonry.

F. Waterproof Construction.

1. Comply with Division 07 – Thermal and Moisture Protection.
2. Include membrane clamps, sheet metal flashing, counter flashing, caulking and sealant as required for waterproofing of mechanical penetrations and sealing penetrations in or through fire walls, floors, ceiling slabs and foundation walls.
3. All penetrations through vapor barriers at slabs on grade shall be taped and made vapor tight.
4. Provide galvanized sheet metal weather protection canopies, hoods or enclosures over all out-of-doors equipment, the operation or maintenance of which would be impaired by rainwater; this requirement applies to damper operators and bearings, damper motors, controls and instruments. See other Sections in this Division for application of this requirement to motors, drives, ducts and fans.

G. Restoration of Damage.

1. Repair or replace, as directed by Architect, materials and parts of premises which become damaged.
2. Remove replaced parts from premises at no additional cost to the Owner.

H. Review architectural drawings and coordinate with Architect and other contractors to be sure that all architectural shafts, plenums, rated duct enclosures etc. required for mechanical systems are properly located and dimensioned.

I. Access Panels and Doors.

1. Coordinate size requirements and exact location with Contractor who will install access doors.
2. Minimum Sizes: 18 inches by 18 inches unless otherwise shown on Drawings or approved by Architect.
3. Provide where shown, or required by Regulatory Agencies, for access of all concealed equipment such as terminal units, valves, fire/smoke dampers, etc., for Mechanical Work:

    a. Equipment shall be located wherever practical over accessible ceilings or rooms to avoid access doors.
    b. Access doors shall not be used solely for access to balancing dampers; use instead, remote control devices specified under Section 233300 – Air Duct Accessories.

J. Openings.

1. Coordinate and fully dimension all openings in walls, floors, roofs, and structural elements required for mechanical work.
2. Provide all required fire-stopping around pipe, duct and other penetrations required for mechanical work in rated partitions where required by code.
3. Fire damper openings: Contractor shall provide damper UL installation requirements to contractor installing partitions to ensure construction complies with listing.
4. Air outlet openings.

    a. Contractor shall coordinate exact locations of air outlets in floors, walls and ceilings with contractor installing partition.

b. Contractor shall coordinate additional T-bar or spline required to accept air outlets with contractor providing and installing ceiling and associated materials.

3.3 PROTECTION OF EQUIPMENT AND MATERIALS DURING CONSTRUCTION

A. See Division 01 – General Requirements.

B. Provide protective covers, skids, plugs or caps to protect equipment and materials from damage or deterioration during construction.

C. Store equipment and material under cover, and off the ground or floors exposed to rain.

D. For outdoor storage, protective covers of 10 mil thick black sheet plastic shall be fitted over equipment and materials. Covers shall be reinforced to withstand wind and precipitation. Set equipment and material on skids or platforms of height to avoid damage or deterioration from spattering and ground water.

E. Protect coils against damage by installing temporary closure panels over exposed coil faces. Panels shall be minimum 24-gauge sheet metal or 0.375" plywood.

F. Completely cover motors and other moving machinery to protect from dirt and water during construction.

G. Close open ends of fans, air valves, terminal units, energy recovery units, air handling units, and ductwork with temporary closures of sheet plastic taped in place.

H. Plug ends of pipes when work is stopped to prevent debris from entering the pipes.

I. Provide dust and debris protection for ductwork, coils, fans, equipment, motors, and bearings operated during construction up to date of substantial completion.

J. Cover open ends of exhaust and return ducts with temporary filter media while fan systems are operating.

K. Material, equipment or apparatus damaged because of improper storage or protection will be rejected.

1. Remove from site and provide new, duplicate, material, equipment or apparatus in replacement of that rejected.
2. Any porous materials, such as duct liner, insulation or flexible ductwork that becomes wet; for example, due to rain shall be replaced; drying is not sufficient (due to possible microbial contamination).

L. Perform Work in manner precluding unnecessary fire hazard.

3.4 ADJUSTMENT

A. Preliminary Operation.

1. Operate any portion of installation for Owner’s convenience if so requested by Architect. Such operation does not constitute acceptance of Work as complete but does constitute beneficial use. Cost of utilities, such as gas and electrical power, will be borne by the Owner if operation is requested by Owner.

B. Startup Service.

1. Prior to startup, ensure that systems are ready, including checking the following: Proper equipment rotation, proper wiring, auxiliary connections, lubrications, venting fan balance, controls and installed and properly set relief and safety valves. See pre-function tests in Division 23 – Mechanical.
2. Start and operate all systems.
3. Provide services of factory trained technicians for startup of major equipment and systems including boilers, chillers, fire pumps, etc.
4. Adjusting: See Section 230593 – Testing, Adjusting and Balancing for HVAC.
5. Functional Testing: See Section 230900 – Energy Management & Control Systems.
6. Life Safety Testing.

    a. Assist Division 26 Electrical contractor in testing fire alarm controls, including control of smoke dampers and shut-off of fan systems.
    b. Correct any problems related to equipment supplied under Division 23 – Mechanical.
    c. Complete the control matrix with details such as fan tags, FSD tags, etc. based on control matrix provided with Life Safety Report.
    d. Assist Life Safety System commissioning agent in testing and commissioning Life Safety System.
    e. Provide all tests, air balance and start-up personnel require to start and commission the system and for assisting the design/construct team in demonstrating system compliance with the local fire district and building department.

7. Submit startup checklist and narrative from equipment manufacturer on specialized equipment as boilers, chiller, MAU, and VRF/VRV systems.

C. Noise.

1. Cooperate in reducing any objectionable noise or vibration caused by mechanical systems to the extent of adjustments to specified and installed equipment and appurtenances.
2. Completely correct noise problems caused by failure to make installation in accordance with Contract Documents, including labor and materials required as a result of such failure, at no additional cost to the Owner.

3.5 SPECIAL TOOLS

A. Furnish to Owner at completion of work.

1. One set of any special tools required to operate, adjust, dismantle, or repair equipment furnished under any section of this Division.
2. Pressure gage and temperature sensor for piping test plug.

3.6 CLEANING

A. Cleaning.

1. See Division 01 – General Requirements.

B. Thoroughly clean equipment, fans, pumps, motors, piping and other materials under this Division free from all rust, scale and all other dirt before any covering or painting is done, or the systems put in operation; leave in condition satisfactory to Architect.

C. At all times keep the premises free from accumulation of waste material and debris caused by his employees. At the completion of the Project, and at other times as Architect may direct, remove refuse from within and around the building. All tools, scaffolding and surplus materials shall also be removed, leaving the Site of his Work clean.

D. Completely cover all plumbing fixtures and all motors and other moving machinery to prevent entry of dirt and water during construction.

E. Effectively cap all openings into ducts and pipes to keep moisture and foreign matter out during construction.

F. Clean and polish identification plates.

G. Clean equipment, ductwork, insulation, piping, conduit, and room surfaces of dust and dirt and maintain in a clean condition from date of substantial completion until final completion of work and corrective work.

3.7 PAINTING

A. Painting.

1. Piping exposed to outdoors and, where indicated elsewhere.

   a. One coat primer.
   b. Two coat alkyd oil paint, UV resistant for PVC piping, color as indicated.
   c. Not required for copper, galvanized steel, or insulated piping.

2. Steel hangers and supports exposed to outdoors.

   a. One coat primer.
   b. Not required for galvanized steel.

3. Interior of ductwork and duct accessories, including insulation stick pins, at air outlets as far back as visible from occupied spaces.

   a. Flat black.

4. Marred surfaces of factory painted equipment.

   a. Spot coat to match adjacent coat.

5. Insulation exposed to sunlight:

B. Execution.

1. Protect flooring and equipment with drop cloths.
2. Paint and materials stored in location where directed.
3. Oily rags and waste removed from building every night.
4. Wire brush and clean off all oil, dirt and grease areas to be painted before paint is applied.
5. Workmanship.

   a. No painting or finishing shall be done with:

      1) Dust laden air.
      2) Unsuitable weather conditions.
      3) Space temperature below 60 deg. F.

   b. Pipes painted containing no heat and remain cold until paint is dried.
   c. Paint spread with uniform and proper film thickness showing no runs, sags, crawls, or other defects.
   d. Finished surfaces shall be uniform in sheen, color, and texture.

e. All coats thoroughly dry before succeeding coats are applied, minimum 24 hours between coats.
f. Priming undercoat of slightly different color for inspection purposes.

6. Piping continuously painted in all exposed areas.

C. Paint.

1. High gloss medium or long alkyd paint.
2. Best grade for its purpose.
3. Deliver in original sealed containers.
4. Apply in accordance with manufacturer's instructions.

D. Colors.

1. Colors as directed by Architect unless specified herein.
2. Interior of ductwork as far back as visible from outside: flat black.
3. Uncoated hangers, supports, rods and insets: dip in zinc chromate primer.

E. Factory Finish.

1. Ceiling and wall mounted air outlets in acoustical tile ceilings: Baked white enamel.
2. Aluminum air outlets that are not to be painted: anodized.
3. Exposed fan coil units: baked enamel.
4. Unit ventilators and unit heaters: baked enamel.
5. Fans, pumps, compressors, tanks and like items.
6. Air handlers, pumps, water heaters and like items, where exposed.

F. Marred surfaces of prime coated equipment and piping: spot prime coat to match adjacent coat.

G. Properly prepare Work under this Division to be finish painted under Division 09 – Painting.

H. Provide moisture resistant paint for exterior painting and heat resisting paint for hot piping, equipment, and materials.

I. For the following, provide factory prime coat. Also, provide factory finish painting on each if not specified in Painting Division.

1. Other air outlets.

J. Paint all equipment out-of-doors and equipment supports with two coats of weather resistant enamel.

K. Protect all finished surfaces of fixtures with heavy paper pasted thereon, or by other means, throughout the period of construction.

L. Refinish Work supplied with final finish under this Division if damaged under this Division to satisfaction of Architect.

3.8 FIELD QUALITY CONTROL

A. See Division 01 – General Requirements (Quality Control).

B. Tests.

1. Perform as specified in individual sections and as required by authorities having jurisdiction.
2. Duration as noted.

C. Provide required labor, material, equipment and connections.

D. Furnish written report and certification that tests have been satisfactorily completed.

E. Repair or replace defective work, as directed by Architect in writing, at no additional cost to the Owner.

F. Restore or replace damaged work due to tests as directed by Architect in writing, at no additional cost to the Owner.

G. Restore or replace damaged work of others, due to tests, as directed by Architect in writing, at no additional cost to the Owner.

H. Remedial work shall be performed to the satisfaction of the Architect, at no additional cost to the Owner, including:

1. Work related to all Division 23 – Mechanical tests.
2. Division 23 – Mechanical work related to Section 230593 – Testing, Adjusting and Balancing for HVAC.

I. Remedial work shall include performing any tests related to remedial work and additional time at no additional cost to the Owner.

3.9 EXISTING EQUIPMENT AND SYSTEMS

A. Owner has first right of refusal of all existing equipment and components indicated to be removed.

B. Material and equipment which has been removed and not accepted by the Owner shall become the property of the Contractor and shall be removed from the site.

C. Material and equipment which has been removed shall not be used in the new work, except as specified herein.

D. Where existing piping, ductwork and equipment is indicated on the Drawings, its size and location shall be verified.

3.10 EQUIPMENT AND INSTALLATION REQUIREMENTS

A. Air systems shall operate without aerodynamic noise generated from the faulty installation of ductwork or any component of the air distribution system.

B. Equipment shall be installed and connected as specified herein or indicated on the Drawings in accordance with the manufacturers' instructions and recommendations for this Project. Furnish and install auxiliary piping, water seals, valves, and electrical connections recommended by the manufacturer for operation.

C. Provide roughing, fittings, accessories, and connecting piping, and make final connections to all equipment. Coordinate carefully with equipment vendor prior to starting rough-in work.

D. In unfinished areas designated for future build-out, install piping, ductwork, conduit, and equipment tight against the structure to maximize future ceiling height.

E. Motor quantities, sizes and equipment wattage ratings specified herein or indicated on the Drawings are the minimum requirements, unless noted otherwise. Motor quantities, sizes, and equipment wattage ratings less than those specified herein or indicated on the Drawings are not acceptable. Larger motor sizes and equipment wattage ratings may only be provided, if necessary, to meet the prescriptive

requirements specified herein or indicated on the Drawings. Where multiple motors or motor sizes or equipment wattage ratings larger than specified herein or indicated on the Drawings are furnished, provide and coordinate the corresponding increased number or capacity of feeders and other electrical equipment serving them, at no additional cost to the Owner.

F. Field-installed equipment controls, or sensor wiring shall be installed in conduit. Low voltage control and sensor wiring shall be installed in conduits separate from line voltage control wiring and power wiring.

G. Where water connection sizes at equipment vary from the pipe size indicated on the Drawings, provide appropriate reducers/increasers directly adjacent to the pipe-equipment unions. Unless otherwise specified herein or indicated on the Drawings, the size of the valves and accessories dedicated to the equipment shall not be less than the pipe size to which they are connected.

H. Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible and with the manufacturer's minimum required clearances provided. Minor deviations from the drawings may be made to accomplish this, but changes of substantial magnitude shall not be made without written approval.

1. Group concealed valves, controls and equipment requiring access, so as to be freely accessible through access doors.

3.11 EXCAVATION AND BACKFILLING

A. In accordance with the requirements of Division 31 – Earthwork for excavating, trenching, and backfilling.

B. Provide barricades, signs, lanterns, shoring, sheeting, and pumping as part of Work in this Division as required to ensure safe conditions. Comply with OSHA requirements.

C. Dig trenches straight, true to line and grade with sides and bottoms smoothed of any rock points.

1. Excavate 6 inches below grade of pipe.
2. Fill with sand properly packed.
3. Support pipe for entire length on packed sand.
4. Shape or pack bottom of trenches for pipe, duct fittings, hubs, couplings, etc., using templates to fit outside periphery of lower third of piping and ductwork.
5. Provide piping outside building with 36-inch minimum cover from top of pipe to finished grade.
6. Minimum width 16 inches.

D. Dispose of all surplus excavation material and seepage water as directed by the Architect.

E. Backfill.

1. After piping has been installed, tested, and approved, backfill all excavation, tamp and compact by motor powered or compressed air tampers.
2. Backfill to 6-inches above crown of pipe with unwashed sand, with remainder of trench back-filled and mechanically tamped in 6-inch maximum layers of selected excavated materials, free from organic matter, rocks, etc. Provide 90-percent compaction in accordance with ASTM D 1557-58T; 95-percent compaction for trenches below building slabs.

F. In any asphalt or concrete paved areas, backfill only to subgrade level.

G. When piping is installed, prior to backfilling, advise Architect; do not backfill without acceptances of Architect.

H. Replace to original condition all paving, curbs, gutters, walks, grass/sod, etc., which become disturbed by trenching.

3.12 DIAGRAMS

A. Frame and mount the following information:

Information	Location
HVAC diagrams, start-stop procedures, valve schedules, and valve location floor plans.	Appropriate mechanical rooms.
Energy Management control diagrams and sequences.	Adjacent to each control panel.
Appropriate control and interface drawings, including a simplified guide to local programming through the digital display unit, a directory of I/O points connected to that panel, and variables which may be displayed.	Posted on the inside cover of each EMCS panel.
VRF System design tree (piping schematic, includes pre-charge and additional refrigerant added)	Laminated and installed in each outdoor unit. Frame and mount adjacent to VRF system controller

B. Diagrams shall be computer generated.

C. Diagrams shall be as-built, and shall include interfaces and interlocks with other equipment.

D. Diagram framing system: 0.125" thick acrylic with satin finish aluminum frames.

3.13 MAINTENANCE

A. Equipment operated prior to the date of substantial completion shall be maintained in accordance with manufacturer's recommendations. In addition, provide complete water treatment for hydronic and steam systems operated prior to date of substantial completion.

B. Prepare and submit a lubrication chart listing for each piece of equipment:

1. Points requiring lubrication.
2. Recommendations for a single manufacturer's lubricants with brand name and designation.
3. Frequency of lubrication required.

C. Lubricate each item of apparatus requiring lubrication prior to start-up in accordance with the manufacturer's recommendations.

END OF SECTION 230010

SECTION 230020 - MECHANICAL CLOSE-OUT REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Summary Includes

1. As-Built Drawings.
2. Operation and maintenance documentation directory.
3. Emergency manuals.
4. Operation manuals for systems, subsystems, and equipment.
5. Maintenance manuals for the care and maintenance of systems and equipment.
6. Closeout Documentation Checklists.

B. Related Sections:

1. Section 230010 – Mechanical General Provisions.
2. Section 230030 – Demonstration and Training for Mechanical Systems.

1.3 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions.

B. Initial Submittal: Submit draft copy of each manual a minimum of 60 days prior to requesting Substantial Completion inspection. Include a complete operations and maintenance directory. Architect will return draft copy and mark whether general scope and content of manuals are acceptable.

C. Submit manuals according to the following table.

1. “R” means required.

Item	Product Data	O&M Manual	Samples	Shop Drawing
As-Built drawings		R		
Operation and Maintenance Documentation Directory		R		
Emergency Manual		R		
Operation Manual		R		
Systems and Equipment Maintenance Manual		R		
Closeout Documentation Checklists		R		

PART 2 - PRODUCTS

2.1 AS-BUILT DRAWINGS

A. Maintain at job site a set of contract record documents kept current by indicating thereon all changes, substitutions, etc., between work as specified and as installed.

B. Show on record documents actual air quantities, water flow rates, valve or damper positions after balancing, etc.; also show, by actual dimension, location of all new and known existing underground work.

C. At the completion of the project, furnish the Owner three sets of drawings and three complete, clean sets of specifications showing installed location, size, etc., of all work and material as taken from record documents. All as-built (on record) drawings shall be labeled “As-Built Drawings,” dated and certified accurate by Contractor with his signature, on front page of all Drawing sets and Specifications.

2.2 OPERATION AND MAINTENANCE MANUALS

A. These operation and maintenance manual requirements supplement operation and maintenance manual documentation requirements of other Sections of these specifications.

B. Operation and maintenance documentation, in hardback 3-ring loose-leaf binders except full size drawings and CDs, shall cover the HVAC and building automation systems. Documentation shall include an operations and maintenance documentation directory, emergency information, operating manual, maintenance manual, test reports, and construction documents.

C. Initial Submittal: The operation and maintenance documentation package shall be submitted as one comprehensive package to the Owner 1 month before systems start-up, and shall be updated, revised and completed at completion of construction.

D. Final Submittal: Provide four (4) complete manuals.

1. Correct or modify each manual to comply with Architect’s comments. Submit Final manuals shall be submitted 15 working days prior to demonstration and training of Owner’s personnel. Manuals are to be used in training sessions by Owner’s personnel.

E. Compile and coordinate the documentation for equipment and systems installed. Unless otherwise indicated, organize each manual into a separate section for each system and subsystem and a separate section for each piece of equipment not part of a system. Documentation shall be typewritten and shall contain, at a minimum, the following information.

1. Introduction:

a. Project name, contractors' and subcontractors' names, addresses, telephone numbers, email addresses and facsimile numbers. Indicate the portion of the work for which each subcontractor was responsible.
b. List of Documents.
c. List of systems.
d. List of equipment.
e. Table of Contents.

2. Operations and Maintenance Documentation Directory:

a. Explanation of the identification system used, including lists of systems, equipment, and component identifiers and names. Use the same system, subsystem and equipment

designation as used in the Contract Documents. If no designation exists, assign a designation according to ASHRAE Guideline 4, "Preparation of Operating and Maintenance Documentation for Building Systems."

3. Manual Organization: Unless otherwise indicated, organize each manual into a separate section for each system and subsystem, and a separate section for each piece of equipment not part of a system. Each manual shall contain the following materials, in the order listed:

    a. Title page.
    b. Warranty Page
    c. Table of contents.
    d. Manual contents.

4. Manual Title Page: Enclose title page in transparent plastic sleeve. Include the following information:

    a. Project name, contractors' and subcontractors' names, addresses, telephone numbers, email addresses and facsimile numbers. Indicate the portion of the work for which each subcontractor was responsible.
    b. Subject matter included in manual.
    c. Name and address of Project.
    d. Name and address of Owner.
    e. Date of submittal.
    f. Name, address, telephone number, fax number and email address of Contractor.
    g. Name and address of Architect and other Architects.
    h. Cross-reference to related systems in other operation and maintenance manuals.

5. Warranty Page

    a. Provide table as shown at end of section. Table to be on separate page in O&M. Three copies of table to be laminated and turned over to owner. All products to be listed in table.

6. Manual Table of Contents: List each product included in manual, identified by product name, indexed to the content of the volume and cross-referenced to Specification Section number in Project Manual.

    a. If operation or maintenance documentation requires more than one volume to accommodate data, include comprehensive table for all volumes in each volume of the set.

7. Manual Contents: Organize into sets of manageable size. Arrange contents alphabetically by system, subsystem and equipment. If possible, assemble instructions for subsystems, equipment and components of one system into a single binder.

    a. Binders: Heavy-duty, 3-ring, vinyl-covered, loose-leaf binders, in thickness necessary to accommodate contents, sized to hold 8-1/2 x 11-inch paper; with clear plastic sleeve on spine to hold label describing contents and with pockets inside covers to hold folded oversize sheets.

        1) If two or more binders are necessary to accommodate data of a system, organize data in each binder into groupings by subsystem and related components. Cross-reference other binders if necessary, to provide essential information for proper operation or maintenance of equipment or system.
        2) Identify each binder on front and spine, with printed title "OPERATION AND MAINTNANCE MANUAL," Project title or name, project number and subject matter contents. Indicate volume number for multiple-volume sets and six-digit Section number on bottom of spine.

b. Dividers: Heavy-paper dividers with plastic-covered tabs for each section. Mark each tab to indicate contents. Include typed list of products and major components of equipment included in the system on each divider, cross-referenced to Specification Section number and title of Project Manual.
c. Protective Plastic Sleeves: Transparent plastic sleeves designed to enclose diagnostic software diskettes for computerized electronic equipment.
d. Supplementary Text: Prepared on 8-1/2 x 11-inch, "20-lb" white bond paper.
e. Drawings: Attached reinforced, punched binder tabs on drawings and bind with text.

1) If oversize drawings are necessary, fold drawings to same size as text pages and use as foldouts.
2) If drawings are too large to be used as foldouts, fold and place drawings in labeled envelopes and bind envelopes in rear of manual or reduced drawings. DO NOT USE BINDER POCKETS. At appropriate locations in manual, insert typewritten pages indicating drawing titles, descriptions of contents and drawing locations.

f. Provide color photographs instead of drawings where necessary to demonstrate unusual or complex installations.

8. Emergency Information:

a. Information for technical and nontechnical personnel about actions recommended during emergency situations to protect life and property and to minimize disruption to the building occupants. Emergencies shall, at a minimum, include:

1) Fire.
2) Security breach.
3) Water outage.
4) Power failure.
5) Refrigerant release.
6) Heating failure.
7) Cooling failure.

2.3 OPERATION MANUAL

A. Content: In addition to requirements in this Section, include operation data required in individual Specification Sections and the following information:

1. System, subsystem and equipment descriptions.
2. Performance and design criteria if Contractor is delegated design responsibility.
3. Operating standards.
4. Operating procedures.
5. Operating logs.
6. Wiring diagrams.
7. Control diagrams.
8. Piped system diagrams.
9. Valve tag lists.
10. Precautions against improper use.
11. License requirements including inspection and renewal dates.

B. Descriptions: Include the following:

1. Product name and model number.
2. Manufacturer's name.
3. Equipment identification with serial number of each component.
4. Equipment function.
5. Operating characteristics.

6. Limiting conditions.
7. Performance curves for pumps, fans and heat exchangers.
8. Engineering data and tests.
9. Complete nomenclature and number of replacement parts.

C. Operating Procedures: Include the following, as applicable:

1. Startup procedures.
2. Equipment of system break-in procedures.
3. Routine and normal operating instructions.
4. Regulation and control procedures.
5. Instructions on stopping.
6. Normal shutdown instructions.
7. Seasonal and weekend operating instructions.
8. Required sequences for electric or electronic systems.
9. Special operating instructions and procedures.

D. Systems and Equipment Controls: Describe the sequence of operation and diagram controls as installed.

E. Piped Systems: Diagram piping as installed and identify color-coding where required for identification.

2.4 SYSTEMS AND EQUIPMENT MAINTENANCE MANUAL

A. Content: For each system, subsystem and piece of equipment not part of a system, include source information, product information, maintenance procedures, repair materials, warranty information and bond information as described below.

B. Source Information: List each product included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address and telephone number of Installer or supplier and maintenance service agent. Cross-reference Specification Section number and title in Project Manual.

C. Manufacturer's Maintenance Documentation: Manufacturer's maintenance documentation including the following information for each component part or piece of equipment:

1. Standard printed maintenance instructions and bulletins.
2. Drawings, diagrams and instructions required for maintenance including disassembly and component removal, replacement and assembly.
3. Identification and nomenclature of parts and components.
4. List of items recommended to be stocked as spare parts.

D. Maintenance Procedures: Include the following information and items that detail essential maintenance procedures:

1. Test and inspection instructions.
2. Troubleshooting guide.
3. Precautions against improper maintenance.
4. Disassembly: component removal, repair and replacement and reassembly Instructions.
5. Aligning, adjusting and checking instructions.
6. Manufacturer's demonstration and training videotape or DVD, if available.

E. Maintenance and Service Schedule: Include service and lubrication requirements, list of required lubricants for equipment and separate schedules for preventative and routine maintenance and service with standard time allotment.

1. Scheduled Maintenance and Service: Tabulate actions for daily, weekly, monthly, quarterly, semiannual and annual frequencies.
2. Maintenance and Service Record: Include manufacturer's forms for recording maintenance.

F. Spare Parts List and Source Information: Include lists of replacement and repair parts, with parts identified and cross-referenced to manufacturer's maintenance documentation and local sources of maintenance materials and related services.

G. Maintenance Service Contracts: Include copies of maintenance agreements with name and telephone number of service agent.

H. Warranties and Bonds: Include copies of executed warranties and bonds and lists of circumstances and conditions that would affect validity of warranties and bonds.

1. Include procedures to follow and required notifications for warranty claims.
2. Include all model, serial numbers and information required on table at end of section. Table is available in Excel upon request from Professional.

NOTE: Where manuals contain manufacturer's standard printed data, include only sheets pertinent to product or component installed. Mark each sheet to identify each product or component incorporated into the Work. If data includes more than one item in a tabular format, identify each item using appropriate references from the Contract Documents. Identify data applicable to the Work and delete references to information not applicable.

2.5 CLOSEOUT DOCUMENTATION

A. Seven days prior to requesting a final inspection, the Contractor shall submit all O&M and closeout documentation to the Architect, to be submitted to the Owner at the end of the project.

B. The checklist herein shall be utilized for compiling documentation and shall be included behind front cover of O&M manuals.

C. Contractor shall initial and date each line item once completed and shall email a copy of the completed checklist to the Architect prior to final inspection request.

PART 3 - EXECUTION

3.1 MANUAL PREPARATION

A. Operation and Maintenance Documentation Directory: Prepare a separate manual that provides an organized reference to emergency, operation, and maintenance manuals.

B. Assemble a complete set of the following manuals indicating procedures for each.

1. Emergency manual.
2. Product maintenance manual.
3. Operations and maintenance manual.

C. Manufacturer's Data: When manuals contain manufacturer's standard printed data, include only sheets pertinent to product or component installed. Mark each sheet to identify each product or component incorporated into the Work. If data includes more than one item in a tabular format, identify each item using appropriate references from the Contract Documents. Identify data applicable to the Work and delete references to information not applicable.

1. Prepare supplementary text if manufacturers' standard printed data are not available and where the information is necessary for proper operation and maintenance of equipment or systems.

D. Drawings: Prepare drawings supplementing manufacturer's printed data to illustrate the relationship of component parts of equipment and systems and to illustrate control sequences and flow diagrams. Coordinate these drawings with information contained in Record Drawings to ensure correct illustration of completed installation. Do not use original Project Record Drawings.

1. Do not use original Project Record Drawings as part of operation and maintenance manuals.

3.2 CLOSEOUT DOCUMENTATION CHECKLIST

A. Closeout Documentation Checklists included:

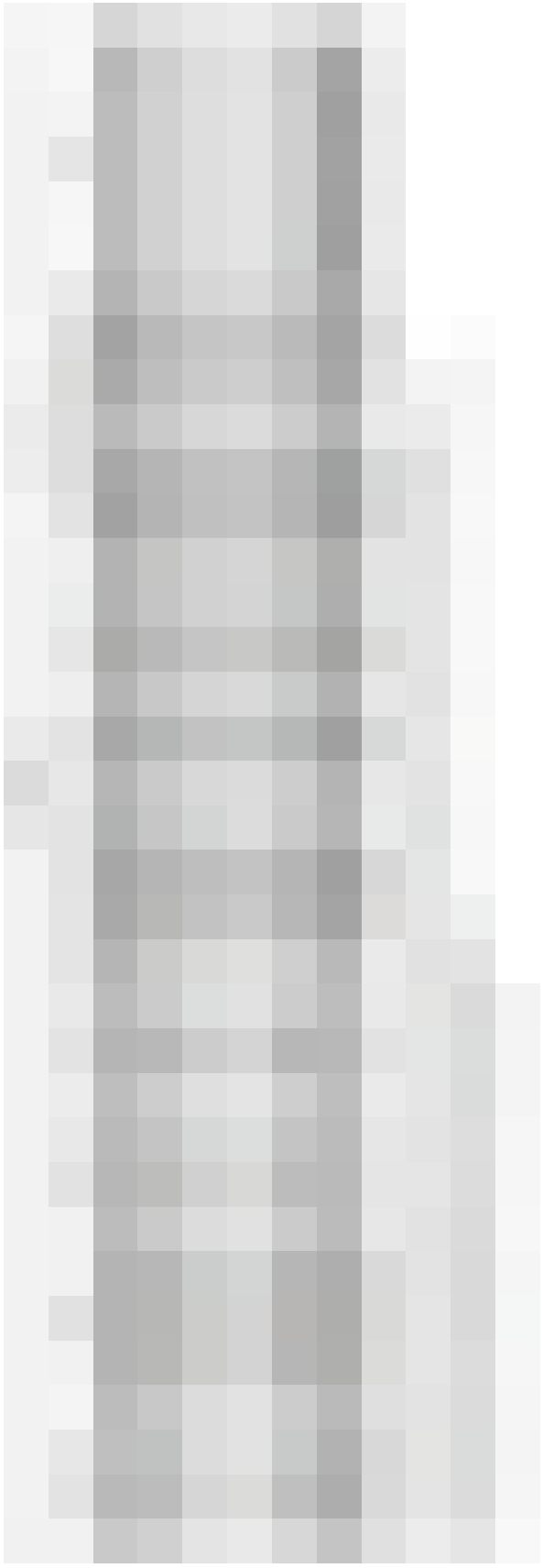
1. Division 21 – Fire Protection.
2. Division 22 – Plumbing.
3. Division 23 – HVAC.

CLOSEOUT DOCUMENTATION CHECKLIST DIVISION 21 – FIRE PROTECTION		
Project Name:		
Initials of person completing task	Date task completed	Description of Contractor's Submittal
		Signed Letter Record of Owners Personnel O & M Training.
		DVD Record of Owners Personnel O & M Training (3 each).
		Valve tag and floor plan location charts.
		Pipe pressure test log. Pipe pressure tests per NFPA 13.
		Provide copy of Installation and Material Certificate per NFPA 13.

CLOSEOUT DOCUMENTATION CHECKLIST DIVISION 22 – PLUMBING		
Project Name:		
Initials of person completing task	Date task completed	Description of Contractor's Submittal
		As-Built Drawings with Contractor's Stamp.
		Warranty Information.
		Pipe pressure test log.

CLOSEOUT DOCUMENTATION CHECKLIST DIVISION 23 – HVAC		
Project Name:		
Initials of person completing task	Date task completed	Description of Contractor's Submittal
		Final TAB Report (3 each required).
		Signed Letter Record of Owners Personnel O & M Training.
		DVD Record of Owners Personnel O & M Training (3 each).
		Operation & Maintenance Manuals.
		As-Built Drawings with Contractor's Stamp.
		Warranty Information.
		Manufacturer's representative(s) shall provide certification(s) that HVAC equipment has been installed in accordance with manufacturer's recommendations. Typical for VRF systems, MAU's, etc.
		Provide list of all spare air filter sets. List number, size, type and location/equipment match-up.
		Certification by Contractor that all bearings requiring periodic lubrication, as recommended by equipment manufacturer, have been initially lubricated and have been tagged. Provide a list of all equipment lubricated.
		Pipe Pressure Test Log.
		Duct Pressure Test Log.
		Original issue BAS (EMCS) software & manuals, trend logs, BAS database backup, etc.
		Control sequences of operation.
		Valve tag and floor plan location charts.
		On a reduced floor plan drawing, the CONTRACTOR shall indicate the location of all variable frequency drives, starters, and switches. These devices shall be properly marked to indicate equipment they serve as designated on the Contract Documents.

		Keys to access doors. (Provide written receipts with Owner's acceptance).
		Keys to control panels and sensor/controller covers (provide written receipts with Owner's acceptance).
		Certification by ION generator technical representative that all units are installed in specified systems are installed properly and functional.



END OF SECTION 230020

SECTION 230030 - DEMONSTRATION AND TRAINING FOR MECHANICAL SYSTEMS

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. Administrative and Procedural requirements for preparing operation and maintenance manuals, including the following:

1. Demonstration of operation of systems, subsystems, and equipment.
2. Training in operation and maintenance of systems, subsystems, and equipment.

B. Related Sections:

1. Section 230010 – Mechanical General Provisions.
2. Section 230020 – Mechanical Close-Out Requirements.

1.3 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions.

B. Initial Submittal: Submit draft copy of each manual a minimum of 60 days prior to requesting Substantial Completion inspection. Include a complete operations and maintenance directory. Architect will return draft copy and mark whether general scope and content of manuals are acceptable.

C. Submit manuals according to the following table.

1. “R” means required.

Item	Product Data	O&M Manual	Samples	Documentation
Instruction program				R
Qualification data				R
Attendance record				R
Evaluations				R
DVD				R

D. Instruction Program: Submit to the Architect copies of instructional program outline for demonstration and training, including a schedule of proposed dates, times, length of instruction and instructors’ names for each training module. Include learning objective and outline for each training.

1. At completion of training, submit two (2) complete training manuals for Owner’s use.

E. Qualification Data: Include lists of completed projects with project names and addresses, names, and addresses of Architects and Owner and other information specified.

F. Attendance Record: For each training module, submit list of participants and length of instruction time.

G. Evaluations: For each participant and each training module, submit results and documentation of performance-based test.

H. Demonstration and Training DVD's: Submit two copies of each DVD within seven (7) days of recording.

1. Format: Provide high quality color DVDs.
2. Identification: On each DVD, provide an applied label with the following information:

a. Name of project.
b. Name and address of photographer.
c. Name of Engineer.
d. Name of Contractor.
e. Date DVD was recorded.
f. Description of vantage point, indicating location, direction (by compass point) and elevation or construction story.

I. Transcript: Prepared on 8-1/2 x 11" (A4) paper, punched and bound in heavy-duty, 3-ring, vinyl-covered binders. Mark appropriate identification on front and spine of each binder. Include a cover sheet with the same label information as the corresponding DVD. Include name of Project and date of DVD on each page.

1.4 QUALITY ASSURANCE

A. Instructor Qualifications: A factory-authorized service representative experienced in operation and maintenance procedures and training.

B. Photographer Qualifications: An individual of established reputation who has been regularly engaged as a professional video photographer for not less than five years.

C. Pre-instruction Conference: Review methods and procedures related to demonstration and training including, but not limited to the following:

1. Inspect and discuss locations and other facilities required for instruction.
2. Review and finalize instruction schedule and verify availability of educational materials, instructors' personnel, audiovisual equipment, and facilities needed to avoid delays.
3. Review required content of instruction.
4. For instruction that must occur outside, review weather and forecasted weather conditions and procedures to follow if conditions are unfavorable.

1.5 COORDINATION

A. Coordinate instruction schedule with Owner's operations. Adjust schedule as required to minimize disrupting Owner's operations.

B. Coordinate instructors, including providing notification of dates, times, length of instruction and course content.

C. Coordinate content of training modules with content of approved emergency, operation, and maintenance manuals. Do not submit instruction program until operation and maintenance data has been reviewed and approved by Architect.

PART 2 - PRODUCTS

2.1 INSTRUCTION PROGRAM

A. Program Structure: Develop an instruction program that includes individual training modules for each system and equipment not part of a system, as required by individual Specification Sections and as follows:

1. Heat generation including boiler, pumps and heating water distribution piping.
2. Gas-fired heating equipment.
3. Refrigeration systems including chillers, pumps, ice storage tanks and chilled water piping.
4. HVAC systems including air-handling equipment, unit heaters, power ventilators, heat exchangers, piping specialties, etc.
5. Energy Management and Control System.
6. All control end-devices and sensors.
7. Variable Frequency Drives.

B. Training Modules (Basis of System Design, Operational Requirements and Criteria): Develop a learning objective and teaching outline for each module. Include a description of specific skills and knowledge that participants are expected to master. For each module, include instruction for the following (this will be provided through the Architect):

1. System, subsystem, and equipment descriptions.
2. Performance and design criteria.
3. Operating standards.
4. Regulatory requirements.
5. Equipment function.
6. Operating characteristics.
7. Limiting conditions.
8. Performance curves.

C. Training Modules (Documentation): Review the following items in detail:

1. Emergency manuals.
2. Operations manuals.
3. Maintenance manuals.
4. Project record documents.
5. Submittal manual.
6. Identification systems.
7. Warranties and bonds.
8. Maintenance service agreements and similar continuing commitments.
9. Owner requirements to uphold extended warranties.

D. Emergencies: Include the following as applicable:

1. Instructions on meaning of warnings, trouble indications and error messages.
2. Instructions on stopping.
3. Shutdown instructions for each type of emergency.
4. Operating instructions for conditions outside of normal operating limits.
5. Sequences for electric or electronic systems.
6. Special operating instructions and procedures.

E. Operations: Include the following as applicable:

1. Startup procedures.
2. Equipment or system break-in procedures.
3. Routine and normal operating instructions.

4. Regulation and control procedures.
5. Control Sequences.
6. Safety procedures.
7. Instructions on stopping.
8. Normal shutdown instructions.
9. Operating procedures for emergencies.
10. Operating procedures for system, subsystem, or equipment failure.
11. Seasonal and weekend operating instructions.
12. Required sequences for electric or electronic systems.
13. Special operating instructions and procedures.

F. Adjustments: Include the following:

1. Alignments.
2. Checking adjustments.
3. Noise and vibration adjustments.
4. Economy and efficiency adjustments.

G. Troubleshooting: Include the following:

1. Diagnostic instructions.
2. Test and inspection procedures.

H. Maintenance: Include the following:

1. Inspection procedures.
2. Types of cleaning agents to be used and methods of cleaning.
3. List of cleaning agents and methods of cleaning detrimental to product.
4. Procedures for routine cleaning.
5. Procedures for preventative maintenance.
6. Procedures for routine maintenance.
7. Instructions on use of special tools.

I. Repairs: Include the following:

1. Diagnosis instructions.
2. Repair instructions.
3. Disassembly: component removal, repair and replacement and reassembly instructions.
4. Instructions for identifying parts and components.
5. Review of spare parts needed for operation and maintenance.

PART 3 - EXECUTION

3.1 PREPARATION

A. Assemble educational materials necessary for instruction, including documentation and training modules. Assemble training modules into a combined training manual.

B. Set up instructional equipment at instruction location.

3.2 INSTRUCTION

A. Facilitator: The Architect will serve as facilitator to assist the Contractor in preparation of instruction program and training modules, to coordinate instructors and to coordinate between Contractor and Owner for number of participants, instruction times and location.

B. Engage qualified instructors to instruct Owner's personnel to adjust, operate and maintain systems, subsystems, and equipment not part of a system.

1. Architect will furnish an instructor to describe basis of system design, operational requirements, criteria, and regulatory requirements.
2. Owner will furnish an instructor to describe Owner's operational philosophy.
3. Owner will furnish Contractor with names and positions of participants.

C. Scheduling: Provide instruction at mutually agreed on times. For equipment that requires seasonal operation, provide similar instruction at start of each season.

1. Schedule training with Owner, through Architect, with at least forty-five (45) days advance notice.

D. Evaluation: At conclusion of each training module, assess and document each participant's mastery of module by use of a written performance-based test.

E. Demonstration and Training DVD: Record each training module separately. Include classroom instructions and demonstrations, board diagrams and other visual aids, but not student practice.

1. At beginning of each training module, record each chart containing learning objective and lesson outline.

F. Cleanup: Collect used and leftover educational materials and give to Owner. Remove instructional equipment. Restore systems and equipment to condition existing before initial training use.

3.3 DEMONSTRATION AND TRAINING DVDs

A. Demonstration and Training DVDs: Record instruction of Owner's personnel in the operation and maintenance of equipment and systems. Edit DVDs to remove non-instructional conversation. Photographer shall select vantage points to best show equipment, systems and procedures demonstrated.

END OF SECTION 230030

SECTION 230500 – BASIC MECHANICAL MATERIALS AND METHODS

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. Administrative and Procedural requirements for preparing operation and maintenance manuals, including the following:

1. Temporary operation of mechanical equipment.
2. Wall and ceiling access panels.
3. Roof curbs.
4. Fire, smoke, and sound stopping.
5. Pipe Sleeves.
6. Escutcheons.
7. Dielectric Fittings.
8. Protective drip pans.
9. Non-shrink grout.

B. Related Sections:

1. Section 230010 – Mechanical General Provisions.

1.3 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. "R" means required.
2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawings
Wall and ceiling access panels	R			R
Roof curb	R			R
Fire, smoke and sound stopping	R			R
Pipe sleeves and sleeve seals	R			R
Escutcheons	R			
Dielectric fittings	R			
Protective drain pans	R			R
Non-shrink grout	R			

1.4 QUALITY ASSURANCE

A. Equipment Selection: Equipment of higher electrical characteristics, physical dimensions, capacities, and ratings may be furnished provided such proposed equipment is approved in writing and connecting mechanical and electrical services, circuit breakers, conduit, motors, bases, and equipment spaces are increased. Additional costs shall be paid by this Contractor for these increases. If minimum energy ratings or efficiencies of equipment are specified, equipment must minimum requirements.

1.5 TEMPORARY ENVIRONMENTAL CONDITIONING

A. If the Contractor requires temporary heating, cooling, and dehumidification capability prior to the permanent building HVAC system being ready for operation, it shall be the Contractor's responsibly to provide and maintain in working condition the HVAC equipment and system components necessary to meet the recommended indoor environmental conditions. All cost associated with these temporary HVAC systems shall be the Contractor's responsibility and included in their bid.

B. Additionally, if the contractor requires temporary heating, cooling, and dehumidification capability prior to the Architect approving the use of the building mechanical systems, the Contractor shall be responsible for providing and maintaining temporary HVAC systems. All cost associated with these temporary HVAC systems shall be the Contractor's responsibility and included in their bid.

1. See minimum building condition requirements herein for operation of building mechanical equipment and systems.
2. Temporary HVAC systems and controls shall be capable of providing the recommended indoor environmental conditions.

1.6 OPERATION OF BUILDING MECHANICAL EQUIPMENT AND SYSTEMS

A. Temporary operation of the building mechanical equipment and systems shall be provided for this project beginning a minimum of 60 days (or as approved by Architect) prior to the scheduled substantial completion date and maintained until the Owner's final acceptance of the project, or any phase thereof. The beginning of this temporary HVAC period is intended to align with general industry standard construction practice of providing a minimum suitable indoor environment for the installation and curing of millwork, adhesives, finishes, wall covering(s), tile ceiling/floors, etc. This interior space conditioning includes all areas of the project where the space will be similarly conditioned with heating, cooling, and/or dehumidification capability after the project or any portion/phase thereof is completed.

B. Temporary Operation of Building Mechanical Equipment and Systems Procedure:

1. The Contractor shall notify the Architect in writing fourteen (14) days in advance to request temporary operation of the building permanent HVAC systems.
2. The Architect will schedule a site-visit to observe the site conditions to ensure all the items described below have been met prior to temporary operation.
3. The Contractor shall submit in writing an operation and maintenance plan for temporary use of the building HVAC systems. At a minimum the O&M plan shall address:

    a. Equipment, system, and air filter maintenance.
    b. Temporary filter efficiency and installation locations.
    c. Daily, weekly, monthly, etc. cleaning procedures to ensure indoor cleanliness.
    d. Describe in detail how the system will be controlled, and indoor conditions monitored. Procedures for shutting down equipment or isolation of areas where dust, dirt, or particulate producing activities occur.

4. At a minimum the following building components and activities shall be completed prior to operation of the building HVAC systems:

a. Dust or particulate generating construction activities completed.
b. All dirt, dust, and debris have been removed from the building areas being served.
c. Duct and cooling water piping insulation is fully completed and all seams, openings, etc. have been sealed.
d. All HVAC system equipment utilized for temporary heating and cooling shall have been started up per specifications. All manufacturer's authorized representative startup and warranty information (including checklists) shall be completed and submitted to the Architect.
e. All temporary air filters in place of types and installed in locations specified in 234000 "Air Cleaning Devices." All return air and exhaust air distribution devices and openings shall be covered and protected with filter material specified in 234000 "Air Cleaning Devices." All temporary filters shall be continually monitored and replaced periodically when required.

5. Upon completion of the Architect's site visit, review of site conditions and temporary operation plan, the Architect reserves the right to refuse temporary startup and operation if site conditions and plan do not meet specifications. No additional time will be given to the Contractor due to unapproved startup and temporary operation conditions.
6. Additionally, the Architect reserves the right to order the building HVAC systems shut down if the building condition or indoor environmental conditions are not maintained and found to be unacceptable.

C. The building indoor environmental conditions shall be continuously maintained within the following limits:

1. Maximum indoor temperature: 85 ˚F dry bulb.
2. Minimum indoor temperature: 60 ˚F dry bulb.
3. Maximum indoor relative humidity: 60% RH.

D. Temperature and humidity data loggers provided by the Contractor shall be installed throughout the facility to record indoor environmental conditions. Data logger quantity and locations shall be approved by Architect. Data from data loggers shall be submitted to the Architect every two weeks for review. Data shall be submitted on an hourly basis in .csv format or other, format agreed upon by Architect.

E. Contractor shall have either specified or temporary controls in place and fully operational to maintain the specified indoor environmental conditions above. Contractor shall provide all required temporary building services for temporary operation at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work includes but are not limited to the following listed in this specification.

B. Wall and ceiling access doors.

1. Acudor.
2. Williams Brothers.
3. J.R. Smith.
4. Or equal.
5. Or equal.

C. Roof curbs.

1. Custom Curb, Inc.
2. Plenums.

3. Thybar.
4. Or equal.

D. Mechanical sleeve seals.

1. Calpico, Inc.
2. Metraflex Co.
3. Thunderline/Link-Seal.
4. Or equal.

2.2 WALL AND CEILING ACCESS DOORS

A. Access panels shall be provided for all concealed valves, controls, dampers, and other mechanical equipment and devices where occasional access for adjustment or repairs will be necessary. Panels shall have cam and cylinder lock with two keys. All locks shall be keyed alike. Label panels as in accordance with Section 230553 – Mechanical Identification.

B. Size of panels to be large enough to permit servicing or replacement of devices, controls, valves, etc.; minimum size to be 18"x18". Submit schedule with submittal package indicating location and size.

C. General.

1. Fabricate units of all welded steel construction.
2. The frame and panel assembly for fire rated access panels shall be manufactured under the Factory Inspection Service of Underwriters Laboratories, Inc., and shall bear a label reading: "Frame and Fire Door Assembly, Rating 1-1/2 Hr. (B), Temperature Rise 30 Minutes, 250ºF, Maximum".
3. Access panels used in toilets, kitchens, and other areas expected to experience high relative humidity are to be constructed of stainless steel.

D. Flush Panel Access Panels: Acudor Model MS-7000 Security Access Panel.

1. Security access door designed for secure and institutional facilities.
2. Frame and door shall be of one-piece unit body construction and 12-gauge steel. Body shall be 12-gauge steel with a return edge around door opening.
3. Flange shall be 1-3/4” wide.
4. Hinges shall be concealed, piano type, opening to 175 degrees. Number of hinges will vary with size of door.
5. Locks shall be flush, key operated cylinder lock. Number of locks will vary with size of door.
6. Finishes shall be factory applied with a rust inhibiting phosphated undercoat; finish to be chemically bonded oven baked white enamel.
7. For installation in masonry openings, units shall be furnished with flexible metal anchor straps welded to the body.

2.3 ROOF CURBS, CURB ADAPTORS / PENETRATIONS

A. Contractor shall provide all curbs, adaptor curbs and supports required for roof penetrations and equipment installation; the Contractor shall install and flash.

B. Roof curbs and equipment supports shall be constructed as required such that the top is level and plumb.

C. Minimum of 18-gauge galvanized steel construction, fully mitered, welded corners, 3-inch cant, internal bulkhead reinforcing, 2x4 wood nailer and 18 gauge counter flashing. Equipment supports shall span a minimum of two joists. No load shall be applied to a cantilever section exceeding 1'-0" in length.

D. All curbs, pipe supports, etc. shall be a minimum of 14" high (shall be higher if required such that top of curbs are minimum 8" above roof surface) from top of roof insulation (curb heights shall be coordinated with final roof installation and insulation thickness). [Adaptable horizontal dimensions as required for existing roof openings.] It shall be the Contractor's responsibility to coordinate the curb and/or support height with roof construction.

E. All exposed roof curbs, equipment supports, and flashing shall be factory or field painted to match roof color. Coordinate color with Architect.

F. Installation shall be in strict accordance with manufacturer's printed instructions and as detailed on drawings. Curb manufacturer shall coordinate fabrication with Contractor.

G. All curbs of any type, and the equipment associated shall be constructed and include wind resistance rating for 160 MPH per newest code.

2.4 FIRE, SMOKE, AND SOUND STOPPING

A. UL listed penetration sleeve assembly and/or firestop that meets ASTM E-814 E119, and E84, as "3M" systems or equal for the intended applications.

B. All fire, smoke and sound stopping to be done by a licensed and certified Contractor as approved by Architect.

2.5 PIPE SLEEVES AND SLEEVE SEALS

A. Pipe Sleeves.

1. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
2. PVC Pipe Sleeves: Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.
3. Galvanized-Steel Sheet Metal Sleeves: Galvanized sheet metal sleeves with lock seam joints and comply with the following minimum thickness:

    a. 24 gauge for 3 inches and smaller.
    b. 22 gauge for 4 inches to 6 inches inclusive.
    c. 20 gauge for sizes over 6 inches.

B. Sleeve Seals: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Stainless steel.
3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.
4. Link-Seal or equal.

2.6 ESCUTCHEONS (WALL, FLOOR, AND CEILING PLATES)

A. Description.

1. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener in exposed applications.

2. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
3. Split-Casting Brass Type: With polished, chrome-plated rough-brass finish and with concealed hinge and setscrew in exposed applications.
4. Escutcheon thickness: For wall and ceiling plates, not less than 0.025-inches for up to 3-inch pipe and 0.035-inches for larger pipe.
5. Escutcheon thickness: For floor plates, not less than 0.094-inches.

2.7 DIELECTRIC FITTINGS

A. Provide where copper and ferrous metal are joined.

1. 2 inch and less: Threaded dielectric union.
2. 2-1/2 inch and larger: Flange union with dielectric gasket and bolt sleeves.
3. Temperature Rating: 210 ˚F for water systems.

2.8 PROTECTIVE DRAIN PANS

A. Required at following locations:

1. Fan-coil and all air handling units with cooling located in attics or above ceilings and where required by IMC. Not required if main drain pan includes secondary drain connection for this purpose.

    a. Size to capture any overflow from unit condensate drain pan.

2. Fan-coil and all air handling units with cooling located within rooms housing electrical equipment such as power panels, control panels, transformers, and computer equipment.

    a. Size to capture any overflow from unit condensate drain pan and extended to capture drips from control valves, strainers, and unions.

    b. All central station air handling units shall include drip pans to cover the entire footprint of each unit and extend minimum 4" past unit extents of unit housing on all sides, except coil piping side(s), where pan shall extend minimum 18".

B. Construction:

1. Fabricate pans of 20-gauge galvanized sheet metal or stainless steel, minimum two inches deep with rolled top edges on units with capacities no greater than 2000 CFM. Drain pan depth on larger units shall be minimum 3 inches and minimum 16-gauge galvanized metal.
2. Solder all seams watertight, and cross brace pans to prevent sagging and warping.
3. Provide dielectric union at copper pipe/galvanized pan connection point. Water heater and smaller drain pans shall have minimum one inch (1 inch) drain outlet routed to an approved location.
4. Drip pans under HVAC cooling equipment/coils shall be comprehensively insulated with minimum 1/2" Armaflex.
5. Provide 3/4" outlet drain on pans of units smaller than 2000 cfm and route to nearby suitable receptor. Larger units shall include minimum 1" outlet drain.

2.9 NON-SHRINK GROUT

A. Non-shrink, Nonmetallic Grout: ASTM C 1107, Grade B.

1. Characteristics: Post-hardening, volume-adjusting, dry, hydraulic-cement grout, non-staining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psig, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 WALL AND CEILING ACCESS PANEL

A. Coordinate size requirements and exact location with Contractor who will install access doors.

B. Minimum Sizes: 18 inches by 18 inches unless otherwise shown on Drawings or approved by Architect.

C. Provide where shown or required for access of all concealed equipment such as terminal units, valves, fire/smoke dampers, etc., for Mechanical Work. Where ceiling is constructed with removable tiles or sections, access panels are not required.

1. Equipment shall be located wherever practical over accessible ceilings or rooms to avoid access doors.
2. Access doors shall not be used solely for access to balancing dampers; use instead remote control, devices specified under Section 233300 – Air Duct Accessories.

D. Contractor shall provide substantial metal angle frame and support at all ceiling access panels.

3.2 ROOF CURBS, CURB ADAPTORS / PENETRATIONS

A. All roof mounted equipment shall be furnished with a roof curb compatible with both the equipment configuration and roofing system. Top-off curbs/supports shall be installed level, and curbs may be leveled by either shimming (no more than 1") or sloped curb construction. See detail on Drawings for more information on curb construction requirements.

B. Provide auxiliary steel support under all roof mounted equipment and under perimeter curb base and at all ductwork penetrations as approved by Architect.

3.3 FIRE, SMOKE, AND SOUND STOPPING

A. Fire and smoke stopping shall be provided and installed at all locations where new and existing mechanical work passes through rated assemblies. This includes all ductwork, piping, and controls related conduit.

B. Penetrations in “sound-rated” walls shall be similarly acoustically sealed, both sides of wall with caulk or other approved material. New and existing walls extending to the roof/floor structure above are considered sound walls.

3.4 PIPE SLEEVES AND SLEEVE SEALS

A. Install sleeves for pipes passing through exterior walls, concrete beams, foundations, footings, floors and roof decks.

1. Cut sleeves to length for mounting flush with both surfaces.

a. Exceptions:

1) In areas where pipes are exposed, extend sleeves 1/4-inch above finished floor.
2) Extend sleeves installed in floors of mechanical equipment areas or other wet areas (kitchens, toilets, etc.) 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Build sleeves into new walls, beams, foundations, footings, floors, roof decks and slabs as work progresses.
3. Install sleeves large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Pipe shall be capable of free movement within the sleeve.
4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using elastomeric joint sealants. Contractor shall coordinate specific sealing requirements to ensure fire, smoke or sound ratings are maintained through pipe penetration/sleeve assembly.

   a. Use Type S, Grade NS, Class 25, Use O, neutral-curing silicone sealant, unless otherwise indicated.

B. Interior wall pipe penetrations.

1. Galvanized-steel sheet metal sleeves.
2. Interior openings shall be caulked tight with fire, smoke or sound stopping material and sealant to prevent the spread of fire, smoke, and sound. Contractor shall coordinate specific requirements to ensure fire, smoke or sound ratings are maintained.

C. Above grade exterior wall, concrete beams, foundations, footings, waterproofed floors and where sleeve is extended above finished floor pipe penetrations: Seal penetrations using silicone sealant specified above.

1. Install galvanized steel or Schedule 40 PVC pipe sleeve.

D. Below grade exterior wall pipe penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeve for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install galvanized steel or Schedule 40 PVC pipe sleeve.
2. Assemble and install mechanical sleeve seals according to manufacturer's written instructions. Tighten bolts that cause rubber sealing elements to expand and make watertight seal.

E. Sleeves that extend into return air plenums shall be of non-combustible material, either galvanized steel or Schedule 40 steel pipe sleeves.

F. For drilled penetrations in existing floors provide one-inch angle ring flange set in silicone sealant and bolted to the floor in lieu of pipe sleeves with one-inch extension above floor.

3.5 ESCUTCHEONS

A. Install pipe escutcheons for exposed pipe penetrations of concrete and masonry walls, wall board partitions, suspended ceilings, etc.

B. Inside diameter shall fit around insulation or around pipe when not insulated; outside diameter shall cover sleeve and penetration.

C. Use plates that fit tight around insulation or pipes when not insulated.

D. Plates shall cover openings around pipes/insulation and cover the entire pipe sleeve projection. Use deep pattern escutcheons where required to completely conceal protruding fittings and sleeves.

3.6 DIELECTRIC FITTINGS

A. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

B. Wet Piping Systems: Install dielectric coupling, unions, and nipple fittings to connect piping materials of dissimilar metals.

3.7 PROTECTIVE DRAIN PANS

A. Provide minimum 2" deep pitched insulated drain pans, where shown and required under all concealed fan-coil and air handling units with cooling, new and existing storage tank type water heaters, and boilers, and all fluid conducting piping that is over electric switchgear, elevator controllers, busways or electric motor starters or as indicated. Pans shall extend minimum two inches beyond each side of the mechanical equipment, pipe or group of pipes being contained. Pans shall extend six inches beyond electrical equipment below.

B. Pitch pans above ceiling and route drain 3/4-inch or larger copper piping to the nearest available open drain or outside as directed by Professional. Separate unit drain and drain pan unless otherwise indicated.

3.8 GROUTING

A. Install nonmetallic, non-shrink, grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, pipe support base plates, and anchors. Mix grout according to manufacturer's written instructions. Cure placed grout according to manufacturer's written instructions.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Place grout, completely filling equipment bases and pipe support base plates.

E. Place grout around anchors.

3.9 CUTTING AND PATCHING

A. Do not cut into any major structural element without written approval of the Architect.

B. Cut required openings through existing masonry or reinforced concrete with diamond core drills. Use of pneumatic hammer type drills, impact type electric drills, and hand or manual hammer type drills, will be permitted only with approval of the Architect. Locate openings that will least affect structural slabs, columns, ribs, or beams. Refer to the Architect for determination of proper design for openings through structural sections and opening layouts for approval prior to cutting or drilling into structure. After Architect’s approval, carefully cut openings through construction no larger than absolutely necessary for the required installation.

C. Patching:

1. Shall be of quality and appearance matching the existing construction.
2. Contractor shall restore all services and construction that remains in use, to its condition prior to Work performed as part of this contract.

END OF SECTION 230500

SECTION 230513 – MOTORS AND CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors, motor controllers (starters) and Variable Speed Drives (VSD) for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1. Motors.
2. Motor controllers.
3. Variable speed drives.

1.3 SUBMITTALS

A. See Section 230010 “Mechanical General Provisions.”

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Motors	R	R		R
Belts and Drives		R		
Variable Speed Drives	R	R		R
Motor Controllers/Starters	R	R		R

C. Submittals shall include certification from the motor manufacturer certifying compliance with NEMA MG-1, part 31 for motors that are driven by variable speed drives.

D. Submit a site-specific harmonic analysis showing total voltage harmonic distortion and total current harmonic distortion is in compliance with IEEE 519. If the analysis indicates that additional external devices or filters are required to meet the power quality requirements of the VSD, provide the devices or filters at no additional cost to the Owner.

1.4 COORDINATION

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

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

1.5 WARRANTY

A. Special Warranty: VSD warranty shall be 60 months from date of start-up certification including all parts, labor, travel time, and expenses.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Motors.

1. General Electric
2. Gould, Inc.
3. Baldor.
4. Or equal.

C. Variable Speed Drives.

1. Yaskawa.
2. Danfoss.
3. ABB.
4. Or equal.

D. Motor Controllers/starters.

1. ABB.
2. Cerus.
3. Square D.
4. Or equal.

2.2 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

2.3 MOTORS

A. General.

1. In accordance with NEMA, IEEE, and ANSI C50 standards.
2. Capacity.

    a. Minimum horsepower indicated.
    b. To operate driven devices under all conditions without overload.

3. Squirrel-cage induction type, NEMA Type "B: insulation class, continuous duty.
4. Speed.

    a. 1750 RPM, unless otherwise indicated.
    b. See schedules on drawings for other speeds.

5. NEMA KVA locked rotor CODE LETTER: "G" or better.
6. Service factor: 1.15.
7. Type unless otherwise scheduled on Drawings.

    a. Voltage: As scheduled on Drawings. Contractor shall verify actual site voltage prior to procurement.
    b. 1/2 horsepower and smaller.

        1) Single-phase, 60 hertz.
        2) With built-in auto-reset thermal overload protection.

    c. 3/4 horsepower and larger.

        1) Three-phase, 60 hertz.
        2) Motors 50 horsepower and over: Reduced voltage start, suitable for star-delta starting or as scheduled on Drawings.

    d. EC Motors.

        1) Where scheduled on Drawings or equipment Specifications.
        2) Equal to GE ECM version 2.2 or greater.
        3) Programmed with fan curve for “constant airflow”.

8. Bearings, unless otherwise scheduled on Drawings or equipment Specifications.

    a. Provide motors with double shielded, grease lubricated, ball bearings, with grease pockets on each side for re-greasing in service. Provide inlet and outlet grease connections in motor housings for each bearing. Provide factory sealed permanently lubricated ball bearings on roof mounted equipment. Similar bearing may be provided on fractional horsepower motors. Provide sleeve bearings where so specified.
    b. Ball type, unless otherwise noted.
    c. Sealed, permanently lubricated, unless otherwise noted or not available in motor size.

B. Enclosure.

1. Open drip-proof (ODP).

    a. Provide ODP motors unless otherwise indicated.

2. Totally enclosed (TEFC).

    a. Motors outside the building or otherwise exposed to the weather.
    b. Non-ventilated: under 1/2 horsepower.
    c. Fan-cooled: 1/2 horsepower and larger.

3. See schedules on drawings for other enclosures.

C. Belt-connected motors.

1. Foundation slide base.
2. Shaft as required for aligning pulleys.

D. Motors 1 horsepower and larger shall be NEMA Premium labeled and have guaranteed efficiencies equal to or exceeding NEMA Table 12-6D.

E. Multi-speed motors.

1. Two speed motors shall be single winding 1800/900 rpm unless otherwise specified or indicated.
2. Provide 1800/1200 rpm multi-speed motors of separate winding, variable torque type, unless otherwise specified or indicated.

F. Motors driven by variable speed drives.

1. Shall meet the requirements of NEMA MG-1 part 31.40.4.2.
2. Where used for pumps or fans shall be capable of operating at 10 percent speed indefinitely.

G. Electrically Commutated Motors (EC Motors).

1. Brushless DC type with electronic commutation from 115 volt or 277-volt single phase power to a DC signal.
2. Speed controllable from a minimum of 20% or less to 100% of full speed.
3. Minimum 80% efficiency at all speeds.
4. Provide the following.

    a. Potentiometer dial mounted on the exterior of the motor housing.
    b. 0-10 VDC control signal input and 0-10 VDC speed feedback output with pre-wired contacts. Motor shall shut off when speed signal is below minimum.

2.4 VARIABLE SPEED DRIVES

A. All variable speed drives other than those that are factory packaged with equipment shall be supplied by one manufacturer.

B. Electrical Characteristics.

1. Efficiency shall be not less than 97 percent at rated voltage, current, and frequency and fundamental power factor shall not be less than 98 percent at all speeds and loads.
2. VSD shall maintain line noise (voltage harmonics) on the input electrical system at or below levels specified in IEEE 519 for a “General System.” Manufacturer shall include in submittals a harmonic distortion analysis (IEEE 519, 3 percent) for this particular jobsite. Provide as a minimum 5% impedance line reactors. The 5% impedance may be from dual

(positive and negative DC bus) reactors or 5% AC line reactors. VSDs with only one DC reactor shall include AC line reactors.

3. VSD shall include EMI/RFI filters that allow the VSD assembly to be CE Marked and meet product standard EN 61800-3 for the First Environment restricted level.

C. Features and Accessories.

1. Plain language LCD display (code numbers not acceptable); all set-up parameters, indications, faults, warnings, and other information shall be displayed in words, not codes.
2. Displays and meters for the following: Output voltage, output frequency, motor rpm, motor current, motor watts, speed signal input, last three faults.
3. Hand-Off-Auto keyboard function with manual speed control, including bump-less transfer of speed reference when switching between Hand and Auto modes.
4. Input line fuses.
5. Adjustable or multiple carrier frequencies up to 12 kHz. Include a carrier frequency control circuit that reduces the carrier frequency based on actual VSD temperature that allows the highest carrier frequency without derating the VSD or operating at high carrier frequency only at low speeds.
6. Isolated 4-20 mA or 0-10 Vdc speed signal input. If the input reference is lost the VSD shall, based on user selectable option, either (1) stopping and displaying a fault, (2) running at a programmable preset speed, (3) hold the speed based on the last good reference received, or (4) cause a warning to be issued.
7. Analog outputs for kW and speed; kW shall be accurate to ±3%.
8. Digital outputs for alarm and motor on/off status; latter shall be based on field adjustable motor current that can indicate broken belt or coupling.
9. Ability to automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable for each fault type.
10. Controls.

    a. Provide a minimum of two digital outputs that can be programmed for multiple purposes and also controlled through the DDC network interface device by the DDC system independent of other VSD functions or status. Control sequence possibilities shall include:

        1) Contact to open fan discharge damper either with fan start or independent of fan operation, controlled via the DDC system and wait for the damper end switch to make before starting the drive; this shall function in the normal drive mode, bypass mode, and life safety mode (if part of smoke control system).

    b. For fans used as part of IBC smoke control system, include:

        1) Programmable digital input that, when external contact is closed by life safety control system, causes VSD to start and operate at a preset adjustable speed, overriding automatic speed and on/off controls, manual speed settings and all keypad and HOA commands.
        2) “Run to destruct” option so that when the digital input is closed, all internal and external safeties that might prevent the VSD from operating at the preset speed will be ignored or overridden.

    c. Provide built-in PID control loop, allowing connection of a pressure or flow signal to the VSD for closed loop control.
    d. Provide factory installed BACnet/MSTP network interface that allows all VSD control points to be communicated to EMCS. See Section 230900 “Energy Management & Control Systems.” At a minimum, the following points shall be provided:

1) Read only: Speed feedback, output speed, current, % torque, kW power, kilowatt hours (resettable), operating hours (resettable), drive temperature, digital input status, analog input values, all diagnostic warning and fault information, keypad “Hand” or “Auto” selected, deceleration rate, and acceleration rate.
2) Read/write: On/off, output speed, digital output open/close, analog output values, remote fault reset, PID setpoint and gains, force the unit to bypass, maximum speed, and minimum speed.

11. Enclosure.

a. NEMA 3R enclosure for outdoor installation or unconditioned space.
b. NEMA 1 enclosure for indoor installation in conditioned space or indirectly conditioned space such as return air plenum.
c. UL Type 12 for wet mechanical rooms.
d. UL listed as plenum rated where located in supply, return, or outdoor air stream.

12. Thermostatically controlled cooling fans shall be provided where required to meet ambient operating conditions. Fans shall be designed for replacement without requiring removal of the VSD from wall mount or removal of circuit boards. Fan sound power shall be no greater than local noise sources where VSD is installed.
13. 3-contactor, constant speed bypass shall be provided to allow the motor to run across the line in the event of VFD shutdown. The transfer from the VFD to the line shall be accomplished manually by means of a selector switch. The bypass circuitry shall be enclosed in a separate well-mounted NEMA 1 cabinet. The bypass cabinet shall include a door interlocked input circuit breaker, a VFD output contactor, and a full voltage starting contactor (both contactors electrically interlocked), a thermal overload relay to provide motor protection, and a control power transformer. Mounted on the cabinet door shall be the bypass selector switch, motor fault light, power ON light, motor on VFD light, and motor online light.

D. Equipment Protection and Safeties.

1. VSDs short-circuit interrupting rating shall equal or exceed that fault current available at the drive.
2. VSD shall protect itself against all normal transients and surges in incoming power line, any grounding or disconnecting of its output power, and any interruption or run away of incoming speed signal without time delay considerations. Protection is defined as normal shutdown with no component damage.
3. The VSD shall be capable of sensing a loss of load (broken belt / broken coupling) and signal the loss of load condition. The VSD shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. Relay output shall include programmable time delays that will allow for drive acceleration from zero speed without signaling a false underload condition.
4. VSD shall protect itself against all phase-to-phase or phase-to-ground faults.
5. VSD shall be able to start into a rotating load at all speeds (forward or reverse) without trip.
6. Anti-regeneration circuit shall match the deceleration rate of the drive to that of the motor to prevent high bus voltage shutdown common to high inertia loads, such as fans.
7. VSD shall ride through an input power dip of 3 cycles without trip.
8. VSD shall operate properly at a -35% +30% voltage fluctuation from rated voltage.
9. VSD shall operate properly at a 10 percent frequency variation from rated frequency.
10. VSD shall employ three current limit circuits to provide trip-free operation: slow current regulation, rapid current regulation, and current limit switch-off limit. VSD shall be designed so that overcurrent trip shall be at least 315 percent of the drive’s current rating.
11. VSD shall have the ability to set a maximum current available to the motor.

12. VSD shall withstand unlimited switching of the output under full load, without damage to the VSD. Operation of a disconnect switch between the motor and VSD shall not have an adverse effect on the VSD, whether the motor is operating or not. Controls conductors between the disconnect and the VSD shall not be required for the safe and reliable operation of the VSD.
13. The VSD shall withstand switching of the input line power up to 20 times per hour without damage to the VSD.
14. The VSD shall be capable of operating continuously at full load in the following service conditions

    a. Ambient temp: 30 to 104 degrees Fahrenheit.
    b. Relative humidity: 0 to 95 percent, non-condensing.

E. Warranty shall be 24 months from date of start-up certification including all parts, labor, travel time, and expenses.

2.5 MOTOR CONTROLLERS/STARTERS

A. General.

1. Manual reset, Class 20, thermal type overload protection for each phase, in accordance with NEMA ICS 2-2000 (R2005).
2. NEMA 3R enclosures for exterior application.
3. Equipment furnished with factory-installed starters shall also be equipped with individual motor disconnect and thermal magnetic circuit breakers or fuses as specified herein with lugs sized to receive a feeder as indicated on the Electrical Drawings.
4. 120 V secondary control power transformer with fused primary and secondary circuit in the enclosure.
5. Unused auxiliary contacts (installed on each contactor): 1 normally open, and 1 normally closed.

B. Motor starters shall be provided with provisions for interfacing with the Energy Management and Control System (EMCS) or other control and interlocking requirements.

1. For all magnetic starters, a minimum of one set of field reversible auxiliary contacts shall be provided with the starter.

C. For 3-phase motors, unless otherwise specified herein:

1. Combination magnetic type and thermal magnetic circuit breaker with:

    a. Circuit breakers having minimum AIC rating as specified in Division 26.
    b. External operating handle capable of being locked in the off or open position.
    c. Hand-off-automatic switch, except those manually controlled.
    d. Starters for motors 50 hp and larger shall be solid-state, reduced-voltage type.

D. For 1-phase, unless otherwise specified herein:

1. Manual starting switch with thermal overload protection and pilot light.

2. Hand-off-automatic switch.
3. Magnetic across-the-line starters with overload protection and Hand-Off-Automatic switch, except for manually controlled equipment.

E. Provide control transformers for equipment with voltage above 240 volts, or as required for complete, operable systems.

F. Coordinate with DIVISION 26: ELECTRICAL.

G. Refer to individual equipment sections for factory-provided controllers.

1. Installed on equipment by manufacturer.
2. Supplied with equipment by manufacturer for field installation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate with work of other trades.

B. Install in accordance with manufacturer's written installation instructions.

C. Drives for packaged equipment shall be mounted and wired by equipment manufacturer.

D. Mounting and power wiring of field mounted variable speed drives and other motor controllers is specified under Division 26 Electrical:

1. Where wall space is not available for mounting VSDs or other motor controllers, provide mounting struts securely mounted to the floor, roof, or adjacent structure.
2. Where VSD has disconnect switch, locate VSD within sight of equipment served so that switch complies with NEC requirements.

E. Set overload devices to suit motors provided in accordance with NEC.

3.2 INSTALLATION

A. Verify that adequate clearance between motor, controllers and adjacent walls or equipment is available to permit maintenance and repairs.

B. Check that motor and controller are properly supported and allows for proper alignment and tension adjustments as necessary for application.

3.3 PRE-OPERATING CHECKS

A. Before operating motors and controllers.

1. Check for proper and sufficient lubrication.
2. Check for correct rotation.
3. Confirm alignment and re-align if required.
4. Check for proper adjustment of vibration isolation.

3.4 STARTUP, TESTING AND ADJUSTING

A. Start and test motors and controllers in accordance with manufacturers written installation instructions.

B. After starting motors.

1. Check for high bearing temperatures.
2. Check for motor overload by taking ampere reading at maximum operating conditions, with all valves open and individual motor running.
3. Check for objectionable noise or vibration; correct as needed at no additional cost to the Owner.

C. Variable speed drives.

1. Certified factory start-up shall be provided. A certified start-up form shall be filled out for each VSD with a copy to the Architect and a copy kept on file by the manufacturer.
2. See Section 230900 “Energy Management and Control Systems” for points to be mapped from the drive controller to the EMCS; coordinate information addresses and other information required with the Section 230900 “Energy Management and Control Systems” contractor.
3. Set variable speed ramp-up rates on variable air volume systems slow enough to prevent high pressure trips and/or damage to duct systems. Coordinate with Section 230900 EMCS contractor.
4. Set minimum speed for all applications in accordance with procedure indicated in Section 230900 “Energy Management and Control Systems.”
5. Set maximum current limit setpoint to the motor to the motor's full load amps.
6. Set voltage to speed ratio (V/f) to “squared”.
7. For fans such as relief fans and cooling tower fans: Run fan through entire speed range and program out speeds that cause fan vibration.
8. After VSD is fully configured and programmed, all settings shall be documented and included with commissioning documentation in electronic format per Section 230010 Mechanical General Provisions. The intent is to allow replacement drive electronics to be readily configured.

D. Motor Controllers/Starters.

1. Provide starters, push buttons, thermal overload switches, and contactors for equipment covered in Division 23 unless otherwise specified herein. Installation of starters, push buttons, and thermal overload switches, not factory installed, is specified under Division 23.
2. Provide 120 V secondary control power transformers for control circuits where equipment is served at 208 V or higher.

E. See Section 230593 “Testing, Adjusting, and Balancing for HVAC.”

3.5 TRAINING

A. See Section 230010 “Mechanical General Provisions.”

B. VSD manufacturer to provide one of the following:

1. 8-hours of customer training.

2. Interactive Computer based training on VSD installation, start-up, programming, and trouble shooting.
3. Professionally produced video cassette on VSD installation, start-up, programming, and trouble shooting in digital format.

END OF SECTION 230513

SECTION 230519 - METERS AND GAUGES

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. Liquid-in-glass thermometers.
2. Duct-thermometer mounting brackets.
3. Thermowells.
4. Dial-type pressure gauges.
5. Gauge attachments.
6. Test plugs.

1.3 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Thermometers	R	R		
Thermowells	R			
Pressure gauges	R	R		
Gauge attachments	R			
Test plugs	R			

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models are acceptable.

B. Thermometers:

1. Weksler.
2. Weiss.
3. Trerice.
4. Or equal.

C. Pressure gauges:

1. Weksler.
2. Weiss.
3. Trerice.
4. Or equal.

D. Pressure-temperature test plugs:

1. Peterson Engineering Company.
2. Taco.
3. Watts.
4. Or equal.

2.2 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Standard: ASME B40.200.
2. Case: Cast aluminum; 9-inch nominal size unless otherwise indicated.
3. Case Form: Adjustable angle unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
6. Window: Glass.
7. Stem: Aluminum and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

8. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
9. Accuracy: Plus, or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.
10. Weiss 9VU or equal.

2.3 DUCT-THERMOMETER MOUNTING BRACKETS

A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.4 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion in piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.

4. Material for Use with Steel Piping: CSA.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.5 PRESSURE GAUGES

A. Pipe or equipment mounted type.

1. Standard: ASME B40.100.
2. Diameter: 4 1/2 inch, except as noted.
3. Case: black finished cast aluminum with flangeless back.
4. Threaded black cast aluminum ring with gasketed glass face.
5. Type 316 stainless steel spring tube.
6. Stainless steel precision movement: Micrometer adjustment on needle.
7. Accuracy: 0.5 of 1 percent full scale range.
8. With calibration adjustment.
9. Quarter turn stop cock: Materials compatible with service.
10. Pressure snubbers.

    a. Filter type.
    b. For liquid, air, and gas.

11. Weksler Type AA44 or equal.

2.6 GAUGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and porous-metal-type surge-dampening device. Include extension for use on insulated piping.

B. Siphons: Loop-shaped section of stainless-steel pipe with NPS 1/4 or NPS 1/2 pipe threads.

C. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.7 TEST PLUGS

A. Description: Test-station fitting made for insertion in piping tee fitting.

B. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

C. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.

D. Minimum Pressure and Temperature Rating: 500 psig at 275 deg F.

E. Core Inserts: Nordel self-sealing rubber.

F. Pete’s Plug: No. 110 with yellow cap or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending one-third of pipe diameter and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions at the most readable position.

F. Install direct-mounted pressure gauges in piping tees with pressure gauge located on pipe at the most readable position.

G. Install valve and snubber in piping for each pressure gauge for fluids (except steam).

H. Install valve and syphon fitting in piping for each pressure gauge for steam.

I. Install test plugs in piping tees.

J. Install test plugs at all temperature, pressure, and flow sensors for calibration. See Section 230900 Energy Management and Control Systems.

3.2 CONNECTIONS

A. Install meters and gauges adjacent to machines and equipment to allow space for service and maintenance of meters, gauges, machines, and equipment.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gauges to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

Installation Location	Thermometer Type	
	Industrial (Metal) Liquid-in-Glass	Test Plug w/Nordel Core
Hydronic Zone	X	X
Boiler Inlet and Outlet	X	X
Chiller Inlet and Outlet (Evaporator and Condenser)	X	X
AHU Coil Inlet and Outlet	X	X
Hydronic Heat Exchager Inlet and Outlet	X	X
Heat Recovery Unit Inlet and Outlet	X	X
Thermal Storage Tank Inlet and Outlet	X	X
Where indicated on Drawings	X	X

A. Thermometer stems shall be of length to match thermowell insertion length.

B. Test plug with Nordel core self-sealing rubber inserts, where shown on Construction Drawings. Also locate adjacent to all EMCS temperature/pressure wells for calibration.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

Application	Scale Range
Chilled Water	0 – 100 deg F
Heating Water	0 – 250 deg F
Domestic Hot Water	0 – 240 deg F
Domestic Cold Water	0 – 110 deg F

3.6 PRESSURE-GAUGE SCHEDULE

Installation Location	Pressure Gauge Type	
	Liquid-filled (Metal) Direct-Mounted	Test Plug w/Nordel Core
Pressure-Reducing Valve	X	X
Boiler Inlet and Outlet	X	X
AHU Coil Inlet and Outlet	X	X
Pump Suction and Discharge	X	X
Domestic Cold Water Building Entrance	X	X
Gas Regulator Inlet and Outlet	X	

3.7 PRESSURE-GAUGE SCALE-RANGE SCHEDULE

Application	Scale Range
Chilled Water	0 – 200 psig
Heating Water	0 – 160 psig
AHU Coil	0 – 100 psig
Domestic cold water building entrance	0 – 100 psig
Pressure gauges indicated on drawings or specifications, not indicated herein	Submit with appropriate range for review

END OF SECTION 230519

SECTION 230523 - VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Work Included in This Section: Materials, equipment, fabrication, installation, and tests in conformity with applicable codes and authorities having jurisdiction for the following:

1. Service valves in hydronic and plumbing systems (other than gas and fire sprinkler).
2. Balancing valves.
3. Check valves.
4. Safety and relief valves.
5. Vent and gas cocks.
6. Manual and automatic air vents.
7. Miscellaneous valves.

1.3 QUALITY ASSURANCE

A. Provide valves with manufacturer's name and pressure rating clearly marked on outside of body.

1.4 SUBMITTALS

A. See Section 230010 Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop and coordination drawings according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Valves, all types	R	R		R
Valve accessories (handle extensions, operators, etc.)	R			
Manual and automatic air vents	R	R		
Pressure/temperature test plug	R	R		

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Ball, gate, and check valves.

1. Nibco Inc.
2. Crane Company.
3. De Zurik Corporation.
4. Or equal.

C. Butterfly valves.

1. Nibco Inc.
2. Crane Company.
3. De Zurik Corporation.
4. Or equal.

D. Balancing valves.

1. ITT Bell and Gossett.
2. Taco Inc.
3. Watts.
4. Or equal.

E. Silent check valves.

1. Nibco Inc.
2. Grinnell.
3. Mueller Steam Specialty.
4. Or equal.

F. Combination check and shut-off valves and Triple duty valves: Not allowed.

G. Safety and relief valves.

1. Watts.
2. Consolidated.
3. ITT Bell and Gossett.
4. Or equal.

H. Vent cocks.

1. Weiss.
2. Weksler.
3. Crane Company.
4. Or equal.

I. Automatic air vents.

1. Amtrol.
2. ITT Bell and Gossett.
3. Dole Valve Company.
4. Or equal.

2.2 GENERAL

A. Where possible, provide valves of same manufacturer for all Mechanical Sections per products in this Section.

B. For copper tubing provide solder-joint valves, flare fittings, or IPS-to-copper adaptor, sized for use with tubing and respective valve.

C. For flanged valves, provide streamline companion flanges, ANSI B16.5, 1988 150 class pounds per square inch.

1. 255 pounds per square inch water on gage (WOG) at 150-degree Fahrenheit.
2. 225 pounds per square inch water on gage (WOG) at 250-degree Fahrenheit unless indicated otherwise.

D. Provide valves rated not less than 125 pounds per square inch steam working pressure, unless indicated otherwise.

E. Provide valve materials suitable for service and temperature of respective systems, especially with respect to discs, plugs, balls, linings, gaskets, and lubricants of globe valves, plug cocks, ball valves, etc.

F. Provide chain-operated hand wheels, rustproof chain, and chain guide for following valves.

1. Provide chain-operated hand wheels, rustproof chain, and chain guide for following valves.
2. As noted.

G. Valves in Insulated Piping: With 2-inch (minimum, greater if insulation thickness is greater than 1 inches) stem extensions and the following features:

1. Ball Valves: With extended operating handle of non-thermal-conductive material and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation and memory stops that are fully adjustable after insulation is applied. Nibco Nib-seal handle extension or equal.
2. Butterfly Valves: With extended neck.

2.3 BALL VALVES

A. 2-1/2 inches and smaller.

1. Two-piece body, bronze ASTM B584 C84400.
2. 316 stainless steel stem and ball.
3. PTFE Seat.
4. Full Port 1/2 to 1 inch; Standard Port 1-1/4 and larger.
5. 600 pounds per square inch at 100-degree F, 125 pounds per square inch saturated steam.
6. Infinite throttling handle with memory stop.

7. Nibco 585-70-66 or equal. Nibco 580-70-66 or equal may be used for 1-1/4 inch and larger.

2.4 BUTTERFLY VALVES

A. Flange Type:

1. Iron body.
2. 316 or 416 stainless steel stem, continuous with pinned disc.
3. Disk shall be either:

    a. 316 stainless-steel.
    b. Aluminum bronze.
    c. Nickel encapsulated ductile iron.
    d. EPDM encapsulated ductile iron.
    e. Nylon encapsulated ductile iron.

4. Steel seat or cast-iron support ring.
5. EPDM body and stem seal.
6. Bronze or copper bushings.
7. Factory tested bubble-tight at 150 pounds per square inch.

B. Type:

1. Lug Type:

    a. Equal to Nibco Series LD-2000.
    b. Lugs drilled and tapped to match ANSI 150 flanges.
    c. Recommended by manufacturer or dead-end service at full pressure without the need for downstream flanges.
    d. Use cap screws both sides.

C. Operator:

1. Infinite throttling handle with memory stop: smaller than 8 inches.
2. Gear operators: 8 inches and larger.

2.5 BALANCING VALVES

A. Calibrated Balancing Valves.

1. Combination balancing and shut-off valves.
2. Calibrated name plate and adjustable memory stop.
3. Capped read-out valves.
4. Pre-formed insulation for chilled water valves.
5. Provide one differential pressure read-out meter for all valves in system.
6. 2-1/2 inches and smaller:

    a. Brass body.
    b. 304 stainless steel ball.
    c. Soldered or threaded ends.
    a. Teflon or TFE seats.
    b. 250 pounds per square inch at 250 degrees Fahrenheit.

7. 3 inches and larger.

    a. Ductile or cast-iron body.
    b. Flanged.
    c. 175 pounds per square inch at 250 degrees Fahrenheit.

8. Devices using venture type flow meter not acceptable (due to propensity for clogging and ease of putting valve with limited flow range in wrong direction).
9. Devices using Pitot tube or Annubar type flow meter not acceptable (due to propensity for clogging).
10. Devices using other than ball or butterfly valves shall not be used for coil isolation – a separate ball valve or butterfly valve shall be added for isolation (to ensure positive shut-off and to allow 90˚ open-close with memory stop) whether shown on schematics or not.
11. Bell & Gossett Circuit-Setter Plus, or equal.

B. Combination shut-off, balancing, and check valve: Not allowed.

2.6 CHECK VALVES

A. Check Valves, General Service.

1. 2 inches and smaller.

    a. Brass body.
    b. Swing check.
    c. Class 125 (125 psi steam, 200 psi water).
    d. Bronze disc.
    e. Screw-in cap.
    f. Soldered ends.
    g. Equal to Nibco S-413-W.

2. 2-1/2 inches and larger.
    a. Ductile or cast-iron body.
    b. Swing Check.
    c. Class 125 (125 psi steam, 200 psi water).
    d. Bronze disc and seat ring.
    e. Bolted cap.
    f. Flanged body.
    g. Equal to Nibco F-918-8.

B. Silent Check Valves.

1. For pump discharges:

    a. Except sump pumps and sewage ejectors.
    b. Variable speed pumps. Check valve pressure drop shall vary roughly as the square of flow rate to near zero flow. Valves that use hydrodynamic profiles (e.g. Victaulic 716 check valve) resulting in high or erratic pressure drop at low flow rates are not acceptable.

2. 2 inches or smaller.

    a. Brass body.
    b. Center-guided, silent check.

c. Class 125 (125 psi steam, 200 psi water).
d. Bronze trim.
e. Equal to Nibco 480.

3. 2-1/2 inches or larger.

a. Ductile or cast-iron body.
b. Globe body silent check.
c. Class 125 (125 psi steam, 200 psi water).
d. Bronze trim.
e. Center-guided.
f. Flanged body.
g. Equal to Nibco F-910.

2.7 SAFETY AND RELIEF VALVES

A. General.

1. Constructed, rated, and stamped in accordance with Section IV of the ASME Boiler and Pressure Vessel Code.
2. Direct spring-loaded type.
3. Adjustable discharge pressure setting.
4. Bronze body and all wetted parts shall be non-ferrous.
5. Suitable and rated for system pressure and temperature.

B. Set pressures.

1. Set pressure as indicated on Drawings: Not to exceed pressure rating of protected equipment.
2. Valves to open, under test, at set pressure with following tolerance:

a. Set pressure up to 70 pounds per square inch gage: plus, or minus 2 pounds per square inch.
b. Set pressure, above 70 pounds per square inch gage: plus, or minus 3 percent.

C. Capacities.

1. Valves shall have capacity to relieve maximum possible generated energy while maintaining pressure in protected equipment at no more than 10 percent above vessel working pressure.
2. Greater than make-up pressure reducing valve capacity.
3. Equipment relief valve capacity to exceed rating of connected equipment.
4. For boiler relief valves, the valve shall have a BTU/h rating in excess of the BTU/h rating of the boiler's heating output.
5. Provide multiple valves if required for capacity even though only one valve may be shown on Drawings.

D. Maintain pressure in protected equipment at not more than the following:

1. Low pressure Boilers: 5 pounds per square inch above boiler working pressure.
2. High pressure Boilers: 6 percent above boiler working pressure.
3. Unfired Pressure Vessels: 10 percent above vessel working pressure.

E. Safety and Relief Valves: Equal to Consolidated.

F. Relief Valves, Water: Equal to Watts.

2.8 VENT AND GAUGE COCKS

A. Bronze body, 1/4-inch size.

B. Lever handle.

C. 125 pounds per square inch steam working pressure.

D. Equal to Weiss LC-14.

2.9 MANUAL AIR VENTS

A. Construction.

1. Vertical.
2. Provide 1/4-inch brass needle valve at top of chamber.
3. To 3-inch pipe: Line size air chamber, 12 inch long.
4. 4 inch to 8 inch: Line size air chamber, 6 inch long.
5. 10 inch and larger: Line size pipe cap.

2.10 AUTOMATIC AIR VENTS

A. Float type.

1. With isolating valve.
2. Brass or semi-steel body.
3. Float copper or stainless steel.
4. Stainless steel valve and valve seat.
5. Suitable for system operating temperature and pressure.
6. Non-opening on negative pressure.
7. Equal to Thrush/Amtrol No. 720.

B. Disc type.

1. All brass with hydroscopic fiber discs.
2. Vent ports.
3. Adjustable cap for manual shut-off.
4. Integral spring-loaded ball check valve.
5. Equal to Dole.

C. Threaded vent connection for piping vent to drain.

D. Upstream ball valve for isolation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate with work of other trades.

B. Install valves in accordance with manufacturer's written installation instructions.

C. Provide valves as shown on drawings and provide shutoff valves around all equipment whether shown with valves on drawings or not.

D. Provide all valves (except control valves), strainers, and check valves of same size as the pipes in which they are installed unless otherwise indicated.

E. Pressure rating of valves same as piping in which installed.

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

G. Install valves with cast directional arrows in direction of flow.

H. Support line valves at the valve in addition to regularly spaced pipe supports shown and specified.

I. Check valves:

1. Provide silent check valves at discharge of pumps. Triple duty valves shall not be used as a substitution for check and shut-off valve.
2. Install swing checks and gravity closing lift checks in horizontal position.

J. Butterfly valves:

1. Piping adjacent to lug type shall be flange removable while valve is in use.

K. Control valves:

1. See Section 230923 – EMCS Basic Materials and Devices for valve specifications.
2. Install so that actuators, wiring, and tubing connections are accessible for maintenance. Where the actuator top and position indicator are below 5 feet above the floor, install with valve stem axis vertical with actuator side up. Otherwise, valves shall be installed with stem horizontal so that the position indicator is visible from the floor. Do not install valves with stem below horizontal or down.

L. Provide blow-down ball valves and hose adaptors with caps at strainers, air separators, tanks, pipe traps, equipment drains, etc. of same size as strainer blow-off connection.

M. Provide drain valves at main shut-off valves, low points of piping and apparatus.

N. Provide extended valve stems to clear insulation on insulated valves.

O. Locate wheel handles to clear obstructions with hand.

P. Install valves only in accessible locations.

Q. Wherever possible, install valves accessible from floor level. Provide guided chain operators on valves over 7 feet above floor in equipment areas. Extend chains to within 6 feet 6 inches of floor.

R. Locate equipment shut-off valves to be accessible without climbing over equipment.

S. Provide operating handles for all valves and cocks without integral operators, unless otherwise noted. Provide adequate clearance for easy operation.

T. Provide discharge pipe to atmosphere from all relief and safety valves, sized with area equal to sum of outlet areas of all valves connected thereto, unless indicated larger. Extend to over code compliant drain receptacle with airgap.

U. Provide ball valves to isolate shock absorbers/water hammer arrestors.

V. Provide open-ended line valves with plugs or blind flanges.

3.2 VALVE APPLICATIONS

A. Valves shall be limited to the applications listed below. Where this section disagrees with drawings, obtain clarification from Architect, and provide as directed by the Architect at no additional cost to the Owner.

B. Ball valves:

1. Throttling and shut-off: water.
2. Use in HVAC, domestic water, and general fire protection piping 2-1/2 inches and smaller.

C. Butterfly valves:

1. Throttling and shut-off: water.
2. Use in HVAC, domestic water, and general fire protection piping 3 inches and larger.

3.3 AIR VENTS

A. Manual air vents.

1. Locate:

a. As shown on drawings.
b. At all high points in closed piping systems.
c. At equipment with vents, such as coils.

2. 1/4-inch copper tube discharged into nearest drain or with 180-degree bend to discharge into portable container.
3. Extend tubing or piping as required to make valve accessible.

B. Automatic air vents.

1. Locate:

a. As shown on drawings.

2. Provide manual cock at automatic air vents. Shut after system is free of air.
3. 1/4-inch copper tube discharged into nearest drain.

3.4 FIELD QUALITY CONTROL

A. Test operate valves from closed-to-open-to-closed position while valve is under test pressure.

B. Test automatic valves including solenoid valves, expansion valves, water regulating valves, pressure reducing valves, pressure relief valves, safety valves and temperature and pressure relief valves for proper operation at settings indicated.

C. Ensure that valves are field checked for packing and lubricant and that disc is for service intended. Replace leaking packing at no additional cost to the Owner. Service valves which do not operate smoothly and properly with suitable lubricant before placing in operation at no additional cost to the Owner.

3.5 INSPECTION & COMPLETION

A. Verify that adequate clearance between valves and adjacent walls or equipment is available to permit maintenance and repairs.

B. Verify valve set for normal operation.

C. Valves tags: See Section 230553 – Mechanical Identification.

D. See Section 230593 – Testing, Adjusting and Balancing for HVAC.

END OF SECTION 230523

SECTION 230529 - HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Equipment supports.

B. Related Sections:

1. Division 22 – Plumbing Work.

1.3 REFERENCE STANDARDS

A. American Society of Mechanical Engineers: ASME Section VIII – Boiler and Pressure Vessel Code – Pressure Vessels.

B. Pipe Supports: ANSI B31.1, Power Piping.

C. Duct Hangers: SMACNA Duct Manuals.

1.4 DEFINITIONS

A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

B. Terminology: As defined in MSS SP-90, “Guidelines on Terminology for Pipe Hangers and Supports”.

1.5 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. “R” means required.

2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Pipe hangers and supports	R	R		R
Structural attachments	R			R
Pipe protection and thermal hanger shields	R	R		R
Equipment supports	R			R
Expansion shields	R			
Welding certificates	R			

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Hangers, Inserts and Supports.

1. Unistrut.
2. Superstrut.
3. B-Line Systems.
4. Or equal.

C. Pipe Protection and Thermal Hanger Shields.

1. Pipe Shields, Inc.
2. Elcen Metal Products Company
3. Superstrut.
4. Or equal.

D. Expansion Shields.

1. Hilti Fastening Systems.
2. ITT Phillips Drill Co.: Red Head.
3. Omark Industries, Inc.
4. Or equal.

E. Pipe Stand Supports.

1. B-Line Systems, Inc.
2. Grinnell Corp.
3. PHD Manufacturing, Inc.
4. Or equal.

F. Powder-Actuated Fastener Systems.

1. Hilti Fastening Systems.

2. ITW Ramset/Red Head.
3. MasterSet Fastening Systems, Inc.
4. Or equal.

G. Insulation Protectors.

1. B-Line Systems, Inc.
2. ITT Grinnell Corporation.
3. PHD Manufacturing, Inc.
4. Or equal.

H. Pipe Supports at Grade.

1. MiFab.
2. B-Line Systems, Inc.
3. Miro.
4. Or equal

I. Miscellaneous Devices.

1. Kopty.
2. Wejit.
3. Or equal.

2.2 PIPE HANGERS AND SUPPORTS

A. Model numbers are Superstrut, unless otherwise indicated.

B. Provide electro-chromate, galvanized or factory painted finish; no plain, "black" hangers allowed.

C. Dielectric Isolators: All uninsulated copper tubing systems; Superstrut isolators or equal, Cush-A-Strip or Cush-A-Clamp on all pipe clamps; for individual hangers, use felt lined hangers.

D. Individual Pipe Hangers.

1. Cold pipe all sizes: Clevis hanger, No. C710.
2. Hot pipe sizes up to 4 in: Clevis hanger, No. C710.
3. Hot pipe sizes above 6 in: Adjustable steel yoke and cast iron, roll No. C729.

E. Multiple or Trapeze Hangers.

1. Factory channel.

a. 12-gauge thick steel.
b. Single or double section.
c. Electro-chromate finish.
d. Strutnuts: Series A-100 or CM-100.
e. Straps: Series 702.
f. No. A-1200 or A-1202.

2. Hot pipe sizes 6 in and larger: cast iron roll and stand; C728 or CR728.

F. Wall Supports.

1. Pipe sizes up to 3 in: Steel bracket No. C738.
2. Pipe sizes 4 in and larger: Welded steel bracket C-735.
3. Hot pipe sizes 6 inches and larger.

    a. Welded steel bracket No. C739.
    b. Adjustable steel yoke and cast iron, roller No.C729.

G. Vertical Support.

1. Riser clamp Series C-720.

H. Floor Support.

1. Hot pipe sizes up to 4 inch; cold pipe, all sizes.

    a. Adjustable cast iron saddle No. R786.
    b. Locknut nipple.
    c. Floor flange.

2. Hot pipe sizes 6 in and larger: Adjustable cast iron roll and stand No. R-730-C.

I. Thermal Hanger Shields (for insulated pipe supports).

1. 180-degree high density insert.

    a. 100 psi waterproofed cellular glass, asbestos-free, K=0.38, encased in a 360-degree galvanized sheet metal shield, ASTM A653.
    b. See Section 230719 Piping Insulation.
    c. Same thickness as adjoining pipe insulation.

2. 180-degree galvanized sheet metal shield (inverted saddle).

    a. Shield length and gauges.

Pipe Size	Shield Length	Minimum Gauge
1/2-1 1/2	4	26
2 - 6	6	20
8 - 10	9	16

3. Insert to extend one inch beyond metal shield ends on insulated piping.
4. Use double layer shield on bearing surface for:

    a. Roller hangers.
    b. Support spacing exceeding 10 feet.

J. Pipe Isolators.

1. Hanger with felt padding.
2. Tolco Fig. 3F or equal felt lined hangers.

K. Anchors and Guides: Provide anchors and guides where indicated on the Drawings and as required. Structural inserts shall be high density cellular glass. Guide slide pads shall be Teflon. Ensure that slide accommodates pipe movement over full range of service and out-of-service temperatures. Guides shall be Pipe Shields, Inc. Model #B3000 or equal. Anchors shall be Pipe Shields, Inc. Model #C4000 or equal. See Section 230719 Piping and Equipment Insulation.

L. Insulated Pipe Strap.

1. 1/2 in to 1 in plumbing piping in wood frame construction.
2. Felt insulated.
3. Kopty or equal.

M. Escutcheons: See Section 230500 – Basic Mechanical Materials and Methods.

N. Flashing and Sleeves.

1. Flashings.

a. See Division 7 – Thermal and Moisture Protection.
b. Flash and counter flash watertight all pipe and duct penetrations of roofs and exterior walls.
c. Flash pipes through roofs with ITWBuildex Dektite or equal.
d. Flash vents through roofs with.

1) Minimum 24-gauge soldered roof jack for flat surface roofs.
2) Minimum 4-pound lead soldered roof jack for roofs other than flat surface roofs.
3) Vandal caps.
4) Provide counter-flashing sleeves and storm collars.
5) Caulk counterflashing and storm collar weather tight.
6) Other flashings shall be minimum 24-gauge galvanized sheet metal.

2. Sleeves.

a. See 230500 – Basic Mechanical Materials and Methods.

b. For insulated piping, sleeve diameter shall not be less than diameter of insulation.

c. Terminate sleeves flush with walls, and ceiling.

d. For exposed vertical pipe, extend sleeves 1 inch above finished floor except where escutcheons are required.

e. Packing through fire rated partitions one of following.

1) 3M Penetration Sealing Systems (PSS 7909) and 3M Fire Barrier Caulk and Putty.
2) Dow-Corning LTV Silicone foam.
3) Or equal.

3. Separate piping through walls, other than concrete walls, from contact with wall construction materials; use non-hardening caulking.

4. Install insulation on piping in walls which require insulation at time of installation.

2.3 DUCT HANGERS AND SUPPORTS

A. See Section 233113 – Metal Ducts.

2.4 STRUCTURAL ATTACHMENTS

A. Model Numbers are Superstrut, unless otherwise indicated.

B. All components shall have galvanized or equal finish.

C. Anchor Bolts: Size as specified for hanger rods.

D. Concrete Inserts.

1. Malleable iron.
2. Place reinforcing steel through insert as recommended by manufacturer for recommended loads.
3. No. 452 or equal.

E. Beam Clamps.

1. All with U-568 safety strap.
2. All with locknuts on.

    a. Set Screw.
    b. Hanger rod.

3. Bottom flange attachment.

    a. Loading 150-pound and less: U-563.
    b. Loading 150-pound to 300-pound: U-562.
    c. Loading more than 300-pound: U-560.

4. Top flange attachment.

    a. Permitted only when bottom flange attachment cannot be used.
    b. Loading 400-pound and less: M-777.
    c. Loading more than 400-pound: M-778.

F. Welded Beam Attachments: No. C-780 or equal.

G. Side Beam Attachments: No. 542 or equal.

H. Hanger Rods.

1. ASTM A575 Hot rolled steel, galvanized.
2. ANSI B1.1 Unified Inch Screw Treads.
3. Threaded both ends, threaded one end, or continuous threaded.

I. Hanger Rod Fixtures.

1. Turnbuckles: No. F-112 or equal.
2. Linked Eye Rod.

    a. Rod swivel.
    b. No. E-131 or equal.

3. Clevis: No. F-111 or equal.

J. Powder or Gas Actuated Anchors.

1. Not allowed on initial building construction; allowed only for revisions made after initial construction and with approval of Owner.
2. Hardened steel stud with threaded shank; size of shank to match hanger rod size.
3. Use only with non-shock loads.
4. Maximum load safety factors:

    a. Maximum anchor load: 100 pounds.
    b. Static loads – 5.
    c. Vibratory loads - 8-10.

5. For concrete and steel, not to be used for light weight concrete, brick or concrete block.
6. 10% testing rate required, testing by contractor.
7. Omark Drivit or equal.

K. Expansion Shields.

1. Carbon-steel anchors, zinc coated.
2. Stainless steel for corrosive atmospheres.
3. For normal concrete use.

    a. Self-drilling anchor.
    b. Sleeve anchor.
    c. Stud anchor.

4. For thin concrete use: wedge anchor.
5. For brick or concrete block use: sleeve anchor.
6. Maximum load safety factors.

    a. Static loads – 4.
    b. Vibratory loads - 8 – 10.
    c. Shock loads - 8 – 10.

7. Size to suit hanger rods.
8. ITT Phillips Red Head or equal.

L. Steel Deck Inserts.

1. Factory stud with.

    a. Clip.
    b. Spring.
    c. Coupling.

2. ITT Phillips Red-Head or equal.

M. Miscellaneous Metal.

1. Steel plate, shapes, and bars: ASTM A36.
2. Steel pipe columns: ASTM A53, Schedule 40, black.
3. Bolts and nuts: regular hexagon-head type, ASTM A307, Grade A.
4. Lag bolts: square head type, Fed. Spec. FF-B-561.
5. Plain washers: round, carbon steel, Fed. Spec. FF-W.92.

2.5 PIPE SUPPORTS AT GRADE

A. All piping HVAC, plumbing, gas, etc. located at grade shall be supported utilizing the following pipe supports.

B. Widebody rubber support base.

C. Materials:

1. Base: 100% recycled rubber, UV resistant.
2. Channel: 14-gauge galvanized steel (1-5/8-inch-wide x 1-5/8-inch high).
3. Rods: Two 1/2-inch electro zinc plated all threaded rod risers.

D. Maximum load: 800 lbs. for each 9.6-inch-long support.

E. Include strut clamp on condensate drain piping.

F. Include roller provisions on gas piping.

G. Sized appropriately for the quantity of piping being supported.

H. Gas Piping Supports: Mifab CR10/CRE10, Miro Model #4-RAH or approved equal.

I. Condensate Pipe Supports: Erico/Caddy Pyramid 50/TCC cushion clamp, or similar by Mifab, or approved equal.

2.6 MISCELLANEOUS MATERIALS

A. Powder-Actuated Drive-Pin Fasteners: Powder-actuated-type, drive-pin attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

C. Structural Steel: ASTM A36/A36M, steel plates, shapes, and bars, black and galvanized.

D. Concrete: Normal weight concrete (145 pcf) using Type I Portland Cement, 1" maximum size coarse aggregate to provide a minimum 28-day compressive strength of 3000 psi.

E. Grout: ASTM C1107, Grade B, factory-mixed and -packaged, non-shrink and nonmetallic, dry, hydraulic-cement grout.

1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.
2. Properties: Non-staining, noncorrosive, and nongaseous.
3. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 PIPE HANGERS, SUPPORTS AND GUIDES

A. General.

1. Assure adequate support for pipe and contents.
2. Provide adjustable hangers for all pipes complete with inserts, adjusters, bolts, nuts, swivels, all-thread rods, etc., except where specified otherwise.
3. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers where possible. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping and do not support piping from other piping.
4. Except as otherwise indicated for exposed continuous pipe runs, install hangers, and supports of same type and style as installed for adjacent similar piping.
5. Install all cast iron piping in accordance with Cast Iron Soil Pipe Industry (CISPI) Standards.
6. Support all piping within 2 feet of each change of direction on both sides of fitting.
7. Thermal hanger shields shall be provided at hangers and supports where piping is insulated.
8. Prevent vibration or swaying.
9. Provide for expansion and contraction.
10. Supports of wire, rope, wood, chain, strap perforated bar or any other makeshift device not permitted.
11. Comply with applicable requirements at ANSI B31.1 and B31.2 for piping.
12. Support piping independently so that equipment is not stressed by piping weight or expansion.
13. Hangers and supports shall have minimum safety factor of five (5), based on ultimate tensile or compressive strength, as applicable, of material used, base calculations on equipment's heaviest operating weight and pipes full of water.
14. Install additional supports or braces if, during normal operation, piping should sway, crawl or vibrate. Piping shall be immobile.
15. Install thrust blocks as required to prevent sway.

B. Horizontal piping, except as noted.

1. Adjustable clevis type and rod; all services at or below 250 degrees F.
2. Rollers or slide bases: not required.
3. Trapeze hangers; guide individual pipes on trapezes with 1/4-inch U-bolt or Superstrut 702 pipe clamp.

    a. Install thermal hanger shield at each support point.

4. Galvanized sheet metal shields between hangers and PVC piping.
5. Threaded steel rods.

    a. 2-inch vertical adjustment with 2 nuts each end for positioning and locking.
    b. Size to 12-inch inside pipe size (IPS).

Pipe, IPS	Rod
to 2 inch	3/8 inch
2-1/2 inch and 3 inch	1/2 inch
4 inch	5/8 inch
6 inch and 8 inch	3/4 inch
10 inch and 12 inch	7/8 inch
14 inch and 18 inch	1 inch
20 inch and 30 inch	1-1/4 inch

    c. Size above 12-inch IPS and multiple pipe standards: safety factor of 5 on ultimate strength on area.

d. For double rod hangers: 1 size smaller than above.

C. Vertical piping.

1. Base support.

a. Base elbow or welded equivalent.
b. Bearing plate on structural support.

2. Guides.

a. At every third floor but not to exceed.

1) 25 feet for piping to 2-inch.
2) 36 feet for piping 2-1/2 inch to 12-inch.
3) 50 feet for piping 14 inch and larger.

b. Or as otherwise designed by the Vibration Isolation vendor.

3. Top support.

a. Special hanger or saddle in horizontal connection.
b. Provisions for expansion.

4. Intermediate supports: steel pipe clamp at floor.

a. Bolted and welded to pipe.
b. Extension ends bearing on structural steel or bearing plates.

5. For multiple pipes: coordinate guides, bearing plates and accessory steel.

D. Horizontal insulated piping.

1. Install saddles for rollers or slide bases.
2. Install thermal hanger shields for all other types of supports.
3. See Section 230719 Piping and Equipment Insulation for insulation connection to shields.

E. Vertical insulated piping.

1. Install thermal hanger shields at guides.
2. See Section 230719 Piping and Equipment Insulation for insulation connection to shields.

F. Install Pipe Isolators between hangers and piping for all uninsulated copper tubing.

G. Miscellaneous Steel.

1. Provide miscellaneous steel members, beams, brackets, etc., for support of work in this division unless specifically included in other divisions.

H. Fire-stopping.

1. At pipe penetrations through rated assemblies.
2. Commercial pipe sleeve assemblies that are UL listed and that have been approved by the fire marshal for this purpose.

I. Roof pipe supports shall be installed per manufacturer's recommendations in coordination with the roofing system and company holding the roof warranty.

3.2 PIPE SUPPORT SPACING

A. Maximum spacing for horizontal piping.

Type of Pipe	Size	MAXIMUM SPACING
Copper	3/4 inch and smaller	5 feet
	1- 1-1/4 inch	6 feet
	1-1/2 - 3 inch	8 feet
	4 inch and larger	10 feet
Plastic	3/4 inch and smaller	3 feet
	1" – 1-1/2"	6 feet
	1-1-1/4 inches	6 feet
	1½″-3″	8 feet
	4 inch and larger	10 feet

B. Spacing Notes: Additional supports at:

1. Changes in direction.
2. Branch piping and runouts over 5 feet.
3. Concentrated loads due to valves, strainers, and other similar items.
4. At valves 4 inch and larger in horizontal piping, support piping on each side of valve.

C. Parallel piping on trapezes.

1. Maximum spacing to be that of pipe requiring closest spacing.

3.3 ATTACHMENT TO STRUCTURE

A. Concrete.

1. Use inserts for suspending hangers from reinforced concrete slabs, walls, and sides of reinforced concrete beams wherever practicable.
2. Set inserts in position in advance of concrete work.
3. Provide reinforcement rod in concrete for inserts carrying.

    a. Pipe over 4-inch.
    b. Ducts over 60 inches wide.

4. Where concrete slabs form finished ceiling, finish inserts flush with slab surface.
5. Where inserts are omitted, install hangers with expansion shields.
6. Through-deck support.

    a. Drill through concrete slab from below.
    b. Provide rod with recessed square steel plate and nut above slab.

7. Where permitted by Owner and only for revisions made after initial construction, powder actuated anchors or expansion shields may be used in lieu of inserts.

a. In bottom of thick slabs.
b. In thin slab construction, only in sides of beams.

8. Pre-Cast Concrete.

a. Use pre-set inserts.
b. Where inserts are not available, field drill through beam or joists at locations as directed by Architect.
c. Through bolt side beam bracket to beam or joist.

9. Poured-In-Place Concrete.

a. With metal form or underdeck.
b. Before concrete is poured.

1) Field drill hole through metal deck.
2) Provide bearing plate, nut, and locknut on rod; or install factory-made steel deck inserts specified hereinbefore.

c. After concrete is poured.

1) Install hangers with expansion shields.

B. Steel Beam Anchors.

1. Beam or channel clamps.
2. Do not cut or weld to structural steel without permission of structural engineer.

C. Steel Deck Anchors.

1. Concrete filled: as specified above.
2. Decking without concrete.

a. Through rod Support.

1) Weld to square plate, 1/4 in thick.
2) Plate to distribute load over minimum of two full cells.
3) Coordinate with floor layouts to clear cells with wiring.

D. Side Wall Supports.

1. Concrete walls: As specified for hangers.
2. Stud Walls.

a. Toggle bolts.
b. Stud welded to structural studs.

E. Support Spreaders.

1. Install spreaders spanning between structural members when hangers fall between them, and hanger load is too great for slab or deck attachment.
2. Spreaders may be one of methods listed below, or combination of both as required.

a. Fabricated from structural channel.

1) End fittings bolted or welded.
2) Secure to structural members.

a) As required by construction.
b) As reviewed by Structural Engineer.

b. Formed channels with fittings, Superstrut or equal.

1) Submit manufacturer's calculations for installation.

3.4 DUCT HANGERS AND SUPPORTS

1. See Section 233113 Metal Ducts.

3.5 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure above or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and floor pipe supports. Finish shall provide a smooth bearing surface.

3.6 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes and equipment supports.

B. Fit exposed connections together to form hairline joints. Field-weld connections that cannot be shop-welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.7 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.8 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 230529

SECTION 230553 – MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Equipment nameplates.
2. Access panel and door markers.
3. Pipe markers.
4. Duct markers.
5. Valve tags.
6. Valve schedules.
7. Warning tags.

1.3 REFERENCE STANDARDS

A. Pipe marker shall comply with ANSI A13-1.

1.4 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Pipe markers	R		R	
Duct markers	R		R	
Equipment tags	R		R	
Valve tags	R		R	
Concealed equipment markers	R		R	
Equipment label and valve tag schedule		R		
Valve numbering scheme		R		
Valve schedules	R	R	R	

1.5 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.

1.6 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with location of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

1. Brimar Industries, Inc.
2. Seton Identification Products.
3. Marking Services, Inc.

2.2 EQUIPMENT IDENTIFICATION DEVICES

A. Equipment Labels:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: White.
3. Background Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: Principal lettering shall be 1/2 inch. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
9. Label Content: Include equipment's Drawing designation or unique equipment number, serial number, drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

B. Warranty Label:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: White.

3. Background Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg. F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: Principal lettering shall be 1/2 inch. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
9. Label Content: Include warranty information including start date, end of parts and labor warranty date, contact name and contact number. Coordinate information with professional and end user before making labels.

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

2.3 ACCESS PANEL AND DOOR MARKERS

A. Access panel and access door markers:

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

B. Label access panels and access doors identifying “Fire Damper, Fire/Smoke Damper”, etc.

2.4 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

1. Colors: Comply with ASME A13.1, unless otherwise indicated.
2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
3. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers extending 360 degrees around pipe at each location.
4. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or shaped pipe markers at least three times letter height and of length required for label.

B. Pretensioned Pipe Labels: Pre-coiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Shaped Pipe Markers: Preformed semirigid plastic formed to partially cover circumference of pipe and to attach to pipe with mechanical fasteners that do not penetrate insulation vapor barrier.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

2.5 DUCT LABELS

A. Not required.

2.6 VALVE TAGS

A. Valve Tags: Numbering scheme approved by Architect.

1. General: Identify valves with metal tags, legends to be stamped or embossed. It shall indicate the function of the valve and its normal operating position, such as:

a. “56 HW” (NUMBER AND CONTENT OF PIPE)
b. “ISOLATION” (VALVE FUNCTION)
c. “NC” (NORMALLY CLOSED)

B. Description: 2-inch diameter, stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass beaded chain or S-hook.
3. Automatic Valves and Regulating Valves: Use 1/16-inch thick laminated 3-ply plastic, center ply white, outer ply red, “lamicoid” or equal. Form letters by exposing center ply.
4. Valve Tag Directory: Include tag number, location, exposed or concealed, service, valve size, valve manufacturer, valve model number, tag material, and normal operating position of valve.

C. Valve Schedules: For each piping system, on plastic laminated, standard-size bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Include floor plan location drawing with all valves indicated with the valve tag assigned to each valve. Mark valves for emergency shutoff and similar special uses.

1. Valve-Schedule and Valve Floor Plan Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.
2. Frame: Extruded aluminum.
3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment (including motor starters, VFDs, control panels, etc.)

B. Locate equipment labels where accessible and visible.

C. Install access panel markers with screws on equipment access panels.

3.4 PIPE LABEL INSTALLATION

A. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Within 18” of each valve, valve assembly and control device.
2. Within 3’ of each 90-degree elbow, connection to equipment or vessel and where pipe enters shafts and penetrates outside walls, floors, ceilings, and non-accessible enclosures.
3. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
4. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
5. At access doors, manholes, and similar access points that permit view of concealed piping.
6. Near major equipment items and other points of origination and termination.
7. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
8. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

C. For VRF piping, pipe labels to be as follows:

1. Labels to be placed in strict accordance with Pipe Label Locations above.

2. All piping to be labeled as indicated on manufactures literature and product information.

   a. Example is RL for liquid line, RG for gas line, RLPV for low pressure vapor, RHPV for high pressure vapor, etc.

3. Heat Recovery Units

   a. Piping from Outdoor Unit to Branch Selector to read “FROM ODU-1 TO BS-1” on all piping.
   b. Piping from Branch Selector/Heat Recover Unit to read “FROM BS-1 TO IDU-1.1” all piping.

4. Heat Pump Units

   a. Piping on main branch lines to read “FROM ODU-1”
   b. Piping on branch lines (after Y-Branches) to read “FROM ODU-1 TO IDU-1.1”

D. Pipe Label Color Schedule:

Service	Pipe marker	Background color	Lettering
Chilled water	Chilled water supply	Green	White
	Chilled water return	Green	White
Heating water	Heating water supply	Yellow	Black
	Heating water return	Yellow	Black
Refrigerant Gas	RG	Orange	Black
Refrigerant Liquid	RL	Orange	Black
Refrigerant High-Pressure Vapor	RHPV	Orange	Black
Refrigerant Low Pressure Vapor	RLPV	Orange	Black
Natural gas	Natural gas	Yellow	Black
Cold water	Domestic cold water	Green	White
Hot water	Domestic hot water supply	Yellow	White
	Domestic hot water return	Yellow	White
Sanitary waste	Sanitary waste	Green	White
Condensate drain	Condensate drain	Green	White
Vent	Vent	Green	White

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape: 1-1/2 inches, round.
2. Valve-Tag Colors:

   a. Toxic and Corrosive Fluids: Black letters on a safety-orange background.

b. Flammable Fluids: Black letters on a safety-yellow background.
c. Combustible Fluids: White letters on a safety-brown background.
d. Potable and Chilled Water: White letters on a safety-green background.
e. Hot and Heating Water: White letters on a safety-orange background.
f. Defined by User: White letters on a safety-purple background, black letters on a safety-white background, white letters on a safety-gray background, and white letters on a safety-black background

3.6 VALVE SCHEDULE INSTALLATION

A. Mount valve schedule on wall in accessible location in each major equipment room.

3.7 ADJUSTING

A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

3.8 CLEANING

A. Clean faces of mechanical identification devices and glass frames of valve schedules.

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING

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. Balancing Air Systems:

a. Operational testing and adjusting of air handling equipment.
b. Balancing of air distribution systems.
c. Testing and adjustment of air terminal devices.

2. Balancing HVAC Hydronic Piping Systems:

a. Flow testing and adjusting of hydronic systems.

3. Testing, adjusting, and balancing existing systems and equipment.
4. Witnessing and certification of duct air leakage tests.
5. Control system verification.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. BAS: Building automation systems.

C. NEBB: National Environmental Balancing Bureau.

D. TAB: Testing, adjusting, and balancing.

E. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

F. TDH: Total dynamic head.

1.4 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. “R” means required.

2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
AABC or NEBB certification	R			
Report forms	R			
List of instrumentation	R			
Final hydronic water balancing report		R		
Final air balancing report		R		
Final air balancing report		R		

C. Final Test & Balance Report.

1. At least 15 days prior to Contractor’s request for final inspection, submit electronic copy of final reports on approved reporting forms, and certifications for review and approval by Architect. Once approved, provide required quantity of paper and electronic copies per 230010 “Mechanical General Provisions.”
2. Form of final reports.

    a. Fully completed report forms for all systems specified to be tested and balanced including at a minimum all data specified herein to be recorded.
    b. Each individual final reporting form must bear:
    c. Identify instruments of all types that were used and last date of calibration of each.
    d. Certifications.

1.5 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Certified by AABC or NEBB.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC or NEBB.

B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

C. Prior to start of testing, adjusting, and balancing, verify that required Project conditions are met:

1. System and control system installation is complete and in full operation.
2. All pre-functional tests have been performed.
3. Equipment has been started and tested in accordance with manufacturer’s installation instructions.
4. Doors and windows are in place and closed or under normal traffic conditions.
5. Proper clean air filters are in place.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

E. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.6 PROJECT REVIEW

A. Construction Review.

1. Make on-site visits during progress of construction: Number and timing of visits to be as required to perform the functions specified below.
2. Purpose of review.

a. Identify potential problem for performing total system balance.
b. Identify modifications that will affect air total system balance.
c. Schedule and coordinate total system balance with other work.
d. Identify conditions that could create hazardous environment for building occupants.

3. Typical activities.

a. Check that necessary balancing and measuring hardware is:

1) In place.
2) Located properly and accessibly.
3) Installed correctly.

b. Identify and evaluate variations from system design.
c. Record data from equipment nameplates.
d. Identify and report possible restrictions in systems, such as:

1) Closed fire dampers.
2) Long runs of flexible duct.
3) Poorly designed duct fittings.
4) Questionable piping connections.
5) Others as may arise or based on Agency’s experience.

e. Verify that construction progress will not delay total and/or phased project system balance.
f. Identify best location for duct Pitot tube traverses.
g. Identify scaffolding and other access needs.

1.7 FIELD CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Verify and coordinate TAB activities on projects with phased sequences requirements.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified herein. If not otherwise noted, the following minimum requirements apply.

1. Voltmeter: plus, or minus 1 percent scale.
2. Ammeter: plus, or minus 1 percent scale.
3. Ohmmeter: plus, or minus 0.1 percent scale for calibrating plus or minus 0.4 degrees Fahrenheit resistance temperature sensors, plus or minus 0.25 percent scale for calibrating plus or minus 1 degrees Fahrenheit temperature sensors, plus or minus 1 percent scale for measuring motor current.
4. Ultrasonic time-of-travel strap-on flow sensor: plus, or minus 5 percent of reading.
5. Other flow sensors: plus, or minus 2 percent of reading.
6. Water pressure gauge: plus, or minus1/2 percent scale, ASME Grade 2A.
7. Watt meter, plus, or minus1/2 percent scale: 3 phase split core current transducers.
8. Temperature: plus, or minus 0.4 degrees Fahrenheit.
9. Calibrated balance valve manufacturer's test kit and required instrumentation.

B. All equipment shall be calibrated within 6 months of use, or according to the manufacturer's recommended interval, whichever is shorter, and when dropped or damaged. Calibration tags shall be affixed or certificates readily available and proof of calibration shall be included reports.

PART 3 - EXECUTION

3.1 GENERAL

A. Coordinate with work of other trades.

B. Report to Professional any discrepancies or items not installed in accordance with the Contract Drawings pertaining to proper balance and operation of air and water distribution systems.

C. Perform testing, adjusting, and balancing in accordance with AABC or NEBB standards.

D. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to Section 230713 "Duct Insulation" and Section 230719 "Piping and Equipment Insulation.".

E. Mark equipment settings with paint or other suitable, permanent identification material, including damper control positions, valve indicators, and similar controls and devices, to show final settings.

3.2 CONTROL SYSTEM COORDINATION

A. See Section 230900 "Energy Management & Control Systems (EMCS)."

B. System balance techniques in this Section rely on the operation of the EMCS. Test and balance agency shall coordinate schedule of work with EMCS installer to ensure test and balance work can be executed and completed in a timely manner.

C. Cooperate with EMCS installer in determining operating conditions and setpoints, as indicated in this Section.

D. Cooperate with EMCS installer in calibrating all airflow measuring devices.

E. Obtain and receive training for required software from controls system vendor for setting calibration constants in terminal devices.

F. Test and balance is responsible for ensuring all thermostats are programmed per Owners schedule with proper setpoints.

3.3 AIR SYSTEMS BALANCING

A. General.

1. Do not operate fan systems for test or balance until spaces served have been cleaned of dust and debris, to avoid contamination of supply air or return air paths and equipment.
2. Filters.

    a. Check that proper specified filters are installed, oriented in the proper airflow direction, free of bypass, and clean.
    b. Make no adjustment for dirty filters, fans were selected for clean filters at design airflow.

3. In cooperation with EMCS installer, set adjustments of automatically operated dampers and valves to operate as indicated.
4. Balance hydronic systems prior to air balance and have operational during air balance for air temperature measurements.
5. Coordinate balancing of dampers for minimum ventilation.

B. Air Outlets.

1. Adjust diffusers' throw pattern, grilles and registers to pattern indicated on the Drawings. Review manufacturer's instructions for proper diffuser blade or weir gate positions to provide this throw pattern as it is not always intuitive. It is TAB agency's responsibility to adjust throw patterns for all adjustable throw diffusers. If diffuser has a fixed throw pattern and is incorrectly installed, HVAC contractor shall correct pattern prior to balance.

    a. Ceiling diffusers: As indicated on the Drawings.

        1) Star pattern diffuser deflectors shall be adjusted for corner blow pattern unless otherwise indicated on Drawings.

    b. Double-deflection grilles: Adjust rear blades horizontal 22 degree upward and splay front blades in 45-degree pattern at each end gradually rotating to almost straight at blades in center of grille.
    c. Floor grilles: Not applicable.

2. Test and adjust each diffuser, grille and register to within plus or minus 10 percent of design requirements.

    a. Start with all dampers wide open.
    b. Adjust dampers, starting with nearest to terminal unit or fan. Make adjustments using duct mounted volume dampers rather than dampers at diffuser face (if any) unless absolutely required.
    c. At least one damper shall remain wide open at end of balance.

3. Plenum return air grilles or slots in lights: No balance required.
4. Report.

a. Tag each grille, diffuser and register and mark tag on copy of floor plan.
b. For each grille, diffuser, and register, indicate tag, size, type, and effective area (where applicable).
c. Required velocity/cubic feet per minute.
d. Initially tested velocity/cubic feet per minute.
e. Finally tested cubic feet per minute after adjustments.

C. Terminal Boxes.

1. Balancing Agency shall provide laptop computer or other device for communicating with EMCS system, using software provided by EMCS installer. Cooperate with EMCS installer to learn how to use software to calibrate EMCS zone controller.
2. Terminal box calibration procedure listed below may be modified based on specific features or limitations of digital controller and recommendations of the controller manufacturer. Submit revised procedure for approval by Architect.
3. Use EMCS terminal “commissioning” software where available and record all calibration and test data through the EMCS.
4. Zero transmitter prior to each test.
5. Adjust EMCS calibration constants so that the VAV box controller and measured air flow rate at air outlets matches EMCS reading within range listed at all of the following conditions at a minimum:

    a. Zero airflow.
    b. Maximum airflow setpoint, ±5%.
    c. Minimum airflow setpoint, ±10%.

        1) If EMCS can only calibrate to one point, adjust VAV box controller minimum volume setpoint so that measured air flow rate at air outlets equals desired minimum, even though this will cause EMCS to read improperly.

6. Report:

    a. Tag, manufacturer, and model.
    b. VAV maximum cooling flow rate, design, and measured.
    c. VAV minimum flow rate, design, and measured.
    d. EMCS calibration coefficients at all calibration points.

D. EMCS airflow measuring stations (AFMS).

1. Measure and report airflow and concurrent EMCS AFMS readings at a minimum of three conditions.

2. For factory calibrated AFMS: if measured airflow and EMCS readings differ by more than 10%, consult with Architect for recalibration instructions. Do not change factory calibration without written direction.

3. For field calibrated AFMS: Work with EMCS installer to adjust calibration coefficients. Report coefficients in air balance report.

E. Air Handling Units, Blower Coil Units, Fan Coil Units, Packaged Equipment Air Flow Rate Readings.

1. Total supply air quantities shall be determined at all of the following where applicable:

    a. Pitot traverse in the supply duct downstream, positive pressure side of the fan.

b. Pitot traverse at coil or filter bank.
c. Totaling the readings of individual air outlets.
d. Totaling the readings of individual terminals as read through the EMCS.

2. Total return air quantities shall be determined at all of the following where applicable:

a. Pitot traverse in the return air duct or damper entering air handler.
b. Totaling the readings of individual air outlets if ducted return system.

3. Outside air quantities shall be determined by all of the following where applicable:

a. Subtracting pitot traverses of supply and return ducts.
b. Pitot traverse of outdoor air intake duct.
c. Outdoor airflow sensor reading as read through the EMCS.
d. Note: Balance by measurement of return air, outside air, and mixed air temperatures shall not be used due to inherent inaccuracy.

4. For systems with airflow measuring stations, measure airflow and coordinate with EMCS installer to calibrate airflow stations at a minimum of three conditions:

a. Design air flow.
b. 50 percent of design air flow.
c. Minimum air flow.

F. Variable Air Volume Air Handling Equipment.

1. Adjust fan speed using manual adjustment of variable speed drive for testing only. Do not change or adjust sheaves.
2. Supply fan DP Setpoint.

a. Establish maximum static pressure setpoint (DPmax) in conjunction with the EMCS installer as follows. All adjustments made via the EMCS, not field measurements except as noted.
b. Test conditions.

1) Set all boxes to operate at maximum airflow setpoints: allow controls to stabilize.
2) For cooling systems only to account for diversity: Shut off boxes, starting with boxes whose dampers are the most closed, as indicated by the EMCS, and upstream of the DP sensor, until the airflow equals scheduled design airflow rate.

c. Procedure.

1) Manually lower fan speed slowly while observing VAV box airflow rates downstream of the static pressure sensor. Stop lowering speed when one or more VAV box airflow rates drops 10 percent below maximum airflow rate setpoint.
2) Once flow condition in previous step is achieved, note the EMCS system static pressure reading at the duct static pressure sensor.

a) This reading becomes the maximum static pressure setpoint.
b) Using pressure taps at differential pressure sensor and handheld digital pressure sensor, verify accuracy of EMCS reading.

d. Convey to the EMCS installer.

1) Static pressure setpoints.
2) Any discrepancy between EMCS differential pressure reading and handheld measurement.

e. Report.

1) Static pressure setpoint and concurrent reading of handheld measurement: Initials of EMCS installer to indicate that the information was transmitted to them.
2) Tag of VAV boxes that dropped below design maximum airflow rate in tests above. These are the critical boxes, those requiring the largest static pressure.
3) Concurrent fan data.

a) Volts and amps.
b) Amps and kilowatts from VFD.
c) VFD speed in hertz.
d) Entering and leaving fan static pressure.
e) Flow rate, summed from EMCS terminals.
f) Fan airflow sensor reading from EMCS, where applicable.

3. Minimum outside air flow.

a. Supply air fan and return air fan (if any) shall first be operating at design airflow. For VAV systems with diversity, close enough boxes close to fan to reduce supply airflow to scheduled design condition.
b. For systems with outdoor airflow measuring stations:

1) See EMCS AFMS paragraph herein.

4. Test with system operating at design fan and minimum outside air flow conditions described above and record the following on a schematic of the system:

a. Tags of all equipment.
b. Manufacturer and model of fan and motor.
c. Motor horsepower, rpm, volts, phase, full load amps.
d. Sheave data at motor and fan; belt data.
e. Fan airflow rate at all locations measured, as listed above.
f. Final measured fan speed and amps.
g. Amps and kilowatts, from VFDs.
h. VFD speed in hertz.
i. Static pressures measured at:

1) Return air plenum.
2) Mixed air plenum.
3) Downstream of relief fan (where applicable).
4) Downstream of filter.
5) Downstream of coil.
6) Discharge of supply fans.
7) At static pressure sensor.

j. Concurrent airflow rate readings from EMCS airflow sensors, including sum of VAV box airflow rates.

k. Minimum EMCS outdoor air control setpoints and signals, where applicable.

G. Constant Volume Air Handling Units, Fan Coil Units, Package Equipment.

1. Total air quantities shall be obtained within 10 percent of design by adjustment of fan speed.

a. Adjust sheaves on fans with adjustable sheaves.
b. Change sheaves on fans with fixed sheaves.
c. Adjust speed potentiometer for EC motors.
d. Adjust SCR for direct drive PSC motors.

2. Test and adjust minimum outdoor air flow.

a. Supply air fan shall first be operating at design airflow.
b. For systems with economizers.

1) Open return air damper fully.
2) Adjust the outdoor air damper signal through the EMCS until the minimum outdoor airflow rate is achieved.
3) Convey this minimum signal to EMCS installer and note on air balance report.

c. For systems without economizers.

1) Adjust minimum outdoor air or return air damper balancing damper position or linkage to deliver design minimum outdoor airflow rate.
2) Clearly mark minimum damper position on damper housing.

3. Test with system operating at minimum outside air flow condition described above and record the following on a schematic of the system.

a. Tag.
b. Manufacturer and model of fan and motor.
c. Sheave data at motor and fan; belt data.
d. Motor horsepower, rpm, volts, phase, FLA.
e. Fan airflow rate at all locations measured, as listed above.
f. Final measured amps.
g. Static pressure measured at:

1) Return air plenum.
2) Mixed air plenum.
3) Downstream of filter.
4) Downstream of coil.
5) Discharge of fans.

h. Concurrent airflow rate readings from EMCS airflow sensors, where applicable.
i. Minimum EMCS outdoor air control signal, where applicable.

H. Constant Volume & Variable Volume Exhaust Fans.

1. See herein for air outlet balancing.
2. Total air quantities for fan shall be determined by both:

a. Pitot tube traverse of main ducts near the fan inlet, and.

b. Totaling the readings of individual air outlets (or inlets).

3. Total air quantities shall be obtained within 10 percent of design by adjustment of fan speed.

a. Constant speed fans:

1) Adjust sheaves on fans with adjustable sheaves.
2) Change sheaves on fans with fixed sheaves.
3) Adjust speed potentiometer for EC motors.

b. Variable speed fans:

1) Adjust maximum fan speed at ECM or VFD.

4. Report.

a. Tag.
b. Manufacturer and model of fan and motor.
c. Sheave data at motor and fan; belt data.
d. Motor horsepower, rpm, volts, phase, full load amps.
e. Fan airflow rate at all locations measured, as listed above.
f. Final measured amps.
g. Inlet and outlet static pressure.

3.4 HYDRONIC WATER SYSTEMS BALANCING

A. Prepare water systems for balancing in following manner.

1. Verify the following conditions:

a. Piping systems have been flushed and treated in accordance with Section 232113 “Hydronic Piping.”
b. Strainers have been cleaned.
c. Piping systems are completely full of water, all air properly vented.
d. All coil and heat exchanger isolation shut-off and balance valves are fully open.

2. Check Pump.

a. Rotation.
b. Pump factory impeller trimming by comparing shut-off heads with pump curves from approved submittals.

1) Note that impellers on variable speed pumps should not be trimmed to design flow and head conditions. See 232123 “Hydronic Pumps.”
2) Report discrepancy in shut-off head to Architect and if impeller does not appear to be properly trimmed, wait for direction before proceeding with pump test and balance.

3. EMCS and Central Plant Operability.

a. Do not proceed with any of the following balancing procedures until the EMCS is capable of operating equipment such as fans, pumps, VAV boxes, control valves, and the like, in manual and automatic modes and capable of reading sensors such

as differential pressure, flow rates, temperatures, and the like, of air and hydronic systems to be tested and adjusted.

b. Do not proceed with air handler and fan-coil testing until chilled and hot water at design temperatures are available from the central plant.

B. Pumps.

1. Test and report for each pump at test conditions indicated in Paragraphs below.

a. Tag.
b. Manufacturer and model of pump and motor.
c. Motor horsepower, volts, phase, full load amps.
d. Pump shut-off head from curves, measured shut-off head, and resulting impeller diameter from pump curve.
e. At test condition specified.

1) Volts and amps.
2) Calculated brake horsepower.
3) Entering and leaving gauge pressure and difference in feet.
4) Flow rate deduced from pump curve.
5) For pump with VFD:

a) Speed (Hz).
b) Kilowatts.

C. Heating Water and Chilled Water Distribution System.

1. Coil Test & Balance.

a. System is self-balancing. Two-way control valves at coils prevent each coil from being over-supplied with water, other than minor excursions during transients such as cool-down or warm-up. Conventional balancing (throttling of balancing valves) will increase pump energy use by not allowing aggressive differential pressure setpoint reset. Hence, do not adjust any valves on any coil or pump, except temporary adjustments where noted. Calibrated balancing valves may be provided for flow measurement and diagnostics, but they shall not be modulated for flow balancing. All manual valves at coils and pumps shall be wide open when test and balance work is complete.
b. Report with all control valves open to coil and all pumps (except standby pumps, where applicable) operating at full speed.

1) See Air Balance below for coil temperature data.
2) See Pump test data above for pump data.
3) Coils with modulating two-way or three-way control valves.

a) Terminal tag.
b) Control valve model number and serial number.
c) Pressure drop across coil.
d) Flow as measured by calibrated balancing valve (where applicable).

2. Variable Speed Drive Setpoint Determination.

a. For systems with VFD, determine maximum differential pressure setpoint (DPmax) in conjunction with the EMCS installer as follows:

1) Fully open all control valves serving coils that are located downstream of the differential pressure sensor.
2) Fully close all control valves serving coils that are located upstream of the differential pressure sensor.
3) Start pump(s). Manually adjust speed slowly until design flow (or design pressure drop, for coils without calibrated balance valves) is just achieved through all open coils without modulating any balance valves. One coil should be just at design flow, while others should be at or above design flow.
4) Once flow condition in previous step is achieved, note the EMCS system differential pressure reading at the differential pressure sensor. This reading becomes the differential pressure setpoint. Using pressure taps at differential pressure sensor and handheld digital pressure sensor, verify accuracy of EMCS reading.
5) If there are multiple differential pressure sensors, repeat steps above for each sensor.

b. Convey to the EMCS installer.

1) Differential pressure setpoint.
2) Any discrepancy between EMCS differential pressure reading and handheld measurement.

c. Report at condition described above.

1) Differential pressure setpoint and concurrent reading of handheld measurement. Initials of EMCS contractor to indicate that the information was transmitted to them.
2) Tag of coils downstream of differential pressure sensor, along with the following for each:

a) Design flow rate and pressure drop.
b) Tested flow rate and pressure drop with differential pressure at setpoint determined above.

3) Water flow rate through flow meter (where applicable), through EMCS.
4) See Pump test data above for pump data.

3. Control Valve Shut-Off Test.

a. Close all control valves in the system through the EMCS. Close bypass balance valves of 3-way valves (where applicable). Run all pumps (except stand-by pump, if any) at full speed:

1) Verify that all control valves remain shut with no measurable flow, as indicated by pump differential pressure, flow meters, and any temperature rise across coils.
2) Do not run pumps deadheaded for more than 5-minutes at any one time.
3) After test, return 3-way valve balance valves to prior position and release control valves to automatic operation through the EMCS.

b. Report at condition described above.

1) Tag of coils where flow is detected. Initials of EMCS contractor to indicate that this information was transmitted to them.

2) Measured pump inlet and outlet pressures, and difference converted to feet.
3) Differential pressure reading at all differential pressure sensors, through EMCS.
4) Water flow rate from flow meter, through EMCS.

D. Hot Water Plant.

1. Boiler Balancing.

a. Test and proportionally balance flow to boilers:

1) Start with all balance valves at boilers wide open.
2) Open all coil control valves through EMCS.
3) Run all pumps (except stand-by pump, if any).
4) Adjust balance valves at boilers, starting with nearest to pump, to provide flow rates proportional to design rates (deduced from pressure drop or calibrated balance valve) through each. At least one boiler balance valve shall remain wide open at end of balance.

b. Report at condition described above.

1) Design and final flow rate at each boiler.
2) Design and final inlet and outlet pressure at each boiler.
3) Balance valve position (% open).

2. Boiler Firing Test.

a. Ensure that no gas fired equipment other than the boilers is in operation.
b. Start with the system cold enough so the system does not heat to setpoint within test period.
c. Verify gas manifold pressure downstream of gas valves meets boiler manufacturer's requirements.
d. Open all heating coil control valves.
e. Run all hot water pumps (except stand-by pump, if any).
f. Run each boiler, one at a time, at high fire by raising the HW supply temperature setpoint.
g. Clock the gas meter for a minimum of 10 minutes.
h. Concurrently record natural gas flow meter reading from EMCS (if applicable).
i. Measure the gas pressure at inlet to meter.
j. Determine conversion factor of (Btu per cubic foot) from gas pressure chart, and then calculate the boiler firing rate in Btu/h.
k. Determine boiler flow rate from calibrated balancing valve at boiler or EMCS flow meter.
l. Use flow and temperature rise across each boiler to calculate heat transferred to water ($Q = 490*GPM*\triangle T$).
m. Report.

1) Gas meter test start and stop readings.
2) Boiler input gas rate in cubic feet per hour calculated from gas meter and measured by EMCS.
3) Each boiler.

a) Boiler firing input rate in Btu/h, design and calculated from utility gas meter and from EMCS gas meter.
b) Hot water return temperature.

c) Hot water supply temperature.
d) Flow rate.
e) Calculated heating energy transferred to water Btu/h.
f) Calculated efficiency, heat transferred to water divided by gas energy input.

E. Bypass Balancing at 3-Way Valves.

1. At all 3-way valves serving coils with a design coil pressure drop exceeding 2 feet, adjust balance valve in bypass leg as required to make pressure drop across the coil-valve assembly when valve is in full-bypass position equal to that when control valve is in through-coil position.
2. Report.

a. Differential pressure across coil-valve assembly when control valve is in full-bypass position.
b. Differential pressure across coil-valve assembly when control valve is in through-coil position.
c. Position of bypass valve (% open).

F. Balancing Main Bypass Valves.

1. Coordinate and test operation of hydronic system piping main bypass control valves to maintain 10% excess on minimum flow required of equipment served.

3.5 DUCT AIR LEAKAGE TESTS

A. TAB Agency shall witness duct air leakage tests once Division 23 HVAC contractor confirms in writing that all ductwork has passed the pretest.

B. TAB Agency shall initial Duct Air Leakage Test Log for each section of duct tested certifying that duct passed the maximum permitted air leakage test as specified in Section 233113 – Metal Ducts.

3.6 TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.

1. Measure and record the operating speed, airflow, and static pressure of each fan.
2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
3. Check the refrigerant charge.
4. Check the condition of filters.
5. Check the condition of coils.
6. Check the operation of the drain pan and condensate-drain trap.
7. Check bearings and other lubricated parts for proper lubrication.
8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:

1. New filters are installed.
2. Coils are clean and fins combed.
3. Drain pans are clean.
4. Fans are clean.
5. Bearings and other parts are properly lubricated.
6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.

1. Compare the indicated airflow of the renovated work to the measured fan airflows and determine the new fan speed and the face velocity of filters and coils.
2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the airflow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
4. Balance each air outlet.

3.7 ADDITIONAL COST

A. Fans: If drives are not capable of being adjusted to meet required performance, inform Architect, and replace sheaves as required.

B. Pumps: Do not trim pump impellers. Adjust flow with pump speed via VFD.

3.8 SPOT CHECKING

A. Spot checks shall take place after test and balance work is complete and reports have been prepared and approved.

B. Spot checks shall be witnessed by the Architect. Schedule spot checks with Architect at least 1 week prior to proposed test date.

C. Architect shall select subsets of any tested and balanced air or hydronic system to be spot-checked on the day of tests without prior notice to the Contractor.

1. Spot-checking will not require more than one working day.
2. If additional spot checks are requested by the Architect causing the time limit above to be exceeded, inform Architect, and indicate added price to perform the additional tests. Do not include additional tests in initial bid.

D. Discrepancies.

1. If any of the spot-check measurements differ more than 25 percent from those documented in test and balance reports, the Agency shall completely rebalance the associated system. For balance discrepancies at or downstream of a VAV box, rebalance only is required at or downstream of that box.
2. If discrepancies as described above are found on more than 25 percent of the spot-checks for air systems, all air systems shall be rebalanced.
3. If discrepancies as described above are found on more than 25 percent of the spot-checks for hydronic systems, all hydronic systems shall be rebalanced.

4. Rebalance work shall be witnessed by the Architect at the option of the Architect.
5. All rebalance work shall be documented, and documentation shall be resubmitted as specified above.
6. All rebalance work shall be provided at no additional cost to the Owner.

3.9 TRAINING OWNER PERSONNEL

A. Go over the final Testing, Adjusting and Balancing Report, explaining the layout and the meanings of each data type.

B. Discuss any outstanding deficient items in control, ducting, piping, or design that may affect the delivery of air or water.

C. Identify and discuss any systems or system components that are not meeting their design capacities.

D. Discuss any temporary settings and steps to finalize them for any areas that are not finished or fully occupied.

E. Any other appropriate points that may be helpful for facilities operations, relative to testing, adjusting, and balancing or the mechanical systems.

END OF SECTION 230593

SECTION 230713 - DUCT INSULATION

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 insulating the following duct services:

1. Ducts and plenums, thermal insulation.
2. Duct liner.

B. Related Sections:

1. Section 230719 Piping and Equipment Insulation.

1.3 REFERENCE STANDARDS

A. ASTM B209 – Aluminum and Aluminum-Alloy Sheet and Plate.

B. ASTM C177 – Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.

C. ASTM C335 – Steady-State Heat Transfer Properties of Horizontal Pipe Insulation.

D. ASTM C585 – Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe.

E. ASTM C921 – Properties of Jacketing Materials for Thermal Insulation.

F. ASTM E84 – Surface Burning Characteristics of Building Materials.

G. ASTM E96 – Water Vapor Transmission of Materials.

H. NFPA 255 – Surface Burning Characteristics of Building Materials.

I. SMACNA – HVAC Duct Construction Standards - Metal and Flexible.

J. UL 723 – Surface Burning Characteristics of Building Materials.

K. ASTM E 814 – Standard Test Method for Fire Tests of Through-Penetration Fire Stops.

1.4 DEFINITIONS

A. Duct Dimensions.

1. Duct sizes indicated on Drawings shall be clear inside dimensions unless duct size is specifically indicated as outside dimensions (OD).

1.5 QUALITY ASSURANCE

A. Source Quality Control.

1. Service: Use insulation specifically manufactured for service specified.
2. Labeling: Insulation labeled or stamped with brand name and number.

B. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

1.6 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. "R" means required.
2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Duct insulation, wrap and liner	R			
Jackets	R			
Adhesives and coatings	R			
Mechanical fasteners	R			
Installer qualifications	R			

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Insulation: fiberglass.

1. Owens-Corning Fiberglass Corporation.
2. Johns Manville.
3. Certainteed Corporation.
4. Knauf.
5. Or equal.

C. Adhesives.

1. Childers Brand; H. B. Fuller Construction Products.
2. Foster Brand; H. B. Fuller Construction Products.
3. Mon-Eco Industries, Inc.
4. Or equal.

D. Mechanical Fasteners.

1. AGM Industries, Inc.
2. Miracle Adhesives Corporation.
3. Grip-Nail.
4. Or equal.

2.2 GENERAL

A. Energy Codes: The current versions of ASHRAE 90.1 shall govern where requirements for thickness exceeds thickness specified.

B. All insulation materials, including jackets, facings, adhesives, coatings, and accessories are to be fire hazard rated and listed by Underwriters' Laboratories, Inc., using Standard UL 723 (ASTM E-84), (NFPA-255), (ASA A2.5-1963).

1. Flamespread: maximum 25.
2. Fuel contributed, and smoke developed: maximum 50.
3. Flameproofing treatments subject to deterioration from moisture or humidity are not acceptable.

C. Insulation and accessories shall not provide any nutritional or bodily use to fungi, bacteria, insects, rats, mice, or other vermin, shall not react corrosively with equipment, piping or ductwork, and shall be asbestos free: Duct lining shall meet ASTM C1136 and ASTM C665 for biological growth in insulation

2.3 MATERIALS

A. Duct Wrap with Vapor Barrier, Type DW-V.

1. Insulation: ASTM C553 and C612; flexible, noncombustible blanket.

a. Installed 'K' ('Ksi') value: ASTM C518, 0.27 at 75 degrees Fahrenheit.
b. Maximum service temperature: ASTM C411, 250 degrees Fahrenheit.
c. Maximum moisture absorption: 0.20 percent by volume.

2. Vapor Barrier Jacket - factory installed. (FSK).

a. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
b. Moisture vapor transmission: ASTM E96 Procedure E; 0.02 perm.
c. Secure with pressure sensitive tape.

3. Vapor Barrier Tape: Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based, adhesive.

a. Flexible fiberglass wrap

1) Supply Air: 2.2” Nominal Thickness with Installed R-Value 6.0 (0.75 pcf)
2) Return/Outside/Exhaust Air: 1.5” Nominal Thickness with Installed R-Value 4.2 (0.75 pcf)

b. Installed conductance: 0.27 BTU-inch/hr./square foot/degree Fahrenheit.
c. Factory applied jacket.

1) Foil-scrim-kraft laminate: Aluminum foil facing.
2) Glass scrim reinforcing.
3) Kraft paper backing.

d. Maximum vapor permeance: 0.02 perms,

4. Owens-Corning All Service Faced Duct-Wrap or equal.

B. Duct Board with Vapor Barrier, Type DB-V

1. Insulation: ASTM C612; rigid, noncombustible board.

a. 'K' ('Ksi') value: ASTM C518, 0.23 at 75 degrees Fahrenheit.
b. Maximum service temperature: 350 degrees Fahrenheit.
c. Maximum moisture absorption: 0.20 percent by volume.

2. Vapor Barrier Jacket - factory installed (FSK).

a. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
b. Moisture vapor transmission: ASTM E96 Procedure E; 0.02 perm.
c. Secure with pressure sensitive tape.

3. Vapor Barrier Tape: Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based, adhesive.
4. Installed conductance: 0.23 BTU-inch/hr./square foot/degree Fahrenheit.
5. Thickness per Duct Insulation Type and Thickness Schedule.
6. Factory applied jacket.

a. Foil-scrim-kraft laminate.

1) Aluminum foil facing.
2) Glass scrim reinforcing.

C. Rectangular Duct Liner, Type AL.

1. Material.

a. Insulation: ASTM C423.
b. 'K': ASTM C518, 0.23 at 75 degrees Fahrenheit.
c. Maximum service temperature: 350 degrees Fahrenheit.
d. Maximum moisture absorption: 0.20 percent by volume.
e. Thickness per Duct Insulation Type and Thickness Schedule.
f. 1-1/2 pounds per cubic foot unless shown otherwise to be 3 pounds per cubic foot.
g. Installed conductance: 0.25 BTU-inch/hr./square foot/degree Fahrenheit.

2. Interior air side surface.

a. Smooth black neoprene or matte facing overlay on air side. Coating shall conform to NFPA 90A, ASTM C665, ASTM G21.
b. Suitable for velocity up to 4000 feet per minute.
c. Meet erosion test method described in UL publication No. 181.
d. Durable and mechanically cleanable.
e. EPA registered anti-microbial agent.
f. Certainteed Toughgard Duct Liner or equal.
g. Adhesives.

1) Duct Insulation, Internal: Foster 85-60 or equal.
2) Weld Pins: Duro-Dyne CP or equal.

D. Round Duct Liner, Type RAL.

1. Same material as Type AL.
2. Interior air-side surfaces same as Type AL.
3. Self-supporting, slide-in installation.
4. Schuller Permacote Spiracoustic or equal.
5. Small diameter ducts which cannot be insulated internally using duct lining materials shall be prefabricated. Insulation material shall be fixed between outer duct metal and a perforated metal liner. United McGill k27 series or equal. Fittings shall be insulated to same standard and shall be by same manufacturer.

E. Plenum Liner, Type PL

1. Material.

a. Heavy-density mat-faced Plenum Liner: Comply with ASTM C 1071.
b. 'K': ASTM C518, 0.23 at 75 degrees Fahrenheit.
c. Maximum service temperature: 350 degrees Fahrenheit.
d. Maximum moisture absorption: 0.20 percent by volume.
e. Thickness per Duct Insulation Type and Thickness Schedule.
f. 1-1/2 pounds per cubic foot unless shown otherwise to be 3 pounds per cubic foot.
g. Installed conductance: 0.25 BTU-inch/hr./square foot/degree Fahrenheit.

2. Interior air side surface.

a. Smooth black neoprene or matte facing overlay on air side. Coating shall conform to NFPA 90A, ASTM C665, ASTM G21.
b. Suitable for velocity up to 4000 feet per minute.
c. Meet erosion test method described in UL publication No. 181.
d. Durable and mechanically cleanable.
e. EPA registered anti-microbial agent.
f. Knauf Insulation Rigid Plenum Liner or equal.
g. Adhesives.

1) Duct Insulation, Internal: Foster 85-60 or equal.
2) Weld Pins: Duro-Dyne CP or equal.

PART 3 - EXECUTION

3.1 DUCT & PLENUM INSULATION

A. Duct Insulation Type and Thickness Schedule.

Location	Cooling or Heat/Cool Supply	Return/Outdoor Air	Exhaust
Supply/return ductwork concealed in ceiling or return air plenum	2.2 inches DW-V	1-1/2 inches DW-V	1-1/2 inches DW-V
Concealed in unconditioned spaces	2.2 inches DW-V	1-1/2 inches DW-V	1-1/2 inches DW-V
Exposed outdoors	See Section 233115	-	-
Flex duct	By manufacturer	By manufacturer	-
Air distribution devices, not factory insulated (backpans of grilles, registers, and diffusers)	2.2 inches DW-V	-	-

3.2 NON-INSULATED DUCTWORK

A. No insulation required for ducts so indicated in Duct Insulation Type and Thickness Schedule, and the following:

1. Factory-insulated flexible ducts.
2. Factory-insulated plenums and casings.
3. Indoor flexible connectors.
4. Indoor vibration-control devices.
5. Factory-insulated access panels and doors.

3.3 DUCT INSULATION INSTALLATION

A. General.

1. Ensure that insulation is continuous through all walls.
2. Finish insulation neatly at hangers, supports and other protrusions.
3. Locate insulation joints or cover seams in least visible locations.
4. Where ducts run in groups too close to be individually insulated and finished.

    a. Completely fill all spaces between ducts with rigid or flexible insulating material.
    b. Insulate and finish exterior surfaces of group as specified for particular service.

5. Where ducts cannot be insulated after erection, insulate prior to installation.
6. Where specified thickness of insulation and/or lining exceeds available thickness in single layer, provide insulation and/or lining in 2 or more layers with joints staggered.
7. Preparation:

    a. Do not install covering before ductwork and equipment has been tested and reviewed.
    b. Ensure surface is clean and dry prior to installation.

c. Ensure insulation is dry before and during application.

8. Mechanical fasteners:

a. Use spot weld anchors in all shop fabricated internally lined ducts.
b. Adhered anchors.
c. Clip off pin penetrations flush with insulation surface or facing.
d. Seal pins and washers where pins penetrate vapor barriers.

1) With 4-inch square pieces of vapor barrier material to match facing.
2) Adhere with vapor-seal adhesive.

e. Spacing on rectangular ducts.

1) Typical of horizontal and vertical, unless otherwise specified.
2) Duct board.

a) 3 inches in from edges.
b) Intermediate fasteners: 12 inches on center maximum spacing all directions.
c) Not less than four pins per surface.

3) Duct Wrap.

Side Dimension	Maximum Spacing
24 inches and under	None required.
25 to 32 inches	Horizontal - none. Vertical: 1 row centered, 12 inches on center
33 to 48 inches	2 rows, 12 inches on center.
49 to 60 inches	3 rows, 12 inches on center.
61 inches and over	16 inches on center, all directions.

4) Duct wrap spacing applicable to flat surfaces of flat oval ducts.

9. Provide 24-gauge sheet metal Z section frames over edges of duct and plenum lining.

a. At access openings and doors.
b. Along edges exposed to air flow.

B. Rectangular Duct Wrap.

1. Vapor barrier and sealing continuous without breaks. Vapor proof seal around supports and bracing.
2. 2 inches lap strip at one end.
3. Peel insulation for 2-inch lap strip along longitudinal joints.
4. Seal lap strips with vapor-seal adhesive; Foster's 85-60 or equal.

C. Round Duct Wrap.

1. Adhere flexible insulation to ductwork with adhesive applied in 6-inch-wide strips on 16-inch centers.
2. Provide 16-gauge annealed tie wire tied, spiral wound or half hitched at 16-inch centers.
3. Overlap insulation 2 inches and seal joints and breaks with 2-inch lap of foil adhered over joint.

4. Apply duct wrap with vapor barrier as specified above for rectangular ducts.

D. Duct Board.

1. Comply with published recommendations of manufacturer.
2. Secure on top, sides, and bottom of duct with mechanical fasteners, spacing as scheduled.
3. Secure with 4-inch strips of adhesive, 8-inch on center.

E. Rectangular Duct and Plenum Lining.

1. Comply with SMACNA Duct Liner Application Standard, published recommendations of manufacturer, and following:
2. Apply adhesive over 100 percent of surfaces to be lined.
3. The coated surface shall face air stream.
4. Surface adjacent to air flow, including at joints, to be uniformly flat.
5. Insulation on floors of plenums and large ducts where access is required shall be protected by wire mesh so that lining is not damaged when walked or crawled on.
6. Blank-Off Panels: Insulation, enclosed with sheet metal on all sides; all joints with vapor barrier mastic and taped.
7. Volume Dampers: Where volume dampers do not allow for continuous insulation, terminate insulation clear of handle sweep and finish edges to maintain vapor barrier and to prevent damage to the insulation.
8. Seal butt joints and exposed edges of liner to prevent erosion.
9. Edges at terminal points shall be provided with metal beading and heavily coated with adhesive.
10. Damaged areas replaced or heavily coated with adhesive.
11. Mechanical fasteners.

    a. Use weld pins.
    b. Install mechanical fasteners.

        1) Weld pins flush with liner surface. Weld pins spaced maximum of 12-inch on center in both directions and within 2 inches of all corners and joints, except where SMACNA Standard requires closer spacing.
        2) Within 2 inches of all edges.
        3) Minimum 4 pins per side.
        4) For field alterations of lined ducts, install adhesive and glued pins with washers. Clip-off pins after washers installed. Field installed pins shall be used for unusual conditions only and shall not exceed 1 percent of total pins.

3.4 PENETRATION THROUGH RATED WALLS

A. Refer to drawings for penetrations of rated assemblies.

B. Install per manufacturer’s installation and listing requirements.

3.5 FIELD QUALITY CONTROL

A. Repair separation of joints or cracking of insulation due to thermal movement or poor workmanship.

B. All vapor barriers shall be continuous; tears, holes, staples, etc. shall be coated with vapor barrier mastic and patch with facing or tape.

C. See Section 233113 – Metal Ducts for protection of lined duct during construction.

END OF SECTION 230713

SECTION 230719 – PIPING AND EQUIPMENT INSULATION

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. Work Included in This Section: Materials, equipment, fabrication, installation, and tests in conformity with applicable codes and authorities having jurisdiction for the following:

1. Piping insulation.
2. Pipe insulation jacket.
3. Equipment insulation.

1.3 REFERENCE STANDARDS

A. ASTM B209 – Aluminum and Aluminum-Alloy Sheet and Plate.

B. ASTM C177 – Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.

C. ASTM C335 – Steady-State Heat Transfer Properties of Horizontal Pipe Insulation.

D. ASTM C585 – Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe.

E. ASTM C921 – Properties of Jacketing Materials for Thermal Insulation.

F. ASTM E84 – Surface Burning Characteristics of Building Materials.

G. ASTM E96 – Water Vapor Transmission of Materials.

H. NFPA 255 – Surface Burning Characteristics of Building Materials.

I. SMACNA – HVAC Duct Construction Standards - Metal and Flexible.

J. UL 723 – Surface Burning Characteristics of Building Materials.

K. ASTM E 814 – Standard Test Method for Fire Tests of Through-Penetration Fire Stops.

1.4 QUALITY ASSURANCE

A. Source Quality Control.

1. Service: Use insulation specifically manufactured for service specified.
2. Labeling: Insulation labeled or stamped with brand name and number.

B. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

C. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.

1. Piping Mockups:

   a. One 10-foot section of NPS 2 straight pipe.
   b. One each of a 90-degree threaded, welded, and flanged elbow.
   c. One each of a threaded, welded, and flanged tee fitting.
   d. One NPS 2 or smaller valve, and one NPS 2-1/2 or larger valve.
   e. Four support hangers including hanger shield and insert.
   f. One threaded strainer and one flanged strainer with removable portion of insulation.
   g. One threaded reducer and one welded reducer.
   h. One pressure temperature tap.
   i. One mechanical coupling.

2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
3. Notify Architect seven days in advance of dates and times when mockups will be constructed.
4. Obtain Architect's approval of mockups before starting insulation application.
5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
7. Demolish and remove mockups when directed.

1.5 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Piping insulation	R			
Jackets	R			
Adhesives and coatings	R			
Mechanical fasteners	R			
Installer qualifications	R			

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Insulation: Cellular glass.

1. Pittsburg-Corning
2. Or equal.

C. Insulation: fiberglass.

1. Owens-Corning Fiberglass Corporation.
2. Manville.
3. Certainteed Corporation.
4. Knauf.
5. Or equal.

D. Insulation: Elastomeric Closed Cell.

1. Armstrong World Industries, Inc.
2. Rubatex Corporation.
3. Or equal.

E. Weatherproof Aluminum Jacket.

1. Childers Products Company.
2. Insul-Coustic/Birma Corporation.
3. Or equal.

F. Pre-molded pipe fitting covers and Jacketing.

1. Manville: Zeston.
2. Childers Products Company.
3. Proto Corporation.
4. Insul-Coustic/Birma Corporation.
5. Or equal.

G. Adhesives.

1. Foster Div. Amchem Products Inc.
2. Childers Products Company.
3. Epolux Mfg. Corporation.
4. Insul-Coustic/Birma Corporation.
5. Armstrong 520 Adhesive.
6. Or equal.

H. Mechanical Fasteners.

1. AGM Industries, Inc.
2. Miracle Adhesives Corporation.

3. Grip-Nail.
4. Or equal.

2.2 GENERAL

A. Energy Codes: The current versions of ASHRAE 90.1 shall govern where requirements for thickness exceeds thickness specified.

B. All insulation materials, including jackets, facings, adhesives, coatings, and accessories are to be fire hazard rated and listed by Underwriters' Laboratories, Inc., using Standard UL 723 (ASTM E-84), (NFPA-255), (ASA A2.5-1963).

1. Flamespread: maximum 25.
2. Fuel contributed, and smoke developed: maximum 50.
3. Flameproofing treatments subject to deterioration from moisture or humidity are not acceptable.

C. Insulation and accessories shall not provide any nutritional or bodily use to fungi, bacteria, insects, rats, mice, or other vermin, shall not react corrosively with equipment, piping or ductwork, and shall be asbestos free: Duct lining shall meet ASTM C1136 and ASTM C665 for biological growth in insulation.

D. Provide a continuous vapor seal for any service piping that carries liquid below 60 degrees Fahrenheit.

2.3 PIPE INSULATION

A. Cellular Glass.

1. Insulation (without jacket) ASTM C 552, Type II, Class 1.
2. Insulation (with jacket) ASTM C552, Class 2.
3. Sectional.
4. 0.32 maximum K-factor at 75 degrees Fahrenheit mean temperature.
5. Pittsburg-Corning or equal.

B. Fiberglass.

1. Molded: one piece, with factory-applied, all purpose, vapor retarder jacket, maximum 0.26 K factor at 75 degrees Fahrenheit mean temperature: Owens-Corning ASJ/SSL-II Pipe Insulation or equal.

C. Flexible, closed cell elastomeric thermal insulation.

1. Insulation ASTM C534.
2. Service rating of 220 degrees Fahrenheit.
3. Density 6.0 pounds per cubic foot.
4. Closed cell foam: Vapor permeability ASTM E96 0.2 perm.
5. Max moisture absorption: 1.0 percent by volume, 10 percent by weight.
6. Molded pipe insulation.

a. Maximum 0.27 K factor at 75 degrees Fahrenheit mean temperature
b. Maximum water vapor transmission rating of 0.17 perm-inches,

7. Sheet insulation.

    a. Maximum 0.28 K factor at 75 degrees Fahrenheit mean temperature.
    b. Maximum water vapor transmission rating of 0.17 perm-inches.

8. Seal with Rubatex adhesive or equal: Armstrong Armaflex II or equal.

D. Underground pipe insulation: See Section 232112 – Hydronic Piping.

2.4 EQUIPMENT INSULATION

A. Flexible, closed cell elastomeric thermal insulation.

1. Insulation ASTM C534, Type II sheet material.
2. Service rating of 220 degrees Fahrenheit.
3. Density 6.0 pounds per cubic foot.
4. Closed cell foam: Vapor permeability ASTM E96 0.2 perm.
5. Max moisture absorption: 1.0 percent by volume, 10 percent by weight.
6. Sheet insulation.

    a. Maximum 0.28 K factor at 75 degrees Fahrenheit mean temperature.
    b. Maximum water vapor transmission rating of 0.17 perm-inches.

7. Seal with Rubatex adhesive or equal: Armstrong Armaflex II or equal.

2.5 JACKETS

A. Factory Applied Vapor Barrier All Service Jacket (ASJ).

1. ASTM C921, White kraft paper bonded to aluminum foil and reinforced with glass fiber yarn.
2. Moisture Vapor Transmission: ASTM E96; 0.02 perm inches.
3. Secure with self-sealing longitudinal laps and butt strips.
4. Secure vapor barrier mastic.
5. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum or 0.010 inch thick stainless steel.
6. Vapor Barrier Lap Adhesive: Compatible with insulation.

B. Aluminum Jacket: ASTM B209.

1. Use for weatherproof jacket.
2. Thickness: 0.016 inch sheet.
3. Finish: Embossed.
4. Joining: Longitudinal slip joints and 2 inch laps.
5. Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner.
6. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum or 0.010 inch thick stainless steel.

C. Preformed PVC.

1. Polyvinylchloride covers similar to Manville Zeston.
2. Colors:

a. Chilled Water: Blue.
b. Condenser Water: Light blue.
c. Heating Water: Red.
d. Domestic Cold Water: Green.
e. Domestic Hot Water: Orange.

D. Equipment insulation facings: Foil-scrim-kraft laminate of aluminum foil facing, glass scrim reinforcing, kraft paper backing.

E. Preformed Pipe Fitting Covers:

1. Aluminum.

a. Factory fabricated formed covers.
b. General Aluminum Supply Corporation GASCO or equal.

2. PVC.

a. Factory fabricated formed covers.
b. Manville Zeston or equal.

2.6 ADHESIVES AND COATINGS

A. Foster product names and figure numbers or equal.

1. Lagging adhesive: 30-36.
2. Fiberglass: Zeston Z-Glu.
3. Vapor barrier coating: Tite-fit 30-80, UP Label, comply with MIL-C-19565C, Type II; fire and water resistant.
4. Vaporseal adhesive: 85-60.
5. Cellular glass bedding and sealing compound adhesive: Foamseal 30-45.
6. Outdoor mastic: 30-90.
7. Asphalt mastic: C.I. Mastic 60-25.
8. For elastomeric insulation: 520 contact, adhesive.

2.7 WIRE, BANDING AND FASTENING DEVICES

A. Wire: minimum 16 gauge copper clad annealed steel wire

B. Bands: 3/4 inches nominal width with wing seals, of minimum thickness as follows:

1. Aluminum: 0.007 inches. Except where exposed to weather, 0.020 inches.
2. Stainless steel: 0.010 inches.

C. Staples: outward clinching type of corrosion resistant steel.

2.8 MECHANICAL FASTENERS

A. Mild steel, copper plated.

B. AGM Industries Power Base insulation pins or equal.

C. Insulation washers:

1. Galvanized steel.
2. 1-1/2 inch diameter.
3. AGM Industries SLW-1 or equal.

2.9 PRE-INSULATED PIPE SUPPORT AND SHIELDS

A. Provide insulated pipe supports for all insulated pipe and tubing. Insulated pipe supports shall be Pipe Shields, Inc. or equal.

B. All insulated pipe supports shall be load rated. Load ratings shall be established by pipe support manufacturer based upon testing and analysis in conformance with the latest edition of the following codes: ASME B31.1, MSS SP-58, MSS SP-69, and MSS SP-89.

C. All insulated pipe supports shall have cellular glass insulation and galvanized steel jackets. Pipe supports for use on flat surfaces shall have integral load distribution plates coated with zinc primer minimum 3 mils thick.

D. See Section 230529 – Hangers and Supports.

E. Hangers and supports shall fit outside of all pipe insulation and insulation inserts. Provide pre-insulated pipe supports as specified and install per manufacturer's installation instructions. Shield lengths and gauges shall also be per manufacturer's recommendations.

F. Tape all butt joints where pipe insulation butts up against hanger shield.

1. On hot pipe, apply three inch wide vapor barrier tape or band over the butt joint.
2. On chilled water piping, apply a wet coat vapor barrier lap cement on all butt joints and seal the joints with a minimum of three inch wide vapor tape or band.

2.10 FIRESTOPPING

A. At pipe penetrations through rated assemblies.

B. Commercial pipe sleeve assemblies that are UL listed and that have been approved by the fire marshal for this purpose.

C. Insulation shall be continuous through penetration.

2.11 ACCESSORIES

A. Insulation Protection Saddles: 12-inch long, 16 gauge steel.

B. Paint: Ultraviolet resistant latex paint with special adherence capabilities to the fitting covers, elastomeric, aluminum facing, Kraft paper, tapes, and adhesives.

PART 3 - EXECUTION

3.1 PIPE & EQUIPMENT INSULATION SCHEDULE

A. Type P-1.

1. Molded fiberglass.
2. All-service jacket (ASJ).
3. Vapor sealed.

B. Type P-1A.

1. Molded fiberglass.
2. All-service jacket (ASJ).
3. Vapor sealed.
4. PVC jacket.

C. Type P-1B.

1. Molded fiberglass.
2. All-service jacket (ASJ).
3. Vapor sealed.
4. Metal jacket.

D. Type P-1C

1. Molded fiberglass
2. All-service jacket with a polymer film exterior surface (ASJ-MAX)
3. Vapor sealed
4. Temperature Rating 0-1000°F
5. ASTM E84 tested as an assembly

E. Type P-2.

1. Flexible elastomeric insulation.

F. Type P-3.

1. Cellular glass insulation.
2. All service jacket (ASJ).
3. Vapor sealed.

G. Type P-3A.

1. Cellular glass insulation.
2. All service jacket (ASJ).
3. Vapor sealed.
4. PVC jacket.

H. Type P-3B.

1. Cellular glass insulation.
2. All service jacket (ASJ).
3. Vapor sealed.

4. Metal jacket.

I. Type E-1.

1. Flexible elastomeric insulation.

J. Application Schedule.

Piping Systems	Location	Type	Pipe Size	Insulation Thickness	Freeze Protection
Floor Drain Bodies and related horizontal and vertical Sanitary Drain Lines above floor that receive cold condensate drainage.	Interior	P-2	4” and smaller	3/4"	-
Cold Condensate Drain Lines	Interior	P-2	All Sizes	3/4"	-
Condensate, and sanitary sewer waste/vent piping receiving condensate (horizontal piping and vertical piping, Underside of floor drain bodies receiving condensate)	Interior	P-2	All Sizes	3/4"	
Domestic cold water	Interior concealed	P-1	1-1/2” and smaller	1/2"	-
			2” and larger	3/4"	-
	Interior exposed	P-1A	1-1/2” and smaller	1/2"	-
			2” and larger	3/4"	-
	Exterior exposed	P-1B	All Sizes	3/4"	Yes
Refrigerant suction	All	P-2	All Sizes	3/4"	-
Refrigerant hot gas (VRF systems)	All	P-2	All Sizes	3/4"	-
Chilled Water	Interior concealed	P-3	4" and Smaller	1-1/2”	-
			6" and Larger	2"	-
	Interior exposed	P-3A	4” and Smaller	1-1/2”	-
			6” and Larger	2"	-
	Exterior	P-3B	4” and Smaller	2”	Yes
			6” and Larger	2”	Yes
Heating Water (Max 180 ˚F)	Interior concealed	P-1	2-1/2” and Smaller	1-1/2”	-
			3" and Larger	2-1/2”	-
	Interior exposed	P-1A	2-1/2” and Smaller	1-1/2”	-
			3" and Larger	2-1/2”	-
	Exterior	P-1B	2-1/2” and Smaller	2”	Yes
			3" and Larger	3-1/2”	Yes
			3” to 6"	3”	-
			8" and Larger	3-1/2"	-
	Interior exposed	P-1A	2-1/2" and Smaller	2"	-
			3” to 6"	3”	-
			8" and Larger	3-1/2"	-

L. Non-insulated piping and equipment.

1. Pneumatic tubing.

2. Hot water expansion tanks and piping to them other than the first 3 feet from the point of connection at piping mains.
3. Pot feeders and piping to them other than the first 3 feet from the point of connection at piping mains.
4. Vent, overflow, drain and relief, except as noted otherwise.
5. Hot water control valves. (Note: this exclusion applies only to the valves themselves; all other hot water piping and accessories, including that between isolation valves and coils, shall be insulated.)

3.2 INSTALLATION

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

B. Coordinate with work of other trades.

C. Deliver material to job site in original non-broken factory packaging, labeled with manufacturer's density and thickness.

D. Install insulation where it cannot become wet. If insulation becomes wet, remove, and dispose of properly and replace with new, dry insulation. Wetted insulation is not acceptable. Ensure insulation is dry before and during installation.

E. Insulate all piping, valves, fittings, flanges, and accessories.

F. On piping exposed to public view, locate insulation and cover seams in least visible locations.

G. Insulate fittings, joints, and valves with insulation of same material and thickness as adjoining pipe. Use pre-molded fiberglass fittings. For strainers, expansion joints, fittings and accessories requiring servicing or inspection insulation shall be removable and replaceable without damage. Enclose within two-piece no. 15 gauge aluminum covers fastened with cadmium-plated bolts and nuts.

H. Insulate flanges with insulation sleeve of same material as pipe insulation to cover flange and overlap insulation on adjacent piping.

I. Continue insulation through walls, sleeves, pipe hangers and other pipe penetrations.

J. Finish insulation at supports, protrusions, and interruptions. No hangers or supports shall be embedded in insulation. Do not insulate expansion bellows.

K. Fiberglass insulation.

1. Provide insulation with factory applied vapor barrier jackets.
2. Butt edges neatly. ASJ with 3 inch minimum butt strips.
3. Longitudinal overlaps: Minimum 2 inch self-sealing, double adhesive.
4. Apply additional jacket as specified.
5. For insulation with factory-applied jackets, secure laps with aluminum or stainless steel, bands at 18 inches o.c.
6. For piping conveying fluids below, ambient temperature finish with vapor barrier adhesive.

L. Cellular glass insulation.

1. Provide insulation with factory applied vapor barrier jackets.

2. Butt edges neatly. Seal longitudinal and transverse joints with adhesive to maintain minimum vapor permeance. Adhesive shall be selected and applied in accordance with insulation manufacturer's recommendations.
3. Secure insulation sections with bands without deforming insulation materials.
4. Build up coating of insulating and finishing cement.
5. For insulation with factory-applied jackets, secure laps with aluminum or stainless steel, bands at 18 inches o.c.
6. For piping conveying fluids below, ambient temperature finish with vapor barrier adhesive.
7. Apply additional jacket as specified. If no additional jacket specified apply skim coat of finishing cement to smooth out surface of fitting insulation.

M. Elastomeric Tubing.

1. Butt edges neatly. Seal longitudinal and transverse joints with adhesive to maintain minimum vapor permeance. Adhesive shall be selected and applied in accordance with insulation manufacturer's recommendations.
2. Apply additional jacket as specified.

N. For all pipe systems exposed in the mechanical equipment rooms, finish with an all service PVC jacket.

O. For exterior applications, provide vapor barrier jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

P. For buried piping, provide factory fabricated assembly with inner all-purpose service jacket with self-sealing lap, and asphalt impregnated open mesh glass fabric, with one mil thick aluminum foil sandwiched between three layers of bituminous compound; outer surface faced with a polyester film.

Q. Perform work at ambient and equipment temperatures as recommended by adhesive manufacturer.

R. Protection: Protect against dirt, water, chemical, or mechanical damage before, during, and after installation. Repair or replace damaged insulation at no additional cost.

S. Paint all insulation exposed to ultraviolet light (sunlight).

T. All vapor barriers shall be continuous. Tears, holes, staples, etc. shall be coated with vapor barrier mastic and patch with facing or tape.

U. Joints between insulation and access shall be sealed with vapor barrier mastic.

3.3 PIPE INSULATION APPLICATION

A. General.

1. Before applying insulation.

a. Test piping for tightness and obtain approval.
b. Dry pipe thoroughly.
c. Clean surfaces to be insulated of dust, grease, and foreign matter.

2. Butt edges neatly.
3. Fill voids with insulating cement.
4. Longitudinal overlaps.

    a. 2 inches minimum.
    b. For exposed work: toward ceiling or wall.
    c. For weatherproof aluminum jackets: on side to shed water.

5. Circumferential overlaps on weatherproof aluminum jackets: 2 inches minimum.
6. Continuous insulation passing through sleeves or other openings.
7. Oversize insulation to accommodate heat tracing on piping.

B. Valves, fittings, flanges, and accessory insulation.

1. Unless otherwise noted, insulate:

    a. Valves including bonnets.
    b. Flanges.
    c. Fittings.
    d. Strainers.
    e. Expansion joints.
    f. Specialties.

2. Insulation for strainers, expansion joints, fittings and accessories requiring servicing or inspection.

    a. Insulation removable and replaceable without damage.
    b. Enclosed within two-piece, No. 18 gauge aluminum covers fastened with cadmium plated bolts and nuts.

3. Insulation of same thickness as adjacent piping insulation.
4. For piping systems insulated with fiberglass.

    a. Apply pre-molded insulation sections of the same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
    b. Cover fittings with heavy PVC fitting covers. Overlap PVC covers on pipe insulation jackets at least 1 inch at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

5. For piping systems insulated with cellular glass.

    a. Apply pre-molded insulation sections of the same material as straight segments of pipe when available. Secure according to manufacturer’s written instructions.
    b. When pre-molded insulation elbows and fittings are not available, apply mitered sections of pipe insulation (blanket insulation is not acceptable) to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire, tape, or bands.
    c. Cover fittings with heavy PVC fitting covers. Overlap PVC covers on pipe insulation jackets at least 1 inch at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

6. For piping systems insulated with elastomeric thermal insulation.

a. Apply mitered sections of pipe insulation.
b. Secure insulation materials and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.
c. Prime and paint exterior installations for UV protection.

7. Flanges.

a. Apply preformed pipe insulation to outer diameter of pipe flange.
b. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with the same insulation material as adjacent piping insulation.
d. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch, and seal joints with vapor-retarder mastic.

8. Finish for outdoor locations only: weatherproof aluminum jacket compatible with weatherproof jacket on adjoining pipe insulation.

C. At pipe hangers.

1. Insulation protection shields specified in Section 230529 – Hangers and Supports.
2. Butt insulation to shields.
3. Cold piping: Wet coat of vapor barrier lap cement on all butt joints.

D. Jackets and facings.

1. Vapor-sealed types: continuous; staples not permitted.
2. Adhere longitudinal laps: Adhere 3 inches wide joint strip, of same material as facing, at center of each butt joint.
3. Adhesives.

a. Vapor-sealed insulation: vapor-seal adhesive.
b. Heating service insulation: vapor-seal adhesive.
c. Weatherproof aluminum jacket: sealing compound.
d. PVC jacket: welding compound.
e. Underground asphalt felt jacket: asphalt mastic

E. Wiring, banding, and fastening devices: Secure insulation to piping and equipment in accordance with following minimum requirements.

1. Piping insulation section 3 foot long.

a. Concealed vapor-sealed insulation banded at ends and center.
b. Other concealed insulation banded at ends and center.

2. Pipe fitting insulation.

a. Loops of wire to secure mitered segments of insulation.
b. Wire spiraled on from end to end on blanket insulation

3. Outdoor piping weatherproof aluminum jackets banded at circumferential joints and center of each section: Lap joint at bottom.

4. Provide aluminum banding near ends of unicellular piping valve and accessory insulation where unicellular is allowed by Professional.

3.4 EQUIPMENT INSULATION

A. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Secure insulation to equipment with bands, welded-on anchors, ties or adhesive. Where access to equipment is required for testing or maintenance the insulation shall be installed so that it is removable and so that the vapor barrier can be remade after access.

B. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor barrier cement.

C. For cold equipment or equipment containing fluids below ambient temperature.

1. Insulate entire system.
2. Provide vapor barrier jackets, factory applied, or field applied.
3. Finish with glass cloth and vapor barrier adhesive.
4. Cover with aluminum jacket where specified.

D. For equipment containing fluids above ambient temperature.

1. Insulate entire system.
2. Provide standard jackets, with or without vapor barrier, factory applied, or field applied.
3. Finish with glass cloth and adhesive.
4. Cover with aluminum jacket where specified.
5. For hot equipment containing fluids 140 degrees Fahrenheit or less, do not insulate flanges and unions, but bevel and seal ends of insulation.
6. For hot equipment containing fluids over 140 degrees Fahrenheit, insulate flanges and unions with removable sections and jackets.

E. Finish insulation at supports, protrusions, and interruptions.

F. For equipment in mechanical equipment rooms or in finished spaces, finish with aluminum jacket.

G. Do not insulate over nameplate or ASME stamps; bevel and seal insulation around such.

H. General.

1. Apply insulation with edges tightly butted.

a. Joints staggered and secured in place by steel bands.
b. Where necessary weld on suitable anchors.

2. Seal with 520, adhesive.

I. Special considerations.

1. Chiller heads: removable and replaceable covers to allow tube removal.
2. Strainers and suction diffusers: removable and replaceable covers to allow strainer removal.
3. Pumps: removable and replaceable covers to allow impeller replacement.
4. Provide sufficient clearance around openings for normal operation of equipment.

3.5 PENETRATION THROUGH RATED WALLS

A. Refer to drawings for penetrations of rated assemblies.

B. Install per manufacturer’s installation and listing requirements.

3.6 FIELD QUALITY CONTROL

A. Repair separation of joints or cracking of insulation due to thermal movement or poor workmanship.

B. All vapor barriers shall be continuous; tears, holes, staples, etc. shall be coated with vapor barrier mastic and patch with facing or tape.

END OF SECTION 230719

SECTION 230886 - AIR PURIFICATION SYSTEM

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. Work included in this section: materials, equipment, fabrication, installation, and tests in conformity with applicable codes and authorities having jurisdiction for the following:

1. Bi-Polar Ionization.

1.3 REFERENCE STANDARDS

A. ASHRAE Standard 62 & 52

B. NFPA 70.

1.4 QUALITY ASSURANCE

A. The Air Purification System shall be a product of an established manufacturer in the USA and shall be manufactured and assembled in the USA.

B. A qualified representative from the manufacturer shall be available to inspect the installation of the air purification system to ensure installation in accordance with manufacturer's recommendation.

C. Projects designed using ASHRAE Standard 62.1 IAQ Procedure shall require the manufacturer to provide Indoor Air Quality calculations using the formulas within ASHRAE Standard 62.1 to validate acceptable indoor air quality at the outside air quantity scheduled. The manufacturer shall provide independent test data on a previous installation in a similar application that proves compliance to ASHRAE 62.1 and the accuracy of the calculations.

D. The Air Purification Technology shall have been tested by UL or Intertek/ETL to prove conformance to UL 867-2007 including the ozone chamber testing and peak ozone test for electronic devices. All manufacturers shall submit their independent UL 867 test data with ozone results to the engineer during the submittal process. All manufacturers shall submit a copy with their quotation. Contractors shall not accept any proposal without the proper ozone testing documentation.

1.5 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Air Purification Systems	R	R		

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Filter Media and Frames:

1. Global Plasma.
2. Bioclimatic.
3. Aerisa.

2.2 BI-POLAR IONIZATION DESIGN AND PERFORMANCE CRITERIA

A. Each piece of air handling equipment, so designated on the plans, details, equipment schedules and/or specifications shall contain a plasma ion generator with bipolar ionization output as described here within.

B. The Bi-polar Ionization system shall be capable of:

1. Effectively killing microorganisms downstream of the bipolar ionization equipment (mold, bacteria, virus, etc.).
2. Controlling gas phase contaminants generated from human occupants, building structure, furnishings and outside air contaminants.
3. Reducing space static charges.
4. Reducing space particle counts.
5. When mounted to the air entering side of a cooling coil, keep the cooling coil free from pathogen and mold growth.
6. All manufacturers shall provide documentation by an independent NELEC accredited laboratory that proves the product has minimum kill rates for the following pathogens given the allotted time and in a space condition:

    a. MRSA: 99.5% in 60 minutes or less
    b. E. Coli: 93.5% in 30 minutes or less
    c. H1N1: 86.6% in 60 minutes or less
    d. Aspergillus: 74.8% in 60 minutes or less

7. Manufacturers not providing the equivalent space kill rates shall not be acceptable. All manufactures requesting prior approval shall provide to the engineer independent test

data from a NELEC accredited independent lab confirming kill rates and times meeting the minimum requirements stated in section 2.2 B, points 6a through 6d.

C. The bipolar ionization system shall operate in such a manner that equal amounts of positive and negative ions are produced. Single pole ion devices shall not be acceptable.

1. Airflow rates may vary through the full operating range of a VAV system. The quantity of air exchange shall not be increased due to the air purification system requirements.
2. Velocity Profile: The air purification device shall not have a maximum velocity profile.

D. Humidity: Plasma Generators shall not require preheat protection when the relative humidity of the entering air exceeds 85%. Relative humidity from 0 - 100%, condensing, shall not cause damage, deterioration, or dangerous conditions to the air purification system.

E. Ionization Equipment Requirements:

1. Electrode Specifications (Bi-polar Ionization):

a. Each plasma generator with bipolar ionization output shall include the required number of electrodes and power generators sized to the air handling equipment capacity.
b. Electrodes shall be energized when the main unit disconnect is turned on and the fan is operating.
c. Ionization output when tested in the occupied space shall be between 500 and 800 ions/cm3.
d. Manufacturer shall demonstrate that no voltage potential exists due to exposed electrical components in the duct system or plenum. Exposed needles protruding into the air steam will not be accepted.

F. See schedules for type required. Descriptions are below.

1. Air Handler mounted units

a. Ion generators for air handling units 25 tons and larger shall be Plasma Air's BAR (or approved equal) furnished in a linear or bar mounted configuration to minimize the space required for installation. Ionization BAR shall be no more than 3" deep in the direction of airflow.
b. The mechanical contractor shall mount the plasma ionization BAR and connect it to the remote mount power supply panel using only low voltage wiring. Low voltage wiring shall be defined as 12V. The use of high voltage cabling (600V or higher) shall not be acceptable due to safety concerns.
c. The remote mount power supply panel shall be capable of directly accepting voltage of 12V DC or 24V AC. The panel shall have an on/off switch, ionizer indicator LED, and a set of dry contacts which will indicate ionizer functionality. Dry contacts that indicate power available only shall not be acceptable.
d. For systems that don't utilize a feedback functionality indicating ion production, provide a duct mounted ion sensor powered from 12V DC or 24V AC. Ion sensor to be user adjustable from 500 to 20,000 ions per cm3 and contain a dry contact BMS interface. To be clear, for systems that only indicate power available to the ionizer, vendor must provide duct mounted ion sensor described herein.
e. Needles on air handler mounted units shall be recessed for safety and to avoid fouling of any exposed needles.

2. Duct mounted units

a. For systems less than 25 tons and, where indicated on the plans and/or schedules to be duct mounted, plasma ion generators to be Plasma Air 7000 series (or approved equal) shall be supplied and installed by the mechanical contractor. The contractor shall follow all manufacturer IOM instructions during installation.
b. Generators shall be furnished with a factory-equipped gasketed mounting flange to prevent air leakage and to provide a thermal break. Gasketed flange shall be a minimum of 1 1/8" wide around the perimeter of the ionizer.
c. Ion generators shall be field installed in a location that is convenient for visual inspection, removal, and servicing. They shall include an ion indicator light clearly visible from below the installed location.
d. Needles on duct mounted units shall be recessed for safety and to avoid fouling of any exposed needles.

3. Variable Refrigerant Flow (VRF) Ductless units

a. Ion generators for VRF ductless units shall be brush type needlepoint units, Plasma Air model PA600 (or approved equal) designed to be mounted at the fan inlet.
b. The unit shall be rated to treat up to 2,400 CFM or 6 tons nominal capacity. For airflows greater than 2,400 CFM, multiple units shall be utilized as shown on the plans/schedules.
c. The housing shall be made from ABS plastic, contain an LED ionization output indicating LED, and an in-line 1 Amp fuse.
d. The unit shall contain two (2) mounting feet and shall be configured so the needles are oriented perpendicular to the flow of air entering the fan wheel.

G. Electrical Requirements:

1. Ion generators shall contain a built-in power supply and operate on 24V AC and shall connect to the fan and common terminals of the air handling unit served. Ion generators requiring a loose 24V, 120V or 230V transformer or power supply shall not be accepted.
2. Wiring, conduit and junction boxes shall be furnished and installed by the electrical contractor within housing plenums and shall be UL, NEC and NFPA 70 approved.

H. Control Requirements:

1. All plasma ion generators shall include internal short circuit protection, overload protection, and automatic fault reset. Manual fuse replacement shall not be accepted.
2. All BAR and 7000 series plasma ion generators shall include an external BMS interface to indicate ion generator status and alarm.

PART 3 - EXECUTION

3.1 ASSEMBLY AND INSTALLATION

A. All equipment shall be assembled and installed with a high level of workmanship to the satisfaction of the Owner, Architect, and Engineer.

B. Any material damaged by handling, water or moisture shall be replaced by the mechanical contractor at no cost to the owner.

C. All equipment shall be protected from damage on a daily basis throughout construction.

3.2 COMMISSIONING AND TRAINING

A. A manufacturer's authorized representative shall provide start-up supervision and training of owner's personnel in the proper operation and maintenance of all equipment. This representative shall certify that all specified/scheduled ION generators are properly installed and functional.

B. Provide to the owner a portable handheld, ion counter with a calibrated range of 0 to 20,000 ions/cm3 and an accuracy of +/- 25% within the specified range. Ion counter shall have automatic zeroing capability on 10-minute intervals.

3.3 TRAINING

A. See Section 230010 – Mechanical General Provisions.

END OF SECTION 230886

SECTION 230900 - ENERGY MANAGEMENT AND CONTROL SYSTEM - GENERAL

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. Contractor shall furnish and install a direct digital control and Energy Management and Control System (EMCS).

B. The systems to be controlled under work of this Section include but are not limited to the following:

1. HVAC Systems

1.3 RELATED WORK AND REQUIREMENTS

A. Other EMCS Sections:

1. Section 230913 EMCS Basic Materials and Devices
2. Section 230916 EMCS Operator Interfaces
3. Section 230919 EMCS Field Panels
4. Section 230923 EMCS Communication Devices
5. Section 230926 EMCS Software and Programming
6. Section 230933 EMCS Commissioning

B. Coordination with other Divisions. The table in specification 230010 paragraph 1.2-B shall be used to determine scope of work between Division 23 and other Divisions including Divisions 23 and 26. All work not specified to be a part of the EMCS scope of work shall be provided by General Contractor and associated subcontractors for each building and the infrastructure.

C. Testing and Commissioning.

1. Section 230593 Testing, Adjusting and Balancing for HVAC
2. Section 230933 EMCS Commissioning

D. Communications.

1. Connection to Owner’s IT WAN/LAN and terminations to wall jack shall be by Division 23C Contractor. Coordinate connection location of IT WAN/LAN and terminations with Division 26. This connection shall also provide access to Internet through Owner’s firewall to Internet Services Provider procured by Owner.
2. Network IT WAN/LAN drop at required EMCS location(s) specified under Division 26. It shall be the responsibility of the Division 23C contractor to communicate required IT WAN/LAN drop location(s) with Division 26.

1.4 REFERENCE STANDARDS

A. Nothing in Contract Documents shall be construed to permit Work not conforming to applicable laws, ordinances, rules, and regulations. When Contract Documents differ from requirements of applicable laws, ordinances, rules and regulations, EMCS contractor shall comply with documents establishing the more stringent requirement.

B. The latest published or effective editions, including approved addenda or amendments, of the following codes and standard shall apply to the EMCS design and installation as applicable.

C. State and Local Codes:

1. Local City and County Codes.

D. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).

1. ASHRAE 135: BACnet - A Data Communication Protocol for Building Automation and Control Networks.

E. Electronics Industries Alliance.

1. EIA-232: Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
2. EIA-458: Standard Optical Fiber Material Classes and Preferred Sizes.
3. EIA-485: Standard for Electrical Characteristics of Generator and Receivers for use in Balanced Digital Multipoint Systems.
4. EIA-472: General and Sectional Specifications for Fiber Optic Cable.
5. EIA-475: Generic and Sectional Specifications for Fiber Optic Connectors and all Sectional Specifications.
6. EIA-573: Generic and Sectional Specifications for Field Portable Polishing Device for Preparation Optical Fiber and all Sectional Specifications.
7. EIA-590: Standard for Physical Location and Protection of Below-Ground Fiber Optic Cable Plant and all Sectional Specifications.

F. Underwriters Laboratories.

1. UL 916: Energy Management Systems.

G. NEMA Compliance.

1. NEMA 250: Enclosure for Electrical Equipment.
2. NEMA ICS 1: General Standards for Industrial Controls.

H. NFPA Compliance.

1. NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.

I. Institute of Electrical and Electronics Engineers (IEEE).

1. IEEE 142: Recommended Practice for Grounding of Industrial and Commercial Power Systems.
2. IEEE 802.3: CSMA/CD (Ethernet – Based) LAN.
3. IEEE 802.4: Token Bus Working Group (ARCNET – Based) LAN.

1.5 DEFINITIONS

A. Acronyms

AAC	Advanced Application Controller
AH	Air Handler
AHU	Air Handling Unit
AI	Analog Input
ANSI	American National Standards Institute
AO	Analog Output
APDU	Application Protocol Data Unit
ASC	Application Specific Controllers
ASCII	American Standard Code for Information Interchange
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers.
ASME	American Society of Mechanical Engineers.
ASTM	American Society for Testing and Materials.
A-to-D	Analog-to-Digital
BACnet	Data Communications Protocol for Building Automation and Control Systems
BC	Building Controller
BIBB	BACnet Interoperability Building Blocks
BMA	BACnet Manufacturers Association \
CAD	Computer Aided Drafting
CHW	Chilled Water
CHWR	Chilled Water Return
CHWS	Chilled Water Supply
COV	Change of Value
CSS	Control Systems Server
CU	Controller or Control Unit
CV	Constant Volume
CW	Condenser Water
CWR	Condenser Water Return
CWS	Condenser Water Supply
DCS	Digital Control Stations
DBMS	Database Management System
DDC	Direct Digital Control
DHW	Domestic Hot Water
DI	Digital Input
DO	Digital Output
D-to-A	Digital-to-Analog
EMCS	Energy Management and Control System
EMT	Electrical Metallic Tubing
EP	Electro-Pneumatic
ETL	Edison Testing Laboratories.
GUI	Graphical User Interface
HOA	Hand-Off-Automatic
HVAC	Heating, Ventilating and Air-Conditioning'
HTTP	Hyper-Text Transfer Protocol
I/O	Input/output
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization

LAN	Local Area Network
LANID	LAN Interface Device
LCP	Lighting Control Panel
MAC	Medium Access Control
MHz	Megahertz
MS/TP	Master-Slave/Token-Passing
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association.
NIST	National Institute of Standards and Technology
ODBC	Open Database Connectivity
OI	Operator Interface
OWS	Operator Workstation
P	Proportional
PC	Personal Computer
PI	Proportional-Integral
PICS	Protocol Implementation Conformance Statement
PID	Proportional-Integral-Derivative
POT	Portable Operators Terminal
PTP	Point-to-Point
RAM	Random Access Memory
SOO	Sequence of Operation
SQL	Standardized Query Language
SSL	Secure Socket Layers
TAB	Test, Adjust, and Balance
TDR	Time Delay Relay
THS	Trend Historian Server
UL	Underwriters' Laboratories, Inc.
XML	Extensible Markup Language

B. Terms

Term	Definition
Accessible	Locations that can be reached with no more than a ladder to assist access and without having to remove permanent partitions or materials. Examples include inside mechanical rooms, mechanical equipment enclosures, instrument panels, and above suspended ceilings with removable tiles.
Advanced Application Controller	A device with limited resources relative to the Building Controller. It may support a level of programming and may also be intended for application specific applications.
Application Protocol Data Unit	A unit of data specified in an application protocol and consisting of application protocol control information and possible application user data (ISO 9545).
Application Specific Controller	A device with limited resources relative to the Advanced Application Controller. It may support a level of programming and may also be intended for application-specific applications. .
BACnet Interoperability Building Blocks	A 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 in a specification.
BACnet/BACnet Standard	BACnet communication requirements as defined by the latest version of ASHRAE/ANSI 135 and approved addenda.

Building Controller	A fully programmable device capable of carrying out a number of tasks including control and monitoring via direct digital control of specific systems, acting as a communications router between the LAN backbone and sub-LANs, and data storage for trend information, time schedules, and alarm data.
Change of Value	An event that occurs when a digital point changes value or an analog value changes by a predefined amount
Client	A device that is the requestor of services from a server. A client device makes requests of and receives responses from a server device.
Concealed	Embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces, or in enclosures.
Continuous Monitoring	A sampling and recording of a variable based on time or change of state (e.g., trending an analog value, monitoring a binary change of state).
Contract Documents	Specifications, drawings, and other materials provided with request for bids.
Contractor, EMCS Contractor, or Division 23C Contractor	The Contractor retained by Owner to execute the work defined in Division 23C and associated design documents
Control Systems Server	A computer (or computers) that maintains the systems configuration and programming database.
Controller or Control Unit	Intelligent stand-alone control panel. Controller is a generic reference and shall include BCs, AACs, and ASCs as appropriate.
Digital Control Stations	One or more EMCS control panels
Direct Digital Control	Microprocessor-based control including Analog/Digital conversion and program logic
Energy Management and Control System	The entire integrated management and control system
Equal	Approximately equal in material types, weight, size, design, quality, and efficiency of specified product.
Exposed	Not installed underground or concealed.
Extensible Markup Language	A specification developed by the World Wide Web Consortium. XML is a pared-down version of SGML, designed especially for Web documents. It allows designers to create their own customized tags, enabling the definition, transmission, validation, and interpretation of data between applications and between organizations.
Functional Profile	A collection of variables required to define the key parameters for a standard application. As this applies to the HVAC industry, this would include applications like VAV terminal, fan coil units, and the like.
Gateway	Bi-directional protocol translator connecting control systems that use different communication protocols
Handheld Device	Manufacturer’s microprocessor-based device for direct connection to a Controller.
Inaccessible	Locations that do not meet the definition of accessible. Examples include inside furred walls, pipe chases and shafts, or above ceilings without removable tiles.
Indicated, shown, or noted	As indicated, shown, or noted on drawings or specifications.
Install	To erect, mount and connect complete with related accessories.
Instrumentation	Gauges, thermometers, and other devices mounted in ductwork or piping that are not a part of the automatic temperature control

	system
IT LAN	Reference to the facility's Information Technology network, used for normal business-related e-mail and Internet communication.
LAN Interface Device	Device or function used to facilitate communication and sharing of data throughout the EMCS
Local Area Network	General term for a network segment within the architecture.
Supervisory LAN	Ethernet-based LAN connecting Primary Controller LANs with each other and OWSs, CSS, and THS. See System Architecture below.
Master-Slave/Token Passing	Data link protocol as defined by the BACnet standard.
Motor Controllers	Manual or magnetic starters (with or without switches), individual pushbuttons or hand-off-automatic (HOA) switches controlling the operation of motors.
Open Database Connectivity	An open standard application-programming interface for accessing a database developed. ODBC compliant systems make it possible to access any data from any application, regardless of which database management system is handling the data.
Operator Interface	A device used by the operator to manage the EMCS including OWSs, POTs, and HHDs.
Operator Workstation	The user's interface with the EMCS system. As the EMCS network devices are stand-alone, the OWS is not required for communications to occur.
Piping	Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation, and related items.
Points	All physical I/O points, virtual points, and all application program parameters.
Point-to-Point	Serial communication as defined in the BACnet standard.
Portable Operators Terminal	Laptop PC used both for direct connection to a controller and for remote dial up connection.
Primary Controlling LAN	High speed, peer-to-peer controller LAN connecting BCs and optionally AACs and ASCs. Refer to System Architecture below.
Protocol Implementation Conformance Statement	A written document, created by the manufacturer of a device, which identifies the particular options specified by BACnet that are implemented in the device (ASHRAE/ANSI 135).
Provide	To supply, install and connect up complete and ready safe and regular operation of particular work referred to unless specifically noted.
Reviewed, approved, or directed	As reviewed, approved, or directed by the Owner.
Router	A device that connects two or more networks at the network layer.
Secondary Controlling LAN	LAN connecting AACs and ASCs. Generally lower speed and less reliable than the Primary Controlling LAN. Refer to System Architecture below.
Server	A device that is a provider of services to a client. A client device makes requests of and receives responses from a server device.
Smart Device	A control I/O device such as a sensor or actuator that can directly communicate with the controller network to which it is connected. This differs from an ASC in that it typically deals only with one variable.
Standardized Query Language	A standardized means for requesting information from a database.
Supply	To purchase, procure, acquire and deliver complete with related

	accessories.
Trend Historian Server	A computer (or computers) that maintains the database of recorded trend logs.
Owner	Owner, University, Institution and/or its designated representatives.
Wiring	Raceway, fittings, wire, boxes, and related items.
Work	Labor, materials, equipment, apparatus, controls, accessories, and other items required for proper and complete installation.

1.6 QUALITY ASSURANCE

A. Materials and Equipment

1. Manufacturer's Qualifications: See PART 2 for approved manufacturer.
2. Product Line Demonstrated History: The direct digital control equipment product line being proposed for the project must have an installed history of demonstrated satisfactory operation for a length of one year since date of final completion in at least 10 installations of comparative size and complexity.
3. All products used in this project installation shall be new, currently under manufacture, and shall have been available from the manufacturer for a minimum of 6 months prior to date of proposal and previously installed and proven effective in installations of similar nature, not including test sites. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner in writing. Spare parts shall be available for at least five years after completion of this contract.
4. All BACnet devices must either be certified as complaint with BACnet through the BACnet Manufacturers Association or the vendor must supply proof of having submitted the device for testing by BMA.
5. The EMCS and components shall be listed by Underwriters Laboratories UL 916 as an Energy Management System.

B. Installer

1. EMCS Contractor's Project Manager Qualifications: Individual shall specialize in and be experienced with direct digital control system installation for not less than 3 years. Project Manager shall have experience with the installation of the proposed direct digital control equipment product line for not less than 2 projects of similar size and complexity. Project Manager must have proof of having successfully completed the most advanced training offered by the manufacturer of the proposed product line.
2. EMCS Contractor's Programmer Qualifications: Individual(s) shall specialize in and be experienced with direct digital control system programming for not less than 3 years and with the proposed direct digital control equipment product line for not less than 1.5 years. Programmers must show proof of having successfully completed the most advanced programming training offered by the vendor of the programming application on the proposed product line.
3. EMCS Contractor's Service Qualifications: The installer must be experienced in control system operation, maintenance, and service. EMS Contractor must document a minimum 5-year history of servicing installations of similar size and complexity. Installer must also document at least a 1-year history of servicing the proposed product line.
4. Installer’s Response Time and Proximity.

    a. Installer must maintain a fully capable service facility within Mississippi. Service facility shall manage the emergency service dispatches and maintain the inventory of spare parts.

b. Installer must demonstrate the ability to meet the emergency response times listed in herein.

5. Electrical installation shall be by manufacturer-trained electricians.

a. Exception: Roughing in wiring/conduit and mounting panels may be subcontracted to any licensed electrician.

1.7 SUBMITTALS

A. No work may begin on any segment of this project until the related submittals have been reviewed for conformity with the design intent and the Contractor has responded to all comments to the satisfaction of the Architect.

B. Submit drawings, product data, samples and certificates of compliance required as hereinafter specified. See also Division 1 Shop Drawings, Product Data and Samples. Conditions in this Section take precedence over conditions in above referenced Section.

C. Submittal Schedule: Submittal schedule shall be as follows unless otherwise directed by the Owner:

1. Allow 10 working days for approval unless Architect agrees to accelerated schedule.
2. Submittal Package 1 (Hardware and Shop Drawings) shall be submitted in accordance with schedule established by the Owner in bid documents.
3. Submittal Package 2 (Programming and Graphics) and shall be submitted no less than 30 days before software is to be installed in field devices.
4. Submittal Package 3 (Functional Testing) shall be submitted no less than 30 days prior to conducting tests.
5. Submittal Package 4 (Training Materials) shall be submitted no less than 14 days prior to conducting first training class.
6. Submittal Package 5 (Post-Construction Trend Logs) shall be submitted after demonstration tests are accepted and systems are in full automatic operation. The list of points to be trended shall be submitted for approval 14 days prior to the start of the trend collection period.
7. Submittal Package 6 (End-of-Warranty Trend Logs) shall be submitted 30 days prior to the end of the warranty period.

D. Submission and Resubmission Procedure:

1. Each submittal shall have a unique serial number that includes the associated specification section followed by a number for each sub-part of the submitted for that specification section, such as SUBMITTAL 230900-01.
2. Each resubmittal shall have the original unique serial number plus unique revision number such as SUBMITTAL 230900-01 REVISION 1.
3. Submit one copy of submittal in electronic format specified under each submittal package below. Submissions made in the wrong format will be returned without action.
4. Submit two (2) and only two hardcopies copies of submittals to Architect for review. Any additional copies will be returned without review.
5. Architect will return one copy with comments and corrections noted where required.
6. Make corrections:

a. Revise initial drawings or data.
b. Indicate any changes that have been made other than those requested.
c. Clearly identify resubmittal by original submittal number and revision number.

7. Resubmit two (2) and only two copies of revised submittals to Architect for review until no exceptions are taken.
8. Once submittals are accepted and stamped with no exceptions taken, Contactor shall make photocopies for coordination with other trades, as required by the General Contractor. Photocopies will serve as submittal for record and coordination.

E. Submittals Packages

1. Submittal Package 1 (Hardware and Shop Drawings).

a. Provide Installer and Key personnel qualifications as specified.
b. Hardware

1) Organize by specification section and device tags as tagged in these specifications.
2) Do not submit products that are not used even if included in specifications.
3) Include a summary table of contents listing for every submitted device:

a) Tab of submittal file/binder where submittal is located.
b) Device tag as tagged in these specifications (such as TS-1A, FM-1).
c) Specification section number (down to the lowest applicable heading number).
d) Whether device is per specifications and a listed product or a substitution.
e) Manufacturer.
f) Model Number.
g) Device accuracy (where applicable).
h) Accuracy as installed including wiring and A/D conversion effects (where applicable).

4) Submittal shall include manufacturer’s description and technical data, such as performance data, product specification sheets, and installation instructions for all control devices and software.
5) When manufacturer's cut-sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements.
6) A BACnet_ Protocol Implementation Conformance Statement (PICS) for each type of controller and operator interface shall be included submittals.
7) Format: Electronic word-searchable format.

c. Shop Drawings

1) Format

a) Sheets shall be consecutively numbered.
b) Each sheet shall have a title indicating the type of information included and the mechanical/electrical system controlled.
c) Table of Contents listing sheet titles and sheet numbers.
d) Legend and list of abbreviations.
e) Schematics: (AutoCAD compatible format, 17-inch x 11-inch.)
f) Floor plans: None required.

2) System architecture one-line diagram indicating schematic location of all control units, workstations, LAN interface devices, gateways, etc. Indicate

address and type for each control unit. Indicate media, protocol, baud rate, and type of each LAN.

3) Schematic flow diagram of each air and water system showing fans, coils, dampers, valves, pumps, heat exchange equipment and control devices. The schematics provided with bid package shall be the basis on the EMCS Contractor's schematics with respect to control points, but EMCS Contractor may use alternative graphics format.
4) All physical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses identified as listed in the point summary table.
5) With each schematic, provide a point summary table listing building number and abbreviation, system type, equipment type, full point name, point description, Ethernet backbone network number, network number, device ID, object ID (object type, instance number). See Section 230926 - Part 3 for additional requirements.
6) Label each control device with setting or adjustable range of control.
7) Label each input and output with the appropriate range.
8) Device table (Bill of Materials). With each schematic, provide a table of all materials and equipment including:

    a) Device tag as indicated in the schematic and actual field labeling (use tag as indicated in these specifications where applicable and practical.)
    b) Device tag as indicated in these specifications where applicable and if it differs from schematic device tag.
    c) Description.
    d) Proposed manufacturer and model number.
    e) Range.

9) With each schematic or on separate valve sheet, provide valve and actuator information including size, C_v, design flow, target pressure drop, actual design pressure drop, manufacturer, model number, close off rating, etc. Indicate normal positions of spring return valves and dampers.
10) Indicate all required electrical wiring. Electrical wiring diagrams shall include both ladder logic type diagram for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified. Provide panel termination drawings on separate drawings. Ladder diagrams shall appear on system schematic. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
11) Details of control panels, including controls, instruments, and labeling shown in plan or elevation indicating the installed locations.

d. Do not include sequence of controls on shop drawings or equipment submittals; they are included in Submittal Package 2.
e. Submit along with shop drawings but under separate cover memory allocation projections and calculated and guaranteed response times of the most heavily loaded LAN in the system.

2. Submittal Package 2 (Programming and Graphics).

a. A detailed description of point naming convention conforming to Section 230926 to be used for all software and hardware points.
b. A list of all hardware and software points identifying their text names, device addresses and descriptions.
c. Control Logic Documentation:

1) Submit control logic program listings (graphical programming) consistent with specified English-language Sequences of Operation for all control units.
2) Control logic shall be annotated to describe how it accomplishes the sequence of operation. Annotations shall be sufficient to allow an operator to relate each program component (block or line) to corresponding portions of the specified Sequence of Operation.
3) Include specified English-language Sequences of Operation of each control sequence updated to reflect any suggested changes made by the Contractor to clarify or improve the sequences. Changes shall be clearly marked. SOO shall be fully consistent with the graphical programming. (An electronic version of the sequences of controls on drawings will be provided to the Contractor upon request.)
4) Include control settings, setpoints, throttling ranges, reset schedules, adjustable parameters, and limits.
5) Submit one complete set of programming and operating manuals for all digital controllers concurrently with control logic documentation. This set will count toward the required number of Operation and Maintenance materials specified below.

d. Graphic screens of all required graphics, provided in final colors, one 11” x 8.5” page per screen.
e. Format:

1) Points list: Word-searchable format.
2) Programming: Native electronic file if interpreter is available, otherwise provide pdf files of screen shots.
3) Graphics: Graphical electronic format (pdf, png, etc.).

3. Submittal Package 3 (Functional Testing).

a. Provide pre-functional test forms as required by Section 230933.
b. Provide functional test forms as required by Section 230933.
c. Format: Word-searchable format.

4. Submittal Package 4 (Training Materials).

a. Provide training materials as required by Section 230933.
b. Format: Word-searchable format.

5. Submittal Package 5 and 6 (Trend Logs).

a. Provide a list of points being trended along with trend interval or change-of-value per drawings.
b. Provide trend logs as required by drawings.
c. Format: See Section 230926.

1.8 COMPLETION REQUIREMENTS

A. Procedure.

1. Until the documents required in this section are submitted and approved, the system will not be considered “accepted” and final payment to EMCS Contractor will not be made.
2. Before requesting acceptance of work, submit one set of completion documents for review and approval of Owner.

3. After review, furnish quantity of sets indicated below to Owner.

B. Completion Documents.

1. Operation and Maintenance (O & M) Manuals. Provide in both paper and electronic format per paragraph 1.8C.

    a. Include all submittals (product data, shop drawings, control logic documentation, hardware manuals, software manuals, installation guides or manuals, maintenance instructions and spare parts lists) in maintenance manual; in accordance with requirements of Division 1.
    b. As-built versions of the submittal product data. Submittal data shall be located in tabs along with associated maintenance information.
    c. Engineering, Installation, and Maintenance Manual(s) that explain how to design and install new points, panels, and other hardware; preventive maintenance and calibration procedures; how to debug hardware problems; and how to repair or replace hardware.
    d. Complete original issue documentation, installation, and maintenance information for all third-party hardware and software provided, including computer equipment and sensors.
    e. A list of recommended spare parts with part numbers and suppliers.
    f. Operators Manual with procedures for operating the control systems, including logging on/off, alarm handling, producing point reports, trending data, overriding computer control, and changing set points and other variables.
    g. Programming Manuals with a description of the programming language, control block descriptions (including algorithms and calculations used), point database creation and modification, program creation and modification, and use of the programming editor.
    h. Recommended preventive maintenance procedures for all system components, including a schedule of tasks (inspection, cleaning, calibration, etc.), time between tasks, and task descriptions.
    i. A listing and documentation of all custom software for the project created using the programming language, including the set points, tuning parameters, and point and object database.
    j. English language control sequences updated to reflect final programming installed in the EMCS at the time of system acceptance.

2. Complete original issue USB drive/CDs for all software provided, including operating systems, programming language, operator workstation software, and graphics software.
3. Project Record Drawings.

    a. “As-built” versions of the submittal drawings in reproducible paper and electronic format per paragraph 1.8C.
    b. Provide as-built network architecture drawings showing all BACnet nodes including a description field with specific controller/device identification, description, and location information.
    c. Record floor plans with controller locations with all interconnecting wiring routing including space sensors, LAN wiring, power wiring, low voltage power wiring. Indicate device instance, address and drawing reference number.

4. Commissioning Reports. Completed versions of all Pre-functional, Functional, and Demonstration Commissioning Test reports, calibration logs, etc., per Section 230933.
5. Copy of inspection certificates provided by the local code authorities.
6. Written guarantee and warranty documents for all equipment and systems, including the start and end date for each.
7. Training materials as required by Section 230933.

8. Contact information. Names, addresses, and 24-hour telephone numbers of contractors installing equipment, and the control systems and service representatives of each.

C. Format of Completion Documents.

1. Provide the type and quantity of media listed in table below.
2. Documents such as manuals and control sequences shall be in word-searchable electronic format such as MS Word, Adobe Acrobat (pdf), and HTML and broken into separate files for each type of equipment. Record drawings shall be in original format per paragraph 1.06F.
3. Optical media shall be readable on Operator Workstations.

	Document	Paper (binder or bound)	Electronic	
			Read only optical disk	Loaded onto OWSs and POTs
1.	O&M Manual	5	1	1
2.	Original issue software	–	1 per workstation	1
3.	Project Record Drawings	5	1	1
4.	Control sequences	1	1	1
5.	Commissioning Reports	5	–	–
6.	Inspection Certificates	1	–	–
7.	Warranty documents	1	–	–
8.	Training materials	1 per trainee	–	–
9.	Contact information	1	–	1

D. Permanent On-site Documentation.

1. In panels, provide point list of all points in panel in sufficiently permanent manner that list cannot be easily removed (and lost).
2. Mount half size drawings of primary system schematics and network architecture in glass covered frame. The number of drawings will depend on the complexity of the system; compressed or abridged versions of shop drawings are acceptable provided all control points are shown. Mount the drawings in space available in mechanical rooms. Drawings may be mounted in different locations, e.g., air handler schematic may be in fan room, chiller schematic in chiller room, etc.

1.9 SYSTEM ARCHITECTURE

A. General.

1. The system provided shall incorporate hardware resources sufficient to meet the functional requirements of these Specifications. The Contractor shall include all items not specifically itemized in these Specifications that are necessary to implement, maintain, and operate the system in compliance with the functional intent of these Specifications.
2. The control system shall consist of a high-speed, peer-to-peer network of DDC controllers, a control system server, and an operator workstation capable of expansion as specified herein.
3. System software shall be based on a server/thin-client architecture, designed around the open standards of web technology. The control system server shall be accessed using a Web browser over the control system network, the Owner's local area network, and remotely over the Internet (through the Owner's LAN).

4. The intent of the thin-client architecture is to provide operators complete access to the control system via a Web browser. No special software other than a Web browser shall be required to access graphics, point displays, and trends, configure trends, configure points and controllers, or to edit programming.
5. Performance Monitoring. The EMCS will provide the specified performance monitoring functionality, including required monitoring points and performance metrics, improved through system accuracy, data acquisition and data management capabilities, and required graphical and data displays.
6. Event Response. The EMCS will provide the specified operational changes based on event response from the energy service provider.
7. All control products provided for this project shall comprise an interoperable fully-native BACnet system, including all communication media, connectors, repeaters, hubs, and routers necessary for the network. All control products provided for this project shall conform to ANSI/ASHRAE Standard 135.

B. EMCS network architecture.

1. Supervisory LAN: The LAN shall be an Ethernet-based, 100/1000 Mbps network connecting the control system servers and OWSs to routers in each building. Contractor shall utilize the Owner's Enterprise IT LAN/WAN for this purpose. This network shall be BACnet/IP as defined in Addendum A (Annex J) of the BACnet standard and shall share a common network number for the Ethernet backbone, as defined in BACnet.
2. Primary Controller LAN (Primary LAN): High-speed, peer-to-peer communicating LAN used to connect AACs, ASCs and BCs and communicate exclusively control information. Acceptable technologies include:

    a. Ethernet (IEEE 802.3).

3. Secondary Controller LAN (Secondary LAN or Sub-LAN): Network used to connect AACs and ASCs. These can be Master Slave/ Token Passing or polling, in addition to those allowed for Primary Controller LANs. Network speed vs. the number of controllers on the LAN shall be dictated by the response time and trending requirements.

C. Operator Interfaces and Servers.

1. The Operator Workstations shall provide for overall system supervision, graphical user interface, management report generation, and alarm annunciation.
2. Remote monitoring and control shall be through use of a web browser through the Owner's IT LAN and via the internet through the Owner's IT LAN.

D. Controllers. The BCs, AACs, and ASCs shall monitor, control, and provide the field interface for all points specified. Each BC, AAC, or ASC shall be capable of performing all specified energy management functions, and all DDC functions, independent of other BCs, AACs, or ASCs and operator interface devices.

1.10 SYSTEM PERFORMANCE

A. The communication speed between the controllers, LAN interface devices, and operator interface devices shall be sufficient to ensure fast system response time under any loading condition. This includes when system is collecting trend data for commissioning and for long term monitoring. (See Section 230933.) In no case shall delay times between an event, request, or command initiation and its completion be greater than those listed herein, assuming no other simultaneous operator activity. Contractor shall reconfigure LAN as necessary to accomplish

these performance requirements. This does not apply to gateways and their interaction with non-EMCS-vendor equipment.

1. Object Command. The maximum time between an operator command via the operator interface to change an analog or binary point and the subsequent change in the controller shall be less than 5 seconds.
2. Object Scan. All changes of state and change of analog values will be transmitted over the network such that any data used or displayed at a controller or workstation will have been current within the previous 10 seconds.
3. Graphics Scan. The maximum time between an operator's selection of a graphic and it completely painting the screen and updating at least 10 points shall be less than 10 seconds.
4. Alarm Response Time. The maximum time from when an object goes into alarm to when it is annunciated at the workstation or broadcast to pager (where so programmed) shall not exceed 10 seconds for a Level 1 or 2 alarm, 20 seconds for alarm levels 2 and 3, and 30 seconds for alarm levels 4 and 5. All workstations on the onsite network must receive alarms within 5 seconds of each other.
5. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 seconds. The EMCS Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
6. Control Loop Performance. Programmable controllers shall be able to execute DDC PID control loops at a selectable frequency of at least once per second. The controller shall scan and update the process value and output generated by this calculation at this same frequency.

1.11 OWNERSHIP OF PROPRIETARY MATERIAL

A. All project-developed software and documentation shall become the property of the Owner. These include, but are not limited to:

1. Project graphic images
2. Record drawings.
3. Project database.
4. Project specific application programming code.
5. All documentation.

1.12 WARRANTY

A. In accordance with Division 1 Guarantees, Warranties, Bonds, Service & Maintenance Contracts, and as follows.

B. At the successful completion of the final testing, commissioning, and demonstration phase in accordance with the terms of this specification, if equipment and systems are operating satisfactorily to the Owner and if all completion requirements per paragraph 1.07 have been fulfilled, the Owner shall certify in writing that the control system has been accepted. The date of acceptance shall be the start of the warranty period.

C. Guarantee all materials, equipment, apparatus, and workmanship (including programming) to be free of defective materials and faulty workmanship for period of one year from date of acceptance.

1. Valve and damper actuators shall carry a manufacturer's 5-year warranty.

D. Provide new materials, equipment, apparatus, and labor to replace that determined by Owner to be defective or faulty.

E. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner. The EMCS Contractor shall respond to the Owner's request for warranty service within 24 hours during normal business hours.

F. Operator workstation software, project-specific software, graphic software, database software, and firmware updates that resolve known software deficiencies as identified by the EMCS Contractor shall be provided at no charge during the warranty period. Software bugs (both due to programming misinterpretations and sequence errors) shall be corrected and any reasonable control sequence changes required to provide proper system operation shall also be provided at no additional cost during this period.

1.13 WARRANTY MAINTENANCE

A. The Owner reserves the right to make changes to the EMCS during the warranty period. Such changes do not constitute a waiver of warranty. The Contractor shall warrant parts and installation work regardless of any such changes made by the Owner unless the Contractor provides clear and convincing evidence that a specific problem is the result of such changes to the EMCS.

B. At no cost to the Owner, during the warranty period, the Contractor shall provide maintenance services for software and hardware components as specified below:

1. Maintenance services shall be provided for all devices and hardware specified in Division 23C. Service all equipment per the manufacturer’s recommendations.
2. Emergency Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would result in property damage or loss of comfort control shall be corrected and repaired following telephonic notification by the Owner to the Contractor.
3. Normal Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would not result in property damage or loss of comfort control shall be corrected and repaired following telephonic notification by the Owner to the Contractor.
4. Owner’s Telephonic Request for Service: Contractor shall specify a maximum of three telephone numbers for Owner to call in the event of a need for service. At least one of the lines shall be attended continuously (24/7). Alternatively, pagers can be used for technicians trained in system to be serviced. One of the three paged technicians shall respond to every call within 15 minutes.
5. Technical Support: Contractor shall provide technical support by telephone throughout the warranty period.
6. Preventive maintenance shall be provided throughout the warranty period in accordance with the hardware component manufacturer's requirements.
7. Record drawings and software documentation shall be updated as required to reflect any and all changes made to the system or programming during the warranty period.

PART 2 - PRODUCTS

2.1 MANUFACTURERS (PRODUCT LINE)

A. Johnson Controls (Metasys)

B. Trane (Tracer SC)

C. Siemens (Talon)

D. Schneider (SmartStruxture)

2.2 MATERIALS AND EQUIPMENT

A. Materials shall be new, the best of their respective kinds without imperfections or blemishes and shall not be damaged in any way.

B. To the extent practical, all equipment of the same type serving the same function shall be identical and from the same manufacturer

PART 3 - EXECUTION

3.1 COORDINATION

A. The Contractor shall coordinate work schedule with Architect to complete project on schedule without disruption or delays.

B. The Contractor shall coordinate work with other trades prior to construction.

C. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION

A. Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings.

B. Refer to additional requirements in other Sections of this specification.

3.3 DIGITAL CONTROL STATIONS

A. Individual Digital Control Stations referenced on drawings to indicate allocation of points to each DCS and DCS location. Digital control stations shall consist of one or multiple controllers to meet requirements of this specification. It is the Contractor's responsibility to provide enough controllers to ensure a completely functioning system, according to the point list and sequence of operations.

B. Where a DCS is referenced, Contractor shall provide at least one (1) controller, and additional controllers as required, in sufficient quantity to meet the requirements of this Specification. Restrictions in applying controllers are specified in Section 230919 - EMCS Field Panels.

C. Contractor is responsible for ensuring DCSs do not interfere with other requirements of the project and maintain adequate clearance for maintenance access.

D. DCSs have not been located. The Contractor shall locate DCSs in electrical rooms, mechanical rooms, and adjacent to rooftop equipment where space is available.

E. Contractor is responsible for ensuring DCSs do not interfere with other requirements of the project and maintain adequate clearance for maintenance access.

3.4 CONTROL POWER

A. Division 23C Contractor shall extend power to all EMCS devices, including 120V power to panels, from an acceptable power panel.

1. See Division 26 Electrical drawings for power locations pre-allocated for EMCS system.
2. Where no power source is shown, for bid purposes only, assume a dedicated circuit is available within an average of 50 feet of panel location. If this is not the case, request additional cost prior to submission of shop drawings or no additional costs will be reimbursed.
3. Coordinate with Division 26 during shop drawing development for final connection location.

B. General requirements for obtaining power include the following:

1. Obtain power from a source that feeds the equipment being controlled such that both the control component and the equipment are powered from the same panel. Where equipment is powered from a 460V source, obtain power from the electrically most proximate 120v source fed from a common origin.
2. Where control equipment is located inside a new equipment enclosure, coordinate with the equipment manufacturer and feed the control with the same source as the equipment. If the equipment's control transformer is large enough and of the correct voltage to supply the controls, it may be used. If the equipment's control transformer is not large enough or of the correct voltage to supply the controls, the Contractor shall provide separate transformer(s).
3. Where a controller controls multiple systems on varying levels of power reliability (normal, emergency, and/or interruptible), the controller shall be powered by the highest level of reliability served.
4. Standalone Functionality: Refer to Section 230919.

C. Power line filtering. Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component.

3.5 DELIVERY, STORAGE, AND HANDLING

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons during shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment.

B. Store equipment and materials inside and protect from weather.

3.6 IDENTIFICATION

A. General:

1. Manufacturers' nameplates and UL or CSA labels to be visible and legible after equipment is installed.
2. Identifiers shall match record documents.

3. All plug-in components shall be labeled such that removal of the component does not remove the label.

B. Wiring and Tubing:

1. All wiring and cabling, including that within factory-fabricated panels, shall be labeled at each end within 2" of termination with the DDC address or termination number.
2. Permanently label or code each point of field terminal strips to show the instrument or item served.
3. All pneumatic tubing shall be labeled at each end within 2" of termination with a descriptive identifier.

C. Equipment and Devices

1. Valve and damper actuators: Provide 2" diameter brass tags and brass chains. Lettering shall be 1/2" high, stamped and painted black. Indicate unique valve or damper identifier from record drawings.
2. Sensors: Provide 1"x 3"x 1/8” black micarta or lamacoid labels with engraved white lettering, 1/4" high. Indicate sensor identifier and function (e.g., “CHWS temp”).
3. Panels: Provide 2"x 5" 1/8” black micarta or lamacoid labels with engraved white lettering, 1/2" high. Indicate panel identifier and service.
4. Identify room sensors relating to terminal box or valves with indelible marker on sensor hidden by cover.

3.7 CUTTING, CORING, PATCHING & PAINTING

A. The EMCS Contractor shall provide canning for openings in concrete walls and floors and other structural elements prior to their construction. Should any openings be missed, the EMCS Contractor shall be responsible for all cutting, coring, and patching that may be required for Division 23C work. Structural elements shall not be cut without the written consent of Owner.

B. Penetrations through rated walls or floors shall be filled with an approved material to provide a code compliant firestop.

C. All damage to and openings in ductwork, piping insulation, and other materials and equipment resulting from Division 23C work shall be properly sealed, repaired, and/or re-insulated by experienced mechanics of the trade involved. Repair insulation to maintain integrity of insulation and vapor barrier jacket. Use hydraulic insulating cement to fill voids and finish with material matching or compatible with adjacent jacket material.

D. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired and repainted to original finish.

3.8 CLEANING

A. The EMCS Contractor shall clean up all debris resulting from its activities daily. The EMCS Contractor shall remove all cartons, containers, crates, etc., under its control as soon as their contents have been removed. Waste shall be collected and legally disposed of by EMCS Contractor.

B. At the completion of work in any area, the EMCS Contractor shall clean all of its work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

C. The EMCS Contractor shall use only cleaning materials recommended by the manufacturer of the surfaces to be cleaned and on surfaces recommended by the cleaning material manufacturer.

3.9 FIELD QUALITY CONTROL

A. See Division1 Quality Control.

B. Perform tests as required by authorities having jurisdiction.

C. Repair or replace defective work, as directed by Architect in writing, at no additional cost to the Owner.

D. Restore or replace damaged work due to tests as directed by Architect in writing, at no additional cost to the Owner.

E. Restore or replace damaged work of others, due to tests, as directed by Architect in writing, at no additional cost to the Owner.

F. Remedial work shall be performed to the satisfaction of the Architect, at no additional cost to the Owner, including:

1. Work related to all Division 23C pre-functional, functional, and demonstration tests.
2. Division 23C work related to Section 230593 Testing, Adjusting and Balancing for HVAC.

G. Remedial work shall include performing any commissioning or other tests related to remedial work and additional time at no additional cost to the Owner.

END OF SECTION 230900

SECTION 230913 – EMCS BASIC MATERIALS AND DEVICES

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 WORK INCLUDED

A. Provide and install the following:

1. Field devices including control valves, control dampers, sensors, etc.

B. Refer to Section 230900 for general requirements.

C. Refer to drawings for points list and specific device requirements.

1.3 RELATED WORK AND REQUIREMENTS

A. Other EMCS Sections:

1. Section 230900 Energy Management and Control System (EMCS) - General
2. Section 230916 EMCS Operator Interfaces
3. Section 230919 EMCS Field Panels
4. Section 230923 EMCS Communication Devices
5. Section 230926 EMCS Software and Programming
6. Section 230933 EMCS Commissioning

1.4 GENERAL

A. Sensor selection, wiring method, use of transmitters, A-to-D conversion bits, etc. shall be selected and adjusted to provide end-to-end (fluid to display) accuracy at or better than those listed in the following table.

Measured Variable	Reported Accuracy
Space dry bulb temperature	±1ºF
Ducted air-dry bulb temperature	±0.5ºF
Mixed air-dry bulb temperature	±1ºF
Outside air dry bulb temperature	±0.5ºF
Hot water temperature	±1ºF
Relative humidity – general	±5% RH
Water and gas flow	±1% of full scale
Airflow (terminal)	±10% of reading
Airflow (measuring stations)	±5% of full scale
Air pressure (ducts)	±0.05 inches
Air pressure (space)	±0.01 inches
Water pressure	±2% of full scale

Measured Variable	Reported Accuracy
Electrical power	1% of reading
Carbon Dioxide (CO_2)	±75 ppm

B. The listing of several sensors or devices in each section of Part 2 does not imply that any may be used. Refer to points list on drawings for device specification. Only where two or more devices are specifically listed in points list (e.g., “FM-1 or FM-4”) may the contractor supply any of the listed products.

PART 2 - PRODUCTS

2.1 AIR TUBING

A. Seamless copper tubing, Type L-ACR, ASTM B 88; with cast-bronze solder joint fittings, ANSI B1.18; or wrought-copper solder joint fittings, ANSI B16.22; except brass compression-type fittings at connections to equipment. Solder shall be 95/5 tin antimony, or other suitable lead-free composition solder.

B. Virgin polyethylene non-metallic tubing type FR, ASTM D 2737, and with flame-retardant harness for multiple tubing. Use compression or push-on brass fittings.

2.2 ELECTRIC WIRING AND DEVICES

A. General. All electrical work shall comply with Division 26.

B. Power Wiring.

1. Power wiring and wiring connections required for EMCS shall be provided under this section unless specifically shown on drawings or specified to be under Division 26. See Coordination Section in Section 230900.
2. See Control Power section of 230900.

C. Communication Wiring.

1. Contractor shall supply all communication wiring between Building Controllers, Routers, Gateways, AAC’s, ASC’s and local and remote peripherals (e.g., operator workstations, printers, and modems).
2. Supervisory LAN: For any portions of this network required under this section of the specification, contractor shall use Fiber or Category 5 of standard TIA/EIA 68 (10baseT). Network shall be run with no splices and separate from any wiring over thirty (30) volts.
3. Primary and Secondary Controller LANs: Communication wiring shall be individually 100% shielded pairs per manufacturers recommendations for distances installed, with overall PVC cover, Class 2, plenum-rated run with no splices and separate from any wiring over thirty (30) volts. Shield shall be terminated, and wiring shall be grounded as recommended by BC manufacturer.

D. Signal Wiring.

1. Signal wiring to all field devices, including, but not limited to, all sensors, transducers, transmitters, switches, etc. shall be twisted, 100% shielded pair, minimum 18-gauge wire, with PVC cover. Signal wiring shall be run with no splices and separate from any wiring above thirty (30) volts.

2. Signal wiring shield shall be grounded at controller end only unless otherwise recommended by the controller manufacturer.

E. Low Voltage Analog Output Wiring.

1. Low voltage control wiring shall be minimum 16-gauge, twisted pair, 100% shielded, with PVC cover, Class 2 plenum-rated. Low voltage control wiring shall be run with no splices separate from any wiring above thirty (30) volts.

2.3 CONTROL CABINETS

A. All control cabinets shall be fully enclosed with hinged door, key-lock latch. A single key shall be common to all field panels and sub-panels within each building. Provide 3 keys.

B. Construction.

1. Indoor: NEMA-1.
2. Outdoor: NEMA 4.

C. Interconnections between internal and face-mounted devices shall be pre-wired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL Listed for service, individually identified per control/interlock drawings, with adequate clearance for field wiring. All control tubing and wiring shall be run neatly and orderly in open slot wiring duct with cover. Control terminations for field connection shall be individually identified per control drawings.

D. Provide ON/OFF power switch with over-current protection for control power sources to each local panel.

E. Provide with:

1. Framed, plastic-encased point list for all points in cabinet.
2. Nameplates for all devices on face.

2.4 CONTROL VALVES

A. Manufacturers:

1. Belimo
2. Siemens
3. Johnson Controls
4. Invensys
5. Delta
6. Or equal

B. Plug-Type Globe Pattern for Water Service:

1. Valves shall have cage-type trim, providing seating and guiding surfaces for plug on ‘top-and-bottom’ guided plugs.
2. Temperature Rating: 25˚F minimum, 250˚F maximum.
3. Body:

a. Bronze screwed for 1/2” to 2”.

b. Cast Iron, flanged for 2-1/2" and larger.

4. Valve Trim: Bronze; Stem: Polished stainless steel.
5. Packing: Spring Loaded Teflon or Synthetic Elastomer U-cups, self-adjusting.
6. Plug: Brass, bronze or stainless steel, Seat: Brass.
7. Disc: Replaceable Composition or Stainless Steel Filled PTFE.
8. Ambient Operating Temperature Limits: -10 to 150˚F.

C. Butterfly Type:

1. Body: Extended neck epoxy coated cast or ductile iron with full lug pattern, ANSI Class bolt pattern to match specified flanges.
2. Seat: EPDM replaceable, non-collapsible, phenolic backed.
3. Disc: Polished aluminum bronze or stainless steel, pinned or mechanically locked to shaft. Sanded castings are not acceptable.
4. Bearings: Bronze or stainless steel.
5. Shaft: 416 stainless-steel supported at three locations with PTFE bushings for positive shaft alignment.
6. Close Off: Bubble-tight shutoff at rated differential pressure.
7. Operation: Valve and actuator operation shall be smooth both seating and unseating. Should more than 2 psi dead-band be required to seat/unseat the valve, valve shall be replaced at no additional cost to the Owner.
8. Manufacturers in Addition to those listed above:

a. Jamesbury
b. Keystone
c. Dezurik
d. Or equal

D. Characterized Ball Type:

1. Valves shall be specifically designed for modulating duty in control application with guaranteed average leak-free life span over 200,000 full stroke cycles.
2. Maximum size: 3 inch.
3. Industrial quality with nickel plated forged brass bronze bodies and female NPT threads.
4. Blowout proof stem design, glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 600 PSI rating (two-way valves) or 400 PSI rating (three-way valves). The stem packing shall consist of 2 lubricated O-rings designed for on-off, floating, or modulating service and requiring no maintenance.
5. Valves suitable for water or low-pressure steam shall incorporate an anti-condensation cap thermal break in stem design.
6. Ball: stainless steel.
7. Stem: stainless steel.
8. Port: Segmented design with characterizing disk held securely by a keyed ring.

E. Valve assembly pressure ratings:

1. Chilled water: 125 psi at 60˚F.
2. Hot water: 125 psi at 200˚F.
3. Condenser water. 125 psi at 60˚F.

F. Valve Selection:

1. Valve type:

a. Modulating 2-way or 3-way valves: globe or characterized ball type. Butterfly valves may also be used for applications requiring low valve authority (pressure drop 1 psi and less) such as cooling tower bypass and boiler bypass. Valves (in conjunction with actuator) shall have minimum rangeability of 100 to 1.

1) 3 inch and less: characterized ball type.
2) 4 inch and greater: globe type.

b. Two-position: butterfly or ball valves.

2. Valve Characteristic:

a. 2-way valves: equal percentage or modified equal percentage.
b. 3-way valves controlling cooling coils and condenser water heat exchangers: linear.
c. 3-way valves controlling heating coils: equal percentage or modified equal percentage.
d. Two-position valves: not applicable.

3. Valve Sizing:

a. Modulating Water: Size valve to achieve the following full-open pressure drop:

1) Minimum pressure drop: equal to pressure drop of coil or exchanger.
2) Maximum pressure drop:

a) Hot and chilled water at bridge connection: 2 psi.
b) Hot water at coils: 2 psi.
c) Chilled water at coils: 5 psi.
d) Tower bypass: 1 psi.
e) Boiler bypass: 1 psi.

3) Three-way valves shall be selected for near minimum pressure drop. Two-way valves shall be selected near maximum pressure drop.
4) Flow coefficient (C_v) shall not be less than 1.0 (to avoid clogging).

b. Modulating Steam:

1) The outlet pressure of valves for converters shall be no less than the inlet pressure required for the converters as given in plans for project.
2) As limited above, size modulating valves for applications of 15 psig or less for 80% of inlet gage pressure unless otherwise indicated.
3) As limited above, modulating valves for applications of greater than 15 psig shall be sized for 42% of inlet absolute pressure unless otherwise indicated.

c. Two-position valves: Line size unless otherwise indicated.

2.5 CONTROL DAMPERS

A. See Section 233300 Air Duct Accessories.

2.6 ACTUATORS

A. Manufacturers:

1. Belimo
2. Siemens
3. Johnson Controls
4. Delta
5. Invensys
6. Or equal

B. Warranty: Valve and damper actuators shall carry a manufacturer's 5-year warranty.

C. Electric Actuators.

1. Entire actuator shall be UL or CSA approved by a National Recognized Testing Laboratory.
2. Dampers. The actuator shall be direct coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The clamp shall be steel of a "V" bolt design with associated "V" shaped, toothed cradle attaching to the shaft for maximum strength and eliminating slippage via cold weld attachment. Single bolt or set screw type fasteners are not acceptable. Aluminum clamps are unacceptable.
3. Valves. Actuators shall be specifically designed for integral mounting to valves without external couplings.
4. Actuator shall have microprocessor-based motor controller providing electronic cut off at full open so that no noise can be generated while holding open. Holding noise level shall be inaudible.
5. Actuators shall provide protection against actuator burnout using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation or use of magnetic clutches are not acceptable.
6. Modulating actuators:

    a. General: Actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range. Actuators shall have positive positioning circuit so that controlled device is at same position for a given signal regardless of operating differential pressure.

7. Where shown on Drawings or Points List, actuators shall include:

    a. 2 to 10 VDC position feedback signal.
    b. Limit (end) position switches.

8. All 24 VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC. Actuators operating on 120 VAC power shall not require more than 10 VA. Actuators operating on 230 VAC power shall not require more than 11 VA.
9. All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation.
10. Actuators shall be provided with a conduit fitting and a minimum three-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
11. Where fail-open or fail-closed position is required, an internal mechanical, spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe are

not acceptable. All spring return actuators shall be capable of both clockwise, or counterclockwise spring return operation by simply changing the mounting orientation.

12. Actuators shall be capable of being mechanically and electrically paralleled to increase torque where required.
13. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.
14. Actuators shall be designed for a minimum of 60,000 full cycles at full torque and be UL 873 listed.
15. Provide limit (end) position switches, where indicated on schematics.

D. Electric Actuators for Large Butterfly Valves.

1. Entire actuator shall be UL or CSA approved by a National Recognized Testing Laboratory.
2. The valve actuator shall consist of a capacitor-type reversible electric motor, gear train, limit switches and terminal block, all contained in a die cast aluminum enclosure.
3. Enclosure shall meet NEMA 4 weatherproof requirements for outdoor applications. Unless NEMA-3R indicated elsewhere.
4. Output shaft shall be electroless nickel plated to prevent corrosion.
5. Actuator shall have a motor rated for minimum 75% duty cycle. Duty cycle shall be defined as running time / Installed time at maximum torque.
6. Actuator shall be suitable for operation in ambient temperature ranging from -22˚F to +150˚F.
7. A pre-wired cable shall bring wiring outside enclosure to avoid necessity of opening cover.
8. Gears shall be hardened alloy steel, permanently lubricated. A self-locking gear assembly or a brake shall be supplied.
9. Actuator shall be equipped with a hand wheel for manual override to permit operation of the valve in the event of electrical power failure or system malfunction. Hand wheel must be permanently attached to the actuator. When in manual operation electrical power to the actuator will be permanently interrupted.
10. The hand wheel will not rotate while the actuator is electrically driven.
11. Actuator shall have heater and thermostat to minimize condensation within the actuator housing.
12. Provide limit (end) position switches, where indicated on schematics.

E. Normal Position. Actuators shall be spring return to the normal position unless non-spring style is specifically listed as acceptable in table below. Except as specified otherwise, “normal” positions of control devices shall be as follows:

Device	Normal Position	Spring Return Required
Outside air damper	CLOSED	Yes
Return air damper	OPEN	Yes
Exhaust/relief air damper	CLOSED	Yes
AHU heating coil valves	OPEN	
AHU cooling coil valves	CLOSED	
Equipment isolation valves:	OPEN	
Hot water reheat coil valves	CLOSED	
Fan coil HW and CHW valves	CLOSED	
VAV box dampers	OPEN	

F. Valve Actuator Selection:

1. Modulating actuators for valves shall have minimum rangeability of 50 to 1.
2. Water:

    a. Two way and two-position valves:

        1) Tight closing against 125 percent of system pump shut-off head.
        2) Modulating duty against 90 percent of system pump shut-off head.

    b. Three-way shall have close-off against twice the full open differential pressure for which they are sized.

G. Damper Actuator Selection:

1. Actuators shall be direct coupled. For multiple sections, provide one actuator for each section; linking or jack-shafting damper sections shall not be allowed.
2. Provide sufficient torque as velocity, static, or side seals require per damper manufacturer's recommendations and the following.

    a. Torque shall be a minimum 5 in-lb. per sq. ft. for opposed blade dampers and 7 in-lb. per sq. ft. for parallel blade dampers.
    b. The total damper area operated by an actuator shall not exceed 80% of the manufacturer's maximum area rating.

2.7 GENERAL FIELD DEVICES

A. Provide field devices for input and output of digital (binary) and analog signals into controllers (BCs, AACs, ASCs). Provide signal conditioning for all field devices as recommended by field device manufacturers, and as required for proper operation in the system.

B. It shall be the Contractor's responsibility to assure that all field devices are compatible with controller hardware and software.

C. Field devices specified herein are generally ‘two-wire’ type transmitters, with power for the device to be supplied from the respective controller. If the controller provided is not equipped to provide this power, or is not designed to work with ‘two-wire’ type transmitters, or if field device is to serve as input to more than one controller, or where the length of wire to the controller will unacceptably affect the accuracy, the Contractor shall provide ‘four-wire’ type equal transmitter and necessary regulated DC power supply or 120 VAC power supply, as required.

D. For field devices specified hereinafter that require signal conditioners, signal boosters, signal repeaters, or other devices for proper interface to controllers, Contractor shall furnish and install proper device, including 120V power as required. Such devices shall have accuracy equal to, or better than, the accuracy listed for respective field devices.

E. Accuracy: As used in this Section, accuracy shall include combined effects of nonlinearity, non-repeatability, and hysteresis. Sensor accuracy shall be at or better than both that specifically listed for a device and as required herein.

2.8 TEMPERATURE SENSORS (TS)

A. General:

1. Unless otherwise noted, sensors may be platinum RTD, thermistor, or other device that is commonly used for temperature sensing and that meets accuracy, stability, and resolution requirements.
2. When matched with A/D converter of BC, AAC, or ASC, sensor range shall provide a resolution of no worse than 0.3°F (unless noted otherwise).
3. Sensors shall drift no more than 0.3˚F and shall not require calibration over a five-year period.
4. Manufacturers:

    a. Mamac.
    b. Kele Associates
    c. Building Automation Products
    d. Or equal

B. Duct temperature sensors. Shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise. Sensor probe shall be 316 stainless steel.

1. TS-1A. Single point (use where not specifically called out to be averaging in points list).
2. TS-1B. Averaging. Sensor length shall be at least 1 linear foot for each 3 square feet of face area up to 25 feet maximum.

C. Water temperature sensors.

1. TS-2A: Immersion sensors. All piping immersion sensors shall be in brass or stainless- steel wells that allow removal from operating system, with lagging extension equal to insulation thickness, where installed in insulated piping. Wells shall be rated for maximum system operating pressure, temperature, and fluid velocity. The well shall penetrate the pipe by the lesser of half the pipe diameter or four inches. The use of direct immersion or strap-on type sensors is not acceptable.
2. TS-2B. Same as TS-2A except provide matched temperature sensors for differential temperature measurement, e.g., chilled water supply and return temperature.
3. TS-2C. Same as TS-2A or TS-2B (matched pair) with the following added requirements (for extremely high accuracy and stability at central plant main supply/return chilled water temperature sensors): Each assembly shall consist of a 100 Ohm platinum RTD and a solid-state 4-wire, 4-20mA transmitter contained in a housing suitable for pipe mounting, spring-loaded probe to ensure good thermal contact between the sensor and the well. Manufacturer must be certified as meeting the requirements of ISO 9001. RTD shall conform to the DIN 437601980 standards (Ultra precision DIN RTD). 2 Year NIST traceable guarantee. Manufacturer: Accutech AI-2000, or equal.

D. Room sensors: Shall be an element contained within a ventilated cover, suitable for wall mounting, with insulated base.

1. TS-3A.

    a. Thermistor in enclosure with blank cover.
    b. Include a USB port for connection of portable Operator Interface.

2. TS-3B. Same as TS-3A except.

    a. Setpoints shall be adjustable at wall mounted sensor with setpoint knobs with software limits.
    b. Override button capable of being programmed to start system during unscheduled hours.

3. TS-3C. Same as TS-3B except.

    a. Integral LCD display of space temperature and active setpoint.

4. Unless otherwise indicated in points list, locate sensors as follows:

    a. Lobbies, corridors, break rooms, and other public spaces: TS-3B.
    b. Equipment rooms: TS-3A
    c. Offices and other spaces not listed above: TS-3C.
    d. Others not listed: Confirm with Architect through RFI.

E. TS-4. BACnet Communicating Thermostat.

1. Thermistor in enclosure with blank cover.
2. 3H/2C
3. BACnet MSTP communicating thermostat.
4. Temperature setpoint adjustment.
5. LCD color touchscreen display.
6. Occupancy override.
7. Relative humidity sensor accuracy: 5%.
8. IAQ sensor.
9. Schneider SE8600 series or equal.

F. TS-5. Outdoor air sensors shall have a sun shield, utility box, and watertight gasket to prevent water seepage.

G. Temperature Transmitters. Where required by Controller, or to meet specified end-to-end accuracy requirements, sensors as specified above shall be matched with transmitters outputting 4-20 mA linearly across the specified temperature range. Transmitters shall have zero and span adjustments, an accuracy of 0.1˚F when applied to the sensor range.

2.9 HUMIDITY TRANSMITTERS (HT)

A. General:

1. Suitable for duct, wall (room) or outdoor mounting as indicated in points list and Construction Drawings.
2. Two-wire transmitter utilizing bulk polymer resistance change or thin film capacitance change humidity sensor producing a continuous 4-20 mA output proportional to percent relative humidity (%RH).
3. Input Range: 0 to 100% RH.
4. Accuracy (%RH), NIST Traceable and certified at 77˚F over 20-95% RH including hysteresis, linearity and repeatability:

    a. HT-1: ±2%
    b. HT-2: ±3%

5. Sensor Operating Range:

    a. Humidity: 0-99%, non-condensing, sensor.
    b. Temperature: 32˚F to 122˚F

6. Temperature Effect: Less than 0.06% per ˚F at baseline of 77˚F.
7. Sensitivity: 0.1% RH.

8. Repeatability: 0.5 RH.
9. Hysteresis: Less than 1%.
10. Long Term Stability: Less than 2% drift per 5 years.
11. Manufacturer:

    a. Vaisala HM Series
    b. Automation Components Inc. RH Series
    c. Or equal

2.10 CO_2 SENSORS/TRANSMITTERS (CO2)

A. CO2-1. Wall mounted.

1. Non-dispersive infrared sensor with dual beam technology where a reference channel is used to maintain sensor calibration.
2. Detachable base with all field wiring terminations on base.
3. Accuracy: ±50 ppm or 5% of reading from 0 to 1500 ppm at temperatures from 60°F to 90°F.
4. Factory calibrated and set to 0-2000 ppm range (equals 4-20 mA or 0-10 V).
5. Include elevation adjustment.
6. The sensor shall not require recalibration for a minimum of 5 years, guaranteed. If sensor is found to be out of calibration, supplier shall recalibrate at no additional cost to the Owner within 5 years of purchase date.
7. LCD display.
8. Manufacturers:

    a. Telaire 8102
    b. Vaisala GMV21
    c. AirTest EE80-2CT
    d. Or equal

B. CO2-2. Same as CO2-1 except duct mounted.

2.11 DIFFERENTIAL PRESSURE TRANSMITTERS (DPT)

A. DPT-1. Water, General Purpose.

1. Fast-response capacitance sensor.
2. Two-wire transmitter, 4-20 mA output with zero and span adjustments.
3. Accuracy.

    a. Overall Accuracy (at constant temp) ±0.25% full scale (FS).
    b. Non-Linearity, BFSL ±0.20% FS.
    c. Hysteresis 0.10% FS.
    d. Non-Repeatability 0.05% FS.

4. Long Term Stability 0.5% FS per year.
5. Only 316 stainless-steel in contact with fluid.
6. Pressure limits.

    a. 0 to 100 psid range: 250 psig maximum static pressure rating, 250 psig maximum overpressure rating.

b. 100 to 300 psid range: 450 psig maximum static pressure rating, 450 psig maximum overpressure rating.

7. Include brass 3-valve assembly. See sensor installation specifications below.
8. Manufacturers:

a. Setra 230
b. Modus W30
c. Or equal

B. DPT-2. Air, Duct Pressure:

1. General: Loop powered two-wire differential capacitance cell-type transmitter.
2. Output: two wire 4-20 mA output with zero adjustment.
3. Overall Accuracy: ±1% scale.
4. Minimum Range: 0.5 in. w.c.
5. Maximum Range: 10 inches w.c.
6. Housing: Polymer housing suitable for surface mounting.
7. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A-301, Davis Instruments, or equal and connecting tubing.
8. Range: Select as specified in points list or, if not listed for specified setpoint to be between 25% and 75% full-scale.
9. DPT-2A: Include LCD display of reading.
10. Manufacturers:

a. Veris
b. Setra
c. Modus
d. Invensys
e. Dwyer
f. Or equal

C. DPT-3. Air, Low Differential Pressure (space pressure).

1. General: Loop powered, two-wire differential capacitance cell type transmitter.
2. Output: Two-wire 4-20 mA output with zero adjustment.
3. Overall Accuracy:

a. General ±1% FS.
b. Minimum outdoor air damper DP used for minimum outdoor airflow: ±0.25% FS.

4. Range:

a. Non-switch selectable.
b. Minimum Range: 0, -0.1, -0.25, or -0.5 inches w.c.
c. Maximum Range: +0.1, 0.25, or 0.5 inches w.c.
d. Range shall be as specified in points list or, if not listed, selected such that specified setpoint is between 25% and 75% full-scale.

5. Housing: Polymer housing suitable for surface mounting.
6. Static Sensing Element:

a. Ambient sensor: Dwyer A-306.
b. Space sensor: Kele SPS, BAPI ZPS-ACC-01, Dwyer A-417 or 465, or equal wall plate sensor.

c. Filter or duct pressure sensor: Dwyer A-301 or equal.
d. Plenum pressure sensor: Dwyer A-421 or equal.

7. DPT-3A: Include LCD display of reading.
8. Manufacturers:

a. Setra 267
b. Air Monitor
c. Paragon
d. Or equal

D. DPT-4. VAV Velocity Pressure:

1. General: Loop powered two-wire differential capacitance cell type transmitter.
2. Output: Two-wire, 4-20 mA output with zero adjustment.
3. Flow transducer (including impact of A-to-D conversion) shall be capable of stably controlling to a setpoint of 0.004" differential pressure or lower, shall be capable of sensing 0.002" differential pressure or lower, and shall have a ±0.001" or lower resolution across the entire scale.
4. Minimum Range: 0 in. w.c.
5. Maximum Range: 1.5-inch w.c.
6. Housing: Polymer housing suitable for surface mounting.
7. Manufacturer:

a. Trane
b. Johnson Controls
c. Siemens
d. Veris
e. Or equal

2.12 DIFFERENTIAL PRESSURE SWITCHES (DPS)

A. DPS-1. Water: Diaphragm with adjustable setpoint, 2 psig or adjustable differential, and snap-acting Form C contacts rated for the application. 60 psid minimum pressure differential range. 0˚F to 160˚F operating temperature range.

B. DPS-2. Air: Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Provide manufacturer's recommended static pressure sensing tips and connecting tubing.

2.13 WATER LEAK DETECTOR (WLD)

A. WLD-1:

1. Gold plated adjustable sensing probes to detect water from 0 to 1/8 inch above surface.
2. All electronic circuitry encapsulated in epoxy to protect from dirt, fungus and short term, immersion in water.
3. DPDT (2 form C) relay contact outputs rated at 1 amp @ 28 VDC.
4. Powered with 12-24 VAC or VDC from EMCS panel. Battery not acceptable.
5. 5-year warranty minimum.
6. Manufacturer:

a. Dorlen Water Alert SS-4'

b. Or equal

2.14 CURRENT SWITCHES (CS)

A. CS-1

1. Clamp-on or solid-core
2. Range: 1.5 to 150 amps (or as required by application).
3. Trip Point: Adjustable.
4. Switch: Solid state, normally open, 1 to 135 Vac or Vdc, 0.3 Amps. Zero off state leakage.
5. Lower Frequency Limit: 6 Hz.
6. Trip Indication: LED
7. Approvals: UL, CSA
8. May be combined with relay for start/stop.
9. Where used for single-phase devices, provide the CS/CR in a self-contained unit in a housing with override switch. Kele RIBX, Veris H500, or equal.
10. Manufacturers:

    a. Veris Industries H-608/708/808/908; Inc.
    b. RE Technologies SCS1150A-LED
    c. Or equal

2.15 CURRENT TRANSFORMER (CT)

A. Clamp-On Design Current Transformer (for Motor Current Sensing)

1. Range: 1-10 amps minimum, 20-200 amps maximum.
2. Trip Point: Adjustable.
3. Output: 0-5 VDC.
4. Accuracy: ±0.2% from 20 to 100 Hz.
5. Manufacturers:

    a. Kele SC100
    b. Veris 722
    c. Or equal

2.16 FLOW METER (FM)

A. FM-1. Magnetic Insertion Type Flow Meters for Water Service.

1. Magnetic Faraday point velocity measuring device.
2. Insertion type complete with 'hot-tap' isolation valves to enable sensor removal without water supply system shutdown.
3. 4-20 mA transmitter proportional to flow or velocity.
4. Accuracy: ± 1% of reading from 0.25 to 20 fps.
5. Flow range: 0.25 to 20 fps, bidirectional.
6. Each sensor shall be individually calibrated and tagged accordingly against the manufacturer's primary standards which must be accurate to within 0.1% and traceable to the U.S. National Institute Standards and Technology (NIST).
7. Manufacturers:

a. Onicon F-3500
b. FloCat YD20-A
c. Marsh McBirney MultiMag 284
d. SeaMetrics 100/200 Series

2.17 AIRFLOW MEASURING STATIONS (AFMS)

A. AFMS-1. Airflow measurement in ducts, plenums and fan inlets.

1. The AFMS shall be an array of sensors mounted across the entire area of the duct, plenum, and fan inlet in which the AFMS is mounted.
2. Include electronic devices or transducers to provide a 4-20 mA or 0-10 Vdc signal proportional to airflow or velocity with specified accuracy over entire range. Additionally, include one isolated RS-485 network connection to communicate with a BACnet MS/TP network.
3. LCD display.
4. Performance:

a. Sensors shall be calibrated to NIST-traceable standards for airflow/velocity.
b. Factory tested prior to shipment and shall not require calibration or adjustment over the life of the equipment, when installed in accordance to manufacturer's guidelines.
c. The installed total accuracy for airflow shall be better than ±3% of reading over the sensor probe operating ranges when installed in accordance with manufacturers' guidelines. Installed accuracy shall include the probe itself plus the electronics for converting probe signal to an electronic signal proportional to airflow and shall be demonstrated at both maximum and minimum airflow rates of operating range.
d. Operating Range: 50 to 4,000 FPM.

5. Duct & Plenum Mounted Sensor Probes:

a. Sensor probes shall be constructed of anodized aluminum alloy tube with stainless steel mounting brackets. Probes shall be constructed to provide insertion, internal, or standoff mounting, depending on the applications and field installation requirements.
b. Probe Sensor Density. The number of independent sensing points shall be distributed per duct face area, at a minimum quantity as indicated below.

Area (ft^2)	Sensors
<= 1	2
>1 to <4	4
4 to <8	6
8 to <12	8
12 to <16	12
>=16	16

c. Pressure drop: The maximum allowable unrecovered pressure drop caused by the probes shall not exceed .025" at 2000 FPM, or .085" at 4000 FPM.

6. Fan Inlet Mounted Sensor Probes:

a. Sensor probes shall be constructed of anodized aluminum alloy tube with stainless steel mounting brackets. Probes shall be constructed to provide insertion, internal,

or standoff mounting, depending on the applications and field installation requirements.

b. Fan inlet probe size per manufacturer's recommendations.

7. Manufacturers:

a. Ebtron Gold Series
b. Air Monitor
c. Onicon
d. Or equal

2.18 ELECTRONIC CONTROL COMPONENTS

A. Limit Switches (LS): Limit switches shall be UL listed, SPDT or DPDT type, with adjustable trim arm. Limit switches shall be as manufactured by Square D, Allen Bradley, or equal.

B. Line-Voltage Wall Thermostat: Wall-mounted thermostat shall consist of SPDT contacts rated for 120V and current as required for application, temperature setpoint range of 50 to 95□ F, and an adjustable 2-10□F setpoint differential.

C. Low Temperature Detector (Freeze-stat) (LLT-1): Low temperature detector shall consist of a cold spot element that responds only to the lowest temperature along any one foot of entire element, minimum bulb size of 1/8 inch x 20 feet, junction box for wiring connections and gasket to prevent air leakage or vibration noise, DPST (4 wire 2 circuit) with manual reset, Temperature range 15 to 55˚F, factory set at 38˚F.

D. Control Relays: All control relays shall be UL listed, with contacts rated for the application, and mounted in minimum NEMA-1 enclosure for indoor locations, NEMA-4 for outdoor locations.

1. Control relays for use on electrical systems of 120 volts or less shall have, as a minimum, the following:

a. AC coil pull-in voltage range of +10%, -15% or nominal voltage.
b. Coil sealed volt-amperes (VA) not greater than four (4) VA.
c. Silver cadmium Form C (SPDT) contacts in a dustproof enclosure, with 8 or 11 pin type plugs.
d. Pilot light indication of power-to-coil and coil retainer clips.

2. Relays used for across-the-line control (start/stop) of 120V motors, 1/4 HP, and 1/3 HP, shall be rated to break minimum 10 Amps inductive load.
3. Relays used for stop/start control shall have low voltage coils (30 VAC or less) and shall be provided with transient and surge suppression devices at the controller interface.

E. General Purpose Power Contactors: NEMA ICS 2, AC general-purpose magnetic contactor. ANSI/NEMA ICS 6, NEMA type 1 enclosure. Manufacturer shall be Square 'D', Cutler-Hammer, or equal.

F. Control Transformers and Power Supplies:

1. Control transformers shall be UL Listed. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits for Class 2 service per NEC requirements. Mount in minimum NEMA-1 enclosure.
2. Transformer shall be proper size for application. Limit connected loads to 80% of rated capacity.

3. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100 microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand a 150% current overload for at least 3 seconds without trip-out or failure.
4. Unit shall operate between 0°C and 50°C [32°F and 120°F]. EM/RF shall meet FCC Class B and VDE 0871 for Class B, and MIL-STD 810C for shock and vibration.
5. Line voltage units shall be UL Recognized and CSA Approved.

G. Electric Push Button Switch: Switch shall be momentary contact, oil tight, push button, with number of N.O. and/or N.C. contacts as required. Contacts shall be snap-action type and rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen Bradley, Kele, or equal.

H. Alarm Horn: Panel-mounted audible alarm horn shall be continuous tone, 120 Vac Sonalert solid-state electronic signal, as manufactured by Mallory, Kele, or equal.

I. Electric Selector Switch (SS): Switch shall be maintained contact, NEMA ICS 2, oil-tight selector switch with contact arrangement, as required. Contacts shall be rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen-Bradley, Kele, or equal.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION

A. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings. Install electrical components and use electrical products complying with requirements of National Electric Code and all local codes.

3.3 ELECTRICAL INSTALLATION

A. Wiring.

1. Comply with Division 26.
2. All NEC Class 1 (line voltage) wiring shall be UL Listed in approved raceway per NEC requirements and shall be installed by a licensed electrician.
3. All low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.) Class 2 wiring shall be installed in UL Listed approved raceway, except where wires are in concealed in accessible locations, approved cables not in raceway may be used, provided that cables are UL Listed for the intended application. For example, cables used in ceiling return plenums shall be UL Listed specifically for that purpose.
4. Do not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).

5. Do not install wiring in raceway containing tubing.
6. Where Class 2 wiring is used without raceway, it shall be supported from or anchored to structural members neatly tied at 10-foot intervals. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems and at least 1-foot above ceiling tiles and light fixtures.
7. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.
8. All field wiring shall be properly labeled at each end, with self-laminating typed labels indicating device address, for easy reference to the identification schematic. All power wiring shall be neatly labeled to indicate service, voltage, and breaker source.
9. Use coded conductors throughout with different colored conductors.
10. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
11. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the Contractor shall provide step-down transformers.
12. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.
13. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.
14. Size of raceway and size and type of wire shall be the responsibility of the Contractor, in keeping with the manufacturer's recommendation and NEC requirements.
15. Include one pull string in each raceway 1 inch or larger.
16. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.
17. Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 6” from high-temperature equipment (e.g., steam pipes or flues).
18. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.
19. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.
20. The EMCS Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
21. Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 3 feet in length and shall be supported at each end. Flexible metal raceway less than ½” electrical trade size shall not be used. In areas exposed to moisture liquid-tight, flexible metal raceways shall be used.
22. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings (per code). Terminations must be made with fittings at boxes and ends not terminating in boxes shall have bushings installed.
23. Electrical service to controls panels and control devices shall be provided by isolated circuits, with no other loads attached to the circuit, clearly marked at its source. The location of the breaker shall be clearly identified in each panel served by it. If a spare breaker is not available within an electrical panel, the EMCS Contractor shall be responsible for providing any and all equipment and labor necessary to supply an isolated circuit. Controllers controlling only packaged air conditioning equipment may be powered directly from the packaged units control circuit.
24. Wire digital outputs to either the normally-closed or normally-open contacts of binary output depending on desired action in case of system failure. Unless otherwise indicated, wire to the NO contact except the following shall be wired to the NC contact:

    a. Hot water pumps.
    b. Coil recirc’ pumps provided for freeze protection.

25. Hardwire Interlocks.

    a. The devices referenced in this section are hardwire interlocked to ensure equipment shutdown occurs even if control systems are down. Do not use software (alone) for these interlocks.
    b. Hardwire device NC contact to air handler fan starter upstream of HOA switch, or to VFD enable contact.
    c. Where multiple fans (or DDC DI) are controlled off of one device and the device does not have sufficient contacts, provide a relay at the device to provide the required number of contacts.
    d. Provide for the following devices, where shown on plans:

        1) Duct smoke detector.
        2) High discharge static pressure.
        3) Low mixing plenum pressure.
        4) Freeze-stats.

B. Communication Wiring.

1. The EMCS Contractor shall adhere to the requirements of paragraph 3.3A in addition to this section.
2. Communication and signal wiring may be run without conduit in concealed, accessible locations as permitted by paragraph 3.3A only if noise immunity is ensured. Contractor will be fully responsible for noise immunity and rewire in conduit if electrical or RF noise affects performance.
3. All cabling shall be installed in a neat and workmanlike manner. Follow all manufacturers' installation recommendations for all communication cabling. Use shielded wiring if recommended by manufacturer.
4. Do not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.
5. Maximum pulling, tension, and bend radius for cable installation as specified by the cable manufacturer shall not be exceeded during installation.
6. EMCS Contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.
7. All runs of communication wiring shall be un-spliced length when that length is commercially available.
8. All communication wiring shall be labeled to indicate origination and destination data.
9. Grounding of coaxial cable shall be in accordance with NEC regulations Article on Communications Circuits, Cable, and Protector Grounding.
10. Shielded cable shield shall be grounded only at one end.
11. Power-line carrier signal communication/transmission is not acceptable.

3.4 INSTALLATION OF SENSORS

A. Install sensors in accordance with the manufacturer's recommendations.

B. Mount sensors rigidly and adequately for the environment within which the sensor operates.

C. Temperature Sensors.

1. Room temperature sensors/thermostats shall be installed on concealed junction boxes properly supported by the wall framing.
2. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

3. Averaging sensors shall be installed in a serpentine manner vertically across duct. Each bend shall be supported with a capillary clip. Where located in front of filters (e.g., mixed air sensors), access for filter removal shall be maintained.
4. For sensors specified to be calibrated using a dry well bath (see points list), install sensors with a sufficient wiring/flexible conduit lead that sensor may be removed from well or duct and placed in an ice bath or dry well for calibration. The spare wiring/flexible conduit shall be no less than 3' in length.
5. All pipe-mounted temperature sensors shall be installed in wells. Install the sensor in the well with a thermal-conducting grease or mastic. Use a closed-cell insulation patch that is integrated into the pipe insulation system to isolate the top of the well from ambient conditions but allow easy access to the sensor. Install a test plug adjacent to all wells for testing and calibration.
6. Unless otherwise noted, temperature sensors/thermostats, humidity sensors/humidistats, CO_2 sensors, and other room wall mounted sensors shall be installed at same centerline as adjacent electrical switches, 4'-0" above the finished floor where there are no adjacent electrical switches, and within ADA limitations.
7. Unless otherwise noted, install outdoor air temperature sensors on north wall, complete with sun shield, where they will not be influenced by building exhaust, exfiltration, or solar insolation. Do not install near intake or exhaust air louvers.

D. Differential Pressure Sensors.

1. Supply Duct Static Pressure: Locate transmitter in temperature control panel near or in DDC panel to which it is wired. Connect the low-pressure port to tee in building pressure (high) signal of the building static pressure transmitter. Pipe the high-pressure tap to the duct using a static pressure tip. Locate static pressure tip as shown on drawings; if no location is shown, locate at end of duct riser or main as far out in the system as possible but upstream of all smoke and fire dampers. Install pressure tips securely fastened with tip facing upstream in accordance with manufacturer's installation instructions.
2. Filter Differential Pressure:

    a. Install static-pressure tips upstream and downstream of filters with tips oriented in direction of flow.
    b. Mount transmitter on outside of filter housing or filter plenum in an accessible position with LCD display clearly visible. This sensor is used in lieu of an analog gauge and thus must be readily viewable.

3. Building Static Pressure:

    a. Low pressure port of the pressure sensor:

        1) Pipe to the ambient static pressure probe located on the outside and at high point of the building through a high-volume accumulator or otherwise protected from wind fluctuations.

    b. High-pressure port of the pressure sensor:

        1) Pipe to either:

            a) Behind a DDC temperature sensor cover in an interior zone.
            b) Bosco or Dwyer plate sensor mounted in ceiling.

        2) Do not locate near elevators, exterior doors, atria, or (for ceiling sensor applications) near diffusers.

4. All pressure transducers, other than those controlling VAV boxes, shall be located where accessible for service without use of ladders or special equipment. If required, locate in field device panels and pipe to the equipment monitored or ductwork.
5. The piping to the pressure ports on all pressure transducers (both air and water) shall contain a capped test port located adjacent to the transducer.
6. Piping differential pressure transducers shall have three valve manifold, two valves to allow removal of sensor without disrupting the hydronic system plus an equalizing valve to allow the sensor to be zeroed and to prevent sensor from experiencing full static (as opposed to differential) pressure, plus test plugs on each connection (also used as vents).
7. Copper tubing shall be installed in a neat manner (parallel and perpendicular to the building structure, equipment, piping, etc. from which it is supported) and shall be properly supported. Changes to copper tubing installation resulting from failure to comply with this requirement shall be made at the discretion of the Architect at no additional cost to the Owner.

E. Relative Humidity Sensors: Provide element guard as recommended by manufacturer for high velocity installations. For high limit sensors, position remote enough to allow full moisture absorption into the air stream before reaching the sensor.

F. Flow Switches: Install in a straight run of pipe at least 10 diameters in length to minimize false indications.

G. Current Switches for Motor Status Monitoring: Adjust so that setpoint is below minimum operating current and above motor no load current.

H. Airflow Measuring Stations: Install per manufacturer's recommendations in an unobstructed straight length of duct both upstream and downstream of sensor, except those installations specifically designed for installation in fan inlet. For installations in fan inlets, provide on both inlets of double inlet fans and provide inlet cone adapter as recommended by AFMS manufacturer.

I. Fluid Flow Sensors: Install per manufacturer's recommendations in an unobstructed straight length of pipe both upstream and downstream of sensor.

3.5 ACTUATORS

A. Type.

1. Actuators for two-position valves may be pneumatic or electric at the option of the Division 23C contractor.
2. Actuators for high pressure (125 psig) steam, both modulating and two-position, shall be pneumatic.
3. Except where listed above, actuators shall be electric.

B. Mount and link control damper actuators per manufacturer's instructions.

C. Dampers:

1. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage, or follow manufacturer's instructions to achieve same effect.
2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.

3. Provide all mounting hardware and linkages for actuator installation.

D. Control Valves: Install so that actuators, wiring, and tubing connections are accessible for maintenance. Where possible, install with valve stem axis vertical, with operator side up. Where vertical stem position is not possible, or would result in poor access, valves may be installed with stem horizontal. Do not install valves with stem below horizontal, or down.

END OF SECTION 230913

SECTION 230916 – EMCS OPERATOR INTERFACES

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 WORK INCLUDED

A. Provide and install the following:

1. Operator Workstation(s)
2. Uninterruptible Power Supply
3. Backup Device
4. Printers

B. Refer to Section 230900 for general requirements.

1.3 RELATED WORK AND REQUIREMENTS

A. Other EMCS Sections:

1. Section 230900 Energy Management and Control System (EMCS) - General
2. Section 230913 EMCS Basic Materials and Devices
3. Section 230919 EMCS Field Panels
4. Section 230923 EMCS Communication Devices
5. Section 230926 EMCS Software and Programming
6. Section 230933 EMCS Commissioning

PART 2 - PRODUCTS

2.1 OPERATOR WORKSTATION (OWS)

A. Hardware:

1. 3.2 GHz (minimum)
2. 4 GB SDRAM (minimum)
3. 8X DVD +/- RW Drive
4. 250 GB hard disk (minimum)
5. Ethernet 100 GB internal network card (for connection to Supervisory LAN)
6. 32” LED HD color, 1920 x 1080-pixel display monitor
7. 3-button optical USB mouse
8. USB Keyboard
9. Internal speakers
10. Energy Star configured
11. One spare serial port and one spare USB port in addition to those needed for specified peripherals.

12. 24x7 dedicated technical support service that delivers reduced hold time, direct access to advanced level technicians, and reduced time to resolution, minimum 1 year.

B. Software:

1. By PC Supplier (factory installed):

a. Operating system: Microsoft Windows 8 Professional.
b. Browser: Microsoft Internet Explorer.
c. Office Suite: Microsoft Office Professional.
d. CD Burner Software: Standard software provided by computer supplier.
e. All software shall be at least the latest version available as of the date of purchase.

2. By EMCS Contractor:

a. See Section 230926.

PART 3 - EXECUTION

3.1 DEVICE REQUIREMENTS

A. Provide the following Equipment in the Control Room or at location designated by the Owner.

Device	Quantity
Operator Workstation	1

3.2 INSTALLATION

A. Install all servers and other devices available in a location coordinated with the Owner and Architect.

B. Install all hardware and software and configure all devices in accordance with manufacturer's instructions.

C. Provide all licenses, keys, etc. and all documentation and information required to install, configure, operate, diagnose, and maintain the system shall be provided.

D. Network connections:

1. See System Architecture in Section 230900.
2. Connect OWS to Supervisory LAN.
3. Connect OWS to Owner's IT WAN/LAN. Contractor shall coordinate with the Owner's IT representative to establish IP addresses and communications parameters to assure proper operation.

E. Backup:

1. After completion and acceptance of installation, create a backup of all OWSs and server database and configuration files for permanent record of initial installation.
2. Configure backup software to provide automatic backup of OWS and CSS on a weekly basis.
3. All other backup configuration shall be by the Owner.

F. Anti-virus software and installation shall be by the Owner.

END OF SECTION 230916

SECTION 230919 – EMCS FIELD PANELS

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 WORK INCLUDED

A. Provide and install the following:

1. Building Controller (BC)
2. Advance Application Specific Controller (AAC)
3. Application Specific Controller (ASC)

B. Refer to Section 230900 for general requirements.

1.3 RELATED WORK AND REQUIREMENTS

A. Other EMCS Sections:

1. Section 230900 Energy Management and Control System (EMCS) - General
2. Section 230913 EMCS Basic Materials and Devices
3. Section 230916 EMCS Operator Interfaces
4. Section 230923 EMCS Communication Devices
5. Section 230926 EMCS Software and Programming
6. Section 230933 EMCS Commissioning

PART 2 - PRODUCTS

2.1 GENERAL

A. Point information from any controller (including BCs, AACs, and ASCs) and from any gateway shall be capable of being used in a control sequence in any other panel. The use of OWS or CSS to serve as a communications server between control panels and gateways is not acceptable.

B. For all controllers, operating configuration and software shall be retained in the event of a power outage without requiring a download from upper-level controllers by one or a combination of the following:

1. Volatile RAM shall have a replaceable battery backup using a lithium battery with a rated service life of 10,000 hours continuous, and a rated shelf life of at least 7 years.
2. Volatile RAM shall have an automatically rechargeable battery backup using a lithium battery with a rated service life of 50 hours continuous, and a rated shelf life of at least 10 years.
3. EEPROM, EPROM, or NOVROM non-volatile memory.

C. Controllers shall allow independent operation regardless of the status of the other controllers or OWS or CSS. All energy management logic shall reside in field hardware and shall not be dependent on the OWS or CSS for operation.

D. Each controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:

1. Assume a predetermined failure mode.
2. Generate an alarm notification to the master controller and/or Operator Workstation.

E. All input points and output points shall be protected such that shorting of the point to itself — to another point, or to ground — will cause no damage to the controller. All input and output points shall be protected from voltage up to 24V of any duration, such that contact with this voltage will cause no damage to the controller.

F. Controller hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures, and shall be rated for operation at 0°F to 150°F.
2. Controllers used in conditioned space shall be mounted in dust--resistant enclosures, and shall be rated for operation at 32°F to 120°F.

G. Programmability. All controllers, including BCs, AACs, and ASCs, shall be fully user programmable. See Section 230926. Configurable pre-programmed logic shall not be acceptable in any controller. (This is required due to non-standard control sequences at AHUs and VAV terminal units.)

2.2 STAND-ALONE FUNCTIONALITY

A. General: These requirements clarify the requirement for stand-alone functionality relative to packaging I/O devices with a controller. Stand-alone functionality is specified with the controller and for each Application Category specified in Part 3. This item refers to acceptable paradigms for associating the points with the processor.

B. Functional Boundary: Provide controllers so that all points associated with and common to one unit or other complete system/equipment shall reside within a single control unit. The boundaries of a standalone system shall be as dictated in the contract documents. Generally, systems specified for the Application Category will dictate the boundary of the standalone control functionality. See related restrictions below. When referring to the controller as pertains to the standalone functionality, reference is specifically made to the processor. One processor shall execute all the related I/O control logic via one operating system that uses a common programming and configuration tool.

C. The following configurations are considered acceptable with reference to a controller's standalone functionality:

1. Points packaged as integral to the controller such that the point configuration is listed as an essential piece of information for ordering the controller (having a unique ordering number).
2. Controllers with processors and modular back planes that allow plug in point modules as an integral part of the controller.
3. I/O point expander boards, plugged directly into the main controller board to expand the point capacity of the controller.

D. The following configurations are considered unacceptable with reference to a controller's standalone functionality:

1. Multiple controllers enclosed in the same control panel to accomplish the point requirement.

2.3 BUILDING CONTROLLER (BC)

A. General Requirements:

1. BCs shall be peer-to-peer devices connected to the Primary Controller LAN.
2. Each BC shall be capable of standalone direct digital operation utilizing its own microprocessor, internal RAM, non-volatile memory, input/output, wiring terminal strips, A/D converters, real-time clock/calendar and voltage transient and lightning protection devices, battery backup, regulated power supply, power conditioning equipment, ports for connection of operating interface devices, and control enclosure. Refer to standalone functionality specified above.
3. The BC(s) shall provide fully distributed control independent of the operational status of the OWSs and CSS. All necessary calculations required to achieve control shall be executed within the BC independent of any other device.
4. BCs shall perform overall system coordination, accept control programs, perform automated HVAC functions, control peripheral devices, and perform all necessary mathematical and logical functions. BCs shall share information with the entire network of BCs and AACs/ASCs for full global control. Each controller shall permit multi-user operation from multiple workstations and portable operator terminals connected either locally or over the Primary Controller LAN.
5. BC shall contain sufficient memory for all specified global control strategies, user defined reports and trending, communication programs, and central alarming.
6. The BC may provide for point mix flexibility and expandability. This requirement may be met via either a family of expander boards, modular input/output configuration, or a combination thereof. Refer to stand alone functionality specified above.
7. All BC point data, algorithms and application software shall be configurable, and all control strategies performed by the BC shall be both operator definable and modifiable, from Operator Interfaces. The point database and all application programs shall be stored in non-volatile, or battery backed volatile memory within the BC and will be able to upload/download to/from the OWS and/or CSS.
8. BC shall provide buffer for holding alarms, messages, trends etc.
9. Each BC shall include self-test diagnostics, which allow the BC to automatically alarm any malfunctions, or alarm conditions that exceed desired parameters as determined by programming input.
10. Each BC shall contain software to perform full DDC/PID control loops.
11. Memory:

    a. Memory for data trending shall reside in BCs; the Operator Workstation shall not need to be connected for data trending to occur. Memory shall be large enough to record 256 records of each hardware point on the panel and an equal number of software points, each record to include both data value and time of occurrence. (See Section 230926 for trending software requirements.)
    b. Provide sufficient internal memory for the specified sequences of operation and trend logging. There shall be a minimum of approximately 25% of available memory free for future programming changes.
    c. Provide an additional BC if needed to comply with this section.

12. For systems requiring end-of-line resistors those resistors shall be located in the BC.
13. Input-Output Processing:

a. Digital Outputs (DO): Outputs shall be rated for a minimum 24 Vac or Vdc, 0.5-amp maximum current. Each shall be configurable as normally open or normally closed. Each output shall have an LED to indicate the operating mode of the output and a supervised manual hand off or auto (HOA) switch to allow for override. HOA override switches shall be monitored via additional input channels to provide dynamic indication of the switch status at any Operator Interface. Each DO shall be discrete outputs from the BC's board (multiplexing to a separate manufacturer's board is unacceptable). Provide suppression to limit transients to acceptable levels.
b. Analog Inputs (AI): AI shall be 0-5 Vdc, 0-10 Vdc, and 0-20 mA. Provide signal conditioning, and zero and span calibration for each input. Each input shall be a discrete input to the BC's board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise). A/D converters shall have a minimum resolution of 12 bits.
c. Digital Inputs (DI): Monitor dry contact closures. Accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the BC and shall be isolated from the main board. Software multiplexing of an AI and resistors is unacceptable.
d. Universal Inputs (UI-AI or DI): To serve as either AI or DI as specified above.
e. Electronic Analog Outputs (AO): Voltage mode: 0-5 Vdc and 0-10 Vdc; Current mode: 4-20 mA. Provide zero and span calibration and circuit protection. Pulse Width Modulated (PWM) analog is not acceptable. D/A converters shall have a minimum resolution of 8 bits. Each output shall have an LED to indicate the operating mode of the output and a supervised manual hand off or auto (HOA) switch and trim potentiometer to allow for override and manual positioning of the output from 0 to 100%. HOA override switches shall be monitored via additional input channels to provide dynamic indication of the switch status at any Operator Interface.
f. Analog Output Pneumatic (AOP), 0-20 psi: Pneumatic outputs via an I/ or V/P transducer. Multiplexed digital to pneumatic transducers are acceptable provided they are supplied as a standard product and part of the BC and provide individual feedback. Multiplexed pneumatic outputs of a separate manufacturer are unacceptable.
g. Pulsed Inputs: Capable of counting up to 8 pulses per second with buffer to accumulate pulse count. Pulses shall be counted at all times.

14. A communication port for operator interface through a terminal shall be provided in each BC. It shall be possible to perform all program and database back-up, system monitoring, control functions, and BC diagnostics through this port. Standalone BC panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or workstations.
15. Each BC shall be equipped with loop tuning algorithm for precise proportional, integral, derivative (PID) control. Loop tuning tools provided with the Operator Workstation software is acceptable. In any case, tools to support loop tuning must be provided such that P, I, and D gains are automatically calculated.
16. All analog output points shall have a selectable failure setpoint. The BC shall be capable of maintaining this failure setpoint in the event of a system malfunction, which causes loss of BC control, or loss of output signal, as long as power is available at the BC. The failure setpoint shall be selectable on a per point basis.
17. Slope intercepts and gain adjustments shall be available on a per-point basis.
18. BC Power Loss:

    a. Upon a loss of power to any BC, the other units on the primary controlling network shall not in any way be affected.
    b. Upon a loss of power, all software, database parameters, and data (except trend data) shall be protected from memory loss as described herein.

c. Upon restoration of power within the specified battery backup period, the BC shall resume full operation without operator intervention. The BC shall automatically reset its clock such that proper operation of any time dependent function is possible without manual reset of the clock. All monitored functions shall be updated.
d. Should the duration of a loss of power exceed the specified battery back-up period or BC panel memory be lost for any reason, the panel shall automatically report, or CSS shall automatically determine, the condition (upon resumption of power) and be capable of receiving a download via the network and connected computer. In addition, the Owner shall be able to upload the most current versions of all energy management control programs, Direct Digital Control programs, database parameters, and all other data and programs in the memory of each BC to the operator workstation via the local area network, or via the telephone line dial-up modem where applicable, or to the laptop PC via the local RS-232C port.

19. BC Failure:

a. Controller LAN Data Transmission Failure: BC shall continue to operate in stand-alone mode. BC shall store loss of communication alarm along with the time of the event. All control functions shall continue with the global values programmable to either last value or a specified value.
b. BC Hardware Failure: BC shall cease operation and terminate communication with other devices. All outputs shall go to their specified fail position.

20. Each BC shall be equipped with firmware resident or software self-diagnostics for sensors and be capable of assessing an open or shorted sensor circuit and taking an appropriate control action (close valve, damper, etc.).
21. BCs may include LAN communications interface functions for controlling Secondary controlling LANs Refer to Section 230923 - EMCS System Communications Devices for requirements if this function is packaged with the BC.
22. BCs shall be mounted on equipment, in packaged equipment enclosures, or locking wall mounted in a NEMA 1 enclosure, as specified elsewhere.

B. BACnet Building Controller Requirements:

1. The BC(s) shall support all BIBBs defined in the BACnet Building Controller (B-BC) device profile as defined in the BACnet standard.
2. Each BC shall be connected to the BACnet Primary Controller LAN communicating to/from other BCs.

2.4 ADVANCED APPLICATION SPECIFIC CONTROLLER (AAC) AND APPLICATION SPECIFIC CONTROLLER (ASC)

A. General Requirements:

1. AACs and ASCs shall be connected to the Primary or Secondary Controller LAN.
2. AACs and ASCs shall provide intelligent, standalone control of HVAC equipment. Each unit shall have its own internal RAM, non-volatile memory and will continue to operate all local control functions in the event of a loss of communications on the Secondary LAN. Refer to standalone requirements by application specified in Part 3 of this section. In addition, it shall be able to share information with every other BC and AAC /ASC on the entire network.
3. Each AAC and ASC shall include self-test diagnostics that allow the AAC /ASC to automatically relay to the BC, LAN Interface Device or workstation, any malfunctions or

abnormal conditions within the AAC /ASC or alarm conditions of inputs that exceed desired parameters as determined by programming input.

4. AACs and ASCs shall include sufficient memory to perform the specific control functions required for its application and to communicate with other devices.
5. Each AAC and ASC must be capable of stand-alone direct digital operation utilizing its own processor, non-volatile memory, input/output, voltage transient and lightning protection devices.
6. All point data: algorithms and application software within an AAC /ASC shall be modifiable from Operator Interfaces.
7. Memory:

    a. Memory for data trending is not required for AACs and ASCs. If not provided in controller, memory for trend data shall reside in BCs connected to the same Network.
    b. Provide sufficient internal memory for the specified sequences of operation. For AACs, there shall be a minimum of approximately 25% of available memory free for future programming changes. Provide additional AACs or a BC if needed to comply with this requirement.

8. AAC Input-Output Processing. Same as BCs (paragraph 2.3A.13) except A/D converters may be 10 bit.
9. ASC Input-Output Processing:

    a. Digital Outputs (DO): Outputs shall be rated for a minimum 24 Vac or Vdc, 0.5-amp maximum current. Each shall be configurable as normally open or normally closed. Each output shall have an LED to indicate the operating mode of the output. Each DO shall be discrete outputs from the ASC's board (multiplexing to a separate manufacturer's board is unacceptable). Provide suppression to limit transients to acceptable levels.
    b. Analog Inputs (AI): AI shall be 0-5 Vdc or direct thermistor connection. Provide signal conditioning, and zero and span calibration for each input. Each input shall be a discrete input to the ASC's board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise). A/D converters shall have a minimum resolution of 10 bits.
    c. Digital Inputs (DI): Monitor dry contact closures. Accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the ASC and shall be isolated from the main board. Software multiplexing of an AI and resistors may only be done in non-critical applications and only with prior approval of the Owner.
    d. Universal Inputs (UI-AI or DI): To serve as either AI or DI as specified above.
    e. Electronic Analog Outputs (AO): Voltage mode: 0-5 Vdc and 0-10 Vdc; Current mode: 4-20 mA. Provide zero and span calibration and circuit protection. Pulse Width Modulated (PWM) analog is not acceptable. D/A converters shall have a minimum resolution of 8 bits.
    f. Analog Output Pneumatic (AOP), 0-20 psi: Pneumatic outputs via an I/ or V/P transducer. Multiplexed digital to pneumatic transducers are acceptable provided they are supplied as a standard product and part of the ASC and provide individual feedback. Multiplexed pneumatic outputs of a separate manufacturer are unacceptable.

B. BACnet AAC(s) and ASC(s) Requirements:

1. The AAC(s) and ASC(s) shall support all BIBBs defined in the BACnet Building Controller (B-AAC and B-ASC) device profile as defined in the BACnet standard.
2. AAC(s) and ASC(s) shall communicate over the BACnet Primary Controller LAN or the Secondary LAN.

PART 3 - EXECUTION

3.1 GENERAL

A. Install systems and materials in accordance with manufacturer's instructions, specifications, roughing-in drawings and details shown on drawings.

3.2 HARDWARE APPLICATION REQUIREMENTS

A. General: The functional intent of this specification is to allow cost effective application of manufacturers standard products while maintain the integrity and reliability of the control functions. A BC as specified above is generally fully featured and customizable whereas the AAC/ASC refers to a more cost-effective unit designed for lower-end applications. Specific requirements indicated below are required for the respective application. Manufacturer may apply the most cost-effective unit that meets the requirement of that application.

B. Software Capability: Regardless of application category listed below, each Control Unit shall be capable of performing the specified sequence of operation for the associated equipment. All physical point data and calculated values required to accomplish the sequence of operation shall originate within the associated CU with only the exceptions enumerated below. Refer to requirements herein above for physical limitations of standalone functionality. Listed below are functional point data and calculated values that shall be allowed to be obtained from or stored by other CUs via LAN.

1. Remote pressure sensors. To meet the requirements of this section, differential pressure sensors controlling fans and pumps shall either be home-run wired back to the CU controlling the fan/pump VFD; or install another DP sensor (not shown in points list) near the fan/pump and connected to the CU controlling the pump, connect remote sensors to remote CUs, and use cascading control loops (remote sensor loops reset setpoint for local sensor loop via the network, and local sensor loop controls the pump/fan).

C. Where associated control functions involve functions from different categories identified below, the requirements for the most restrictive category shall be met.

D. Application Category 0 (Distributed Monitoring).

1. Applications in this category include the following:

a. Monitoring of variables that are not used in a control loop, sequence logic, or safety. Examples include status of sump pumps or associated float switches, temperatures in monitored electrical rooms.

2. Applicable Controllers: Available points on conveniently located BCs, AACs, and ASCs may be used in these applications.
3. Contractor shall verify and document that the network bandwidth is acceptable to accept specified trends of monitored points.

E. Application Category 1 (Application Specific Controller).

1. Applications in this category include the following:

a. Fan Coil Units.
b. Terminal Units (e.g., VAV and Constant Volume Boxes).

c. Miscellaneous heaters.
d. Constant speed exhaust fans and pumps.
e. Unitary single zone units with self-contained controls (Package Terminal AC Units, Package Terminal Heat Pumps, Split-System AC Units, Split-System Heat Pumps, Water-Source Heat Pumps, Computer Room AC units).

2. Applicable Controllers: ASCs may be used in these applications.
3. Standalone Capability: Provide capability to execute control functions for the application for a given setpoint or mode, which shall generally be occupied mode control. Only the following data (as applicable) may be acquired from other controllers via LANs. In the event of a loss of communications with any other controller, or any fault in any system hardware that interrupts the acquisition of any of these values, the ASC shall use the last value obtained before the fault occurred. If such fault has not been corrected after the specified default delay time, specified default value(s) shall then be substituted until such fault has been corrected.

Physical/Virtual Point	Default Value
Time of day	Occupied
Scheduling Mode	Occupied
Morning Warm-Up	Off (cold discharge air)
Load Shed	Off (no shedding)
Trend Data	N/A

4. Mounting:

a. ASCs that control equipment located above accessible ceilings shall be mounted on the equipment in an accessible enclosure and shall be rated for plenum use if ceiling attic is used as a return air plenum.
b. ASCs that control equipment mounted in a mechanical room may either be mounted in/on the equipment, or on the wall of the mechanical room at an adjacent, accessible location.
c. ASCs that control equipment mounted outside or in occupied spaces shall either be located in the unit or in a proximate mechanical/utility space.

5. Mounting: LAN Restrictions: Limit the number of nodes on the network to the maximum recommended by the manufacturer.
6. Trending Restrictions: BCs connected to same Network shall be capable of storing trend data for points associated with ASCs and must still meet the requirement of paragraph 2.3A.11, or special purpose trend storage devices meeting the requirement of paragraph 2.3A.11 for ASC points must be added for this purpose.

F. Application Category 2 (Advanced Application Controller).

1. Applications in this category include the following:

a. Unitary VAV AC Unit with self-contained controls.
b. Single Zone Air Handling Units.
c. Constant or variable speed pump station.
d. DHW Converter control/monitoring.

2. Applicable Controllers:

a. BCs may be used in these applications.

b. AACs may be used in these applications provided the AAC meets all requirements specified below and all control functions and physical I/O associated with a given unit resides in one AAC.

3. Standalone Capability: Only the following data (as applicable) may be acquired from other AACs or BCs via LANs. In the event of a loss of communications with any other AACs, or any fault in any system hardware that interrupts the acquisition of any of these values, the AAC shall use the last value obtained before the fault occurred. If such fault has not been corrected after the specified default delay time, specified default value(s) shall then be substituted until such fault has been corrected.

Physical/Virtual Point	Default Delay Time	Default Value
Outside Air Temperature	3 minutes	80˚F
Trend Data		N/A

4. Trending Restrictions for AACs: BCs connected to same Network shall be capable of storing trend data for points associated with AACs that do not have on-board trend storage capability and must still meet the requirement of paragraph 2.3A.11, or special purpose trend storage devices meeting the requirement of paragraph 2.3A.11 for AAC points must be added for this purpose.
5. Mounting:

a. AACs/BCs that control equipment located above accessible ceilings shall be mounted in a NEMA 1, locking enclosure, and shall be rated for plenum use if ceiling attic is used as a return air plenum.
b. AACs/BCs that control equipment located in occupied spaces, or outside shall either be mounted within the equipment enclosure (responsibility for physical fit remains with the Contractor) or in a proximate mechanical/utility room in which case it shall be enclosed in a NEMA 1, locking enclosure.

G. Application Category 3 (Building Controller)

1. Applications in this category include the following:

a. VAV Air Handlers.
b. Central Cooling Plant.
c. Central Heating Plant.

2. Applicable Controllers: BCs shall be used in these applications.
3. Mounting: See 3.2F.5

3.3 CONTROL POWER

A. Refer to Section 230900 for power to control panels.

END OF SECTION 230919

SECTION 230923 – EMCS COMMUNICATION DEVICES

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 WORK INCLUDED

A. Provide and install the following:

1. LAN Interface Devices/Routers
2. BACnet Gateways

B. Refer to Section 230900 for general requirements.

1.3 RELATED WORK AND REQUIREMENTS

A. Other EMCS Sections:

1. Section 230900 Energy Management and Control System (EMCS) - General
2. Section 230913 EMCS Basic Materials and Devices
3. Section 230916 EMCS Operator Interfaces
4. Section 230919 EMCS Field Panels
5. Section 230926 EMCS Software and Programming
6. Section 230933 EMCS Commissioning

PART 2 - PRODUCTS

2.1 CONTROLLER LOCAL AREA NETWORK INTERFACE DEVICES (LANID)

A. The Controller LANID shall be a microprocessor-based communications device which acts as a gateway/router between the Primary LAN, Secondary LAN, an operator interface, modem to support remote operator interface, or printer. These may be provided within a BC or as a separate device.

B. The LANID shall perform information translation between the Primary LAN and the Secondary LAN, supervise communications on a polling secondary LAN, and shall be applicable to systems in which the same functionality is not provided in the BC. In systems where the LANID is a separate device, it shall contain its own microprocessor, RAM, battery, real-time clock, communication ports, and power supply as specified for a BC in Section 230919. Each LANID shall be mounted in a lockable enclosure.

C. Each LANID shall support interrogation, full control, and all utilities associated with all BCs on the Primary LAN, all AACs and ASCs connected to all secondary LANs under the Primary Controller LAN, and all points connected to those PCUs and SCUs.

D. Upon loss of power to a LANID, the battery shall provide for minimum 100-hour backup of all programs and data in RAM. The battery shall be sealed and self-charging.

E. The LANID shall be transparent to control functions and shall not be required to control information routing on the Primary LAN.

2.2 SUPERVISORY LAN ROUTERS

A. The Supervisory Router shall be a microprocessor-based communications device that acts as a router between the Supervisory LAN CSSs or OWS and the Primary LAN.

B. The Supervisory Router shall not perform information translation. Both Primary LAN and the Supervisory LAN shall use BACnet.

C. The Supervisory Router shall contain its own microprocessor, RAM, communication ports, and power supply. Each Supervisory Router shall be mounted in a lockable enclosure.

D. The Supervisory Router shall allow centralized overall system supervision, operator interface, management report generation, alarm annunciation, acquisition of trend data, and communication with control units. It shall allow system operators to perform the following functions from the CSS, OWSs, and POTs:

1. Configure systems.
2. Monitor and supervise control of all points.
3. Change control setpoints.
4. Override input values.
5. Override output values.
6. Enter programmed start/stop time schedules.
7. View and acknowledge alarms and messages.
8. Receive, store and display trend logs and management reports.
9. Upload/Download programs, database, etc. as specified.

E. Upon loss of power to the Supervisory Router, the battery shall provide for minimum 100-hour backup of all programs and data in RAM. The battery shall be sealed and self-charging.

F. The Supervisory Router shall be transparent to control functions and shall not be required to control information routing on the Primary LAN.

2.3 BACnet BROADCAST MESSAGE ROUTING

A. To allow BACnet broadcast messages to be relayed from remote nodes communicating via the internet and connecting to the Supervisory Router through IP protocol, a BACnet/IP Broadcast Management Device (BBMD) shall be provided which conforms to the Annex J definition of the BACnet standard for two-hop distribution. Multicast messaging or one-hop distribution requiring configuration of IP routers which are not part of the EMCS vendor's scope is not acceptable.

2.4 BACNET GATEWAYS

A. Gateways shall be provided to link non-BACnet control products to the BACnet inter-network. All of the functionality described in this section is to be provided by using the BACnet capabilities. Each Gateway shall have the ability to expand the number of BACnet objects of each type supported by 20% to accommodate future system changes.

B. Each Gateway shall provide values for all points on the non-BACnet side of the Gateway to BACnet devices as if the values were originating from BACnet objects. The Gateway shall also provide a way for BACnet devices to modify (write) all points specified by the AOC using standard BACnet services. All points are required to be writable for each site.

C. The Gateway shall implement BACnet schedule objects and permit both read and write access to the schedules from the workstation.

D. Each Gateway shall provide a way to collect and archive or trend (time, value) data pairs.

E. Each Gateway and any devices that the Gateway represents which have time-of-day information shall respond to workstation requests to synchronize the date and time. Each Gateway and any devices that the Gateway represents shall support dynamic device binding and dynamic object binding.

F. All points in the system shall be made network visible through the use of standard BACnet objects or through proprietary BACnet extensions that the workstation also supports. All points shall be writable using standard BACnet services.

G. All devices shall have a Device Object instance number that is unique throughout the entire inter-network. All BACnet devices shall be configured with a Device Object instance number that is based on the format specified (shown in decimal notation). This includes all physical devices as well as any logical BACnet devices that are physically represented by Gateways.

H. All BACnet Interoperability Building Blocks (BIBBs) are required to be supported for each native BACnet device or Gateway. The Gateway shall support all BIBBs defined in the BACnet Gateway's device profile as defined in the BACnet standard.

I. Upon loss of power to a Gateway, the battery shall provide for minimum 1000-hour backup of all programs and data in RAM. The battery shall be sealed and self-charging.

J. UL 916 CE FCC part 15 Subpart B – Class A with surge and transient protection circuitry for power and communications.

PART 3 - EXECUTION

3.1 GENERAL

A. Install systems and materials in accordance with manufacturer's instructions, specifications, roughing-in drawings, and details shown on drawings.

B. Contractor shall provide all interface devices and software to provide an integrated system.

C. See Control Power in Section 230900 for device power options and requirements.

3.2 LANID AND LAN ROUTERS

A. Provide as required. See System Architecture in Section 230900.

B. At each building, connect Supervisory LAN to Owner's IT/LAN or dedicated EMCS network (whichever is applicable).

C. Connect networks to both sides of device.

D. Thoroughly test to ensure proper operation.

E. Interruptions or fault at any point on any Primary Controller LAN shall not interrupt communications between other nodes on the network. If a LAN is severed, two separate networks shall be formed and communications within each network shall continue uninterrupted. The system shall automatically monitor the operation of all network devices and annunciate any device that goes off-line because it is failing to communicate.

3.3 GATEWAYS

A. General.

1. Wire to networks on both sides of device.
2. Map across all monitoring and control points listed on drawings.
3. Thoroughly test each point to ensure that mapping is accurate.
4. Initiate trends of points as indicated on drawings.

END OF SECTION 230923

SECTION 230926 – EMCS SOFTWARE AND PROGRAMMING

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 WORK INCLUDED

A. Provide and install the following:

1. System Software
2. Programming Software
3. Graphical User Interface Software

B. Refer to Section 230900 for general requirements.

1.3 RELATED WORK AND REQUIREMENTS

A. Other EMCS Sections:

1. Section 230900 Energy Management and Control System (EMCS) - General
2. Section 230913 EMCS Basic Materials and Devices
3. Section 230916 EMCS Operator Interfaces
4. Section 230919 EMCS Field Panels
5. Section 230923 EMCS Communication Devices
6. Section 230933 EMCS Commissioning

1.4 GENERAL

A. System software shall be based on server/thin-client architecture, designed around the open standards of web technology. Servers shall be accessed using a web browser over the control system Supervisory LAN, the Owner intranet, and remotely over the Internet (through the Owner IT WAN/LAN).

B. The intent of the thin-client architecture is to provide operators complete access to the EMCS via a web browser GUI. No special software other than a web browser (including active-x components or fat java clients) shall be required to be installed on OIs used to access the EMCS graphics, point displays, trends, and trend configuration. Additional software other than a browser may be used to configure or modify the EMCS and programming.

C. The Contractor shall furnish and install all software and programming necessary to provide a complete and functioning system as specified. The Contractor shall include all software and programming not specifically itemized in these specifications that is necessary to implement, maintain, operate, and diagnose the system in compliance with these specifications.

D. Software Components: All software components of the BAS system software shall be installed and completed in accordance with thFe specification. BAS system components shall include:

1. Server Software, Database and Web Browser Graphical User Interface
2. System Configuration Utilities for future modifications to the system.
3. Graphical Programming.
4. Direct digital control software.
5. Application Software.

E. Database Open Connectivity: The BAS server database shall be Java DataBase Connectivity (JDBC) compatible, allowing real time access of data via XML/SOAP.

1.5 LICENSING

A. Include licensing and hardware keys for all software packages at all workstations (OWSs and POTs) and servers.

B. Within the limitations of the servers, any number of users shall have web access to the CSS at any given time.

C. All operator interface, programming environment, networking, database management and any other software used by the Contractor to install the system or needed to operate the system to its full capabilities shall be licensed and provided to the Owner.

D. All operator software, including that for programming and configuration, shall be available on all workstations. Hardware and software keys to provide all rights shall be installed on all workstations.

PART 2 - PRODUCTS

2.1 CONTROLLER SOFTWARE

A. BC Software Residency: Each BC shall be capable of control and monitoring of all points physically connected to it. All software including the following shall reside and execute at the BC:

1. Real-Time Operating System software.
2. Real-Time Clock/Calendar and network time synchronization.
3. BC diagnostic software.
4. LAN Communication software/firmware.
5. Direct Digital Control software.
6. Alarm Processing and Buffering software.
7. Energy Management software.
8. Data Trending, Reporting, and Buffering software.
9. I/O (physical and virtual) database.
10. Remote Communication software.

B. AAC/ASC Software Residency: Each AAC/ASC shall be capable of control and monitoring of all points physically connected to it. As a minimum, software including the following shall reside and execute at the AAC/ASC. Other software to support other required functions of the AAC/ASC may reside at the BC or LAN interface device (specified in Section 230923) with the restrictions/exceptions per application provided in Section 230919:

1. Real-Time Operating System software.
2. AAC/ASC diagnostic software.

3. LAN Communication software.
4. Control software applicable to the unit it serves that will support a single mode of operation.
5. I/O (physical and virtual) database to support one mode of operation.

C. Stand Alone Capability: BC shall continue to perform all functions independent of a failure in other BC/AAC/ASC or other communication links to other BCs/AACs/ASCs. Trends and runtime totalization shall be retained in memory. Runtime totalization shall be available on all digital input points that monitor electric motor status. Refer also to Section 230919 for other aspects of stand-alone functionality.

D. Operating System: Controllers shall include a real-time operating system resident in ROM or EEPROM. This software shall execute independently from any other devices in the system. It shall support all specified functions. It shall provide a command prioritization scheme to allow functional override of control functions. Refer also to Section 230919 for other aspects of the controller's operating system.

E. Network Communications: Each controller shall include software/firmware that supports the networking of CUs on a common communications trunk that forms the respective LAN. Network support shall include the following:

1. Building Controller/Primary LAN shall be a high-speed network designed and optimized for control system communication. If a Primary LAN communications trunk is severed, BCs shall reconfigure into two separate LANs and continue operations without interruption or Operator intervention.
2. Controller communication software shall include error detection, correction, and re-transmission to ensure data integrity.
3. Operator/System communication software shall facilitate communications between other BCs, all subordinate AACs/ASCs, Gateways and LAN Interface Devices or Operator Workstations. Software shall allow point interrogation, adjustment, addition/deletion, and programming while the controller is online and functioning without disruption to unaffected points. The software architecture shall allow networked controllers to share selected physical and virtual point information throughout the entire system.

F. Diagnostic Software: Controller software shall include diagnostic software that checks memory and communications and reports any malfunctions.

G. Alarm/Messaging Software: Controller software shall support alarm/message processing and buffering software as specified below.

H. Application Programs: CUs shall support and execute application programs specified.

I. Updating/Storing Application Data: Site-specific programming residing in volatile memory shall be up loadable/downloadable from an OWS or CSS using BACnet services connected locally, to the Primary LAN, to the Local Supervisory LAN and remotely via modem and telephone lines as applicable but all must be available. Initiation of an upload or download shall include all of the following methods; Manually, Scheduled, and Automatically upon detection of a loss or change.

J. Power Loss and Restart: System software shall provide for orderly shutdown upon loss of power. Volatile memory shall be retained. Outputs shall go to programmed fail position, which as a default shall be set to their position in unoccupied mode. Equipment restart shall be automatic upon power restoration and shall include a user definable time delay on each piece of equipment to stagger the restart. Loss of power shall be alarmed at operator interface indicating date and time.

K. Time Synchronization: Operators shall be able to set the time and date in any device on the network that supports time-of-day functionality. The operator shall be able to select to set the time and date for an individual device, devices on a single network, or all devices simultaneously. Automatic time synchronization shall be provided using BACnet services.

L. Anti-dithering. In order to improve the life expectancy of modulating electronic actuators, software shall limit the number of re-positions. This can be accomplished by providing anti-dithering software, a small dead-band for fully proportioning actuators, and by ensuring that floating actuators do not receive control pulses of excessively short duration.

2.2 GRAPHICAL USER INTERFACE SOFTWARE

A. A web browser installed on each OWS, POT, and server (see Section 230916) shall serve as the graphical user interface to the EMCS. Communication between the web server GUI and EMCS server shall be encrypted using 128-bit encryption technology within Secure Socket Layers. Communication protocol shall be Hyper-Text Transfer Protocol.

B. The GUI shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed to “feel” like a single application and provide a complete and intuitive mouse/menu driven operator interface. It shall be possible to navigate through the system using a web browser to accomplish all features specified in this section.

C. The GUI shall (as a minimum) provide a Navigation Pane for navigation and an Action Pane for display of animated graphics, schedules, alarms/events, live graphic programs, active graphic setpoint controls, configuration menus for operator access, reports, and reporting actions for events.

D. Login. Upon launching the web browser and selecting the appropriate domain name or IP address, the operator shall be presented with a login page that will require a login name and password. Navigation in the system shall be dependent on the operator’s role privileges, and geographic area of responsibility. See Security Access below.

E. Navigation Pane

1. The Navigation Pane shall comprise a Navigation Tree which defines a geographic hierarchy of the EMCS system. Navigation through the GUI shall be accomplished by clicking on appropriate level of a navigation tree (consisting of expandable and collapsible tree control like Microsoft’s Explorer program), and/or by selecting dynamic links to other system graphics. Both the navigation tree and action pane defined below shall be displayed simultaneously, enabling the operator to select a specific system or equipment, and view the corresponding graphic. The navigation tree shall as a minimum provide the following views:

    a. Geographic View shall display a logical geographic hierarchy of the system including: Cities, sites, buildings, building systems, floors, equipment and BACnet objects.
    b. Network View shall display the hierarchy of the actual BACnet IP Intranet network. This can include: Systems, Site, Networks, Routers, Half-Routers, Devices, Equipment and all the BACnet Objects in a device.
    c. Groups View shall display Scheduled Groups and custom reports.
    d. Configuration View shall display all the configuration categories (Operators, Schedule, Event, Reporting and Roles).

2. Alternative interface structures will also be accepted if they provide similar ease of navigation through the system hierarchy.

F. Action Pane. The Action Pane shall provide several functional views for each HVAC or mechanical/electrical subsystem specified. A functional view shall be accessed by clicking on the corresponding button:

1. Graphics: Using animated gifs or other graphical format suitable for display in a web browser, graphics shall include aerial building/campus views, color building floorplans, equipment drawings, active graphic setpoint controls, web content, and other valid HTML elements. The data on each graphic page shall automatically refresh as frequently as 6 updates per minute.
2. Properties: Shall include graphic controls and text for the following: Locking or overriding BACnet objects, demand strategies, and any other valid data required for setup. Changes made to the property's pages shall require the operator to depress an 'accept/cancel' button.
3. Schedules: Shall be used to create, modify/edit and view schedules based on the systems geographical hierarchy and in compliance with paragraph 2.2H.
4. Events: Shall be used to view alarm event information geographically (using the navigation tree), acknowledge events, sort events by category, actions and verify reporting actions.
5. Trends: Shall be used to display associated trend and historical data, modify colors, date range, axis and scaling.
6. Logic - Live Graphic Programs: Shall be used to display a 'live' graphic programs of the control algorithm for the mechanical/electrical system selected in the navigation tree.

G. Graphics:

1. The GUI shall make extensive use of color in the graphic pane to communicate information related to setpoints and comfort. Animated graphics and active setpoint graphic controls shall be used to enhance usability.
2. Graphics tools used to create Web Browser graphics shall be non-proprietary and provided and installed on each OWS.
3. Graphical display shall be 1280 x 1024 pixels or denser, 256 color minimum.
4. Links:

    a. Graphics shall include hyperlinks which when selected (i.e., clicked on with mouse) launch applications, initiate other graphics etc.
    b. Screen Penetration: Links shall be provided to allow user to navigate graphics logically without having to navigate back to the home graphic. See additional discussion in Paragraph 3.5.
    c. Informational Links:

        1) On each MEP system and subsystem graphic, provide links to display in a new window the information listed below.

            a) English-language control sequence associated with the system. See drawings.
            b) O&M and submittal information for the devices on the graphic. See Section 230900 and Section 230010.

        2) The display shall identify the target of the link by file name/address.
        3) Information shall be displayed in electronic format that is text searchable.
        4) Window shall include software tools so that text, model numbers, or point names may be found. Source documents shall be read-only (not be editable) with this software, however.

5. Point Override Feature:

    a. Every real output or virtual point displayed on a graphic shall be capable of being overridden by the user (subject to security level access) by mouse point-and-click from the graphic without having to open another program or view.
    b. When the point is selected to be commanded:

        1) Dialog box opens to allow user to override the point (place in “operator mode”) or release the point (“automatic mode”). Operator mode will override automatic control of the point from normal control programs.
        2) Dialog box shall have buttons (for digital points) or a text box and/or slide bar (for analog points) to allow user to set the point’s value when in operator mode. These are grayed out when in automatic mode.
        3) When dialog box is closed, mode and value are sent to controller.
        4) Graphic is updated upon next upload scan of the actual point value.

    c. A list of points that are currently in an operator mode shall be available through menu selection.

6. Point override status (if a digital point is overridden by the supervised manual override per Section 230919 or if a point is in operator mode per 2.2G.5) shall be clearly displayed for each point, e.g., by changing color or flag.
7. The color of symbols representing equipment shall change color or become animated based on status of binary point to graphically represent on/off status.
8. On floor plan displays of spaces, temperature shall be graphically displayed by coloring the zone area in accordance with or similar to the following:

    a. Red: space temperature above cooling setpoint by 2°F (adj.) or more. This condition can be programmed to generate an alarm.
    b. Yellow: space temperature between cooling setpoint and 2°F (adj.) above setpoint.
    c. Green: space temperature between cooling and heating setpoints and space is in occupied mode.
    d. Gray: space temperature between cooling and heating setpoints and space is in unoccupied mode.
    e. Light blue: space temperature between heating setpoint and 2°F (adj.) below setpoint.
    f. Dark blue: space temperature below heating setpoint by 2°F (adj.) or more. This condition can be programmed to generate an alarm.

9. On floor plan displays of spaces, lighting shall be graphically displayed by coloring the lighting zone area in accordance with or similar to the following:

    a. Yellow: lights on by timed override.
    b. Red: lights on by manual override in lighting panel.
    c. Green: lights on by schedule.
    d. Gray: lights off.

10. Floor plans shall include final room names and room numbers as confirmed by the Owner. Room names and room numbers included in Construction Documents are not necessarily the final room names and room numbers. Division 23C Contractor shall be responsible for obtaining and confirming the final room names and room numbers from Owner. Changes to floor plan graphics resulting from wrong room names and room numbers shall be made at no additional charge to the Owner.

H. Graphics Development Package:

1. Graphic development and generation software shall be provided to allow the user to add, modify, or delete system graphic displays.
2. Provide capability to store graphic symbols in a symbol directory and incorporate these symbols into graphics.
3. Provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g., fans, cooling coils, filters, dampers, etc.), mechanical system components (e.g., pumps, chillers, cooling towers, boilers, etc.), complete mechanical subsystems (e.g., VAV reheat zone, etc.) and electrical symbols.
4. The Graphic Development Package shall use a mouse or similar pointing device to allow the user to perform the following:

    a. Define symbols.
    b. Position items on graphic screens.
    c. Attach physical or virtual points to a graphic.
    d. Define background screens.
    e. Define connecting lines and curves.
    f. Locate, orient and size descriptive text.
    g. Define and display colors for all elements.
    h. Establish correlation between symbols or text and associated system points or other displays.
    i. Create hot spots or link triggers to other graphic displays or other functions in the software.

5. A single graphic file shall be used for common control applications (e.g., VAV box) so that any updates to the graphic may be done once and automatically applied to all applications. Displayed points shall be automatically populated based on “wild card” entry of point name in graphic definition.

I. Time and Schedules:

1. Provide a time master that is installed and configured to synchronize the clocks of all BACnet devices supporting time synchronization. Synchronization shall be done using Coordinated Universal Time. All trend sample times shall be able to be synchronized. The frequency of time synchronization message transmission shall be selectable by the operator.
2. System shall automatically change time/date for Daylight Savings Time and leap years.
3. An operator (with password access) shall be able to define a Normal, Holiday or Override schedule for an individual piece of equipment or room or choose to apply a hierarchical schedule to the entire system, site or floor “isolation” area. For example, Independence Day ‘Holiday’ for every level in the system would be created by clicking at the top of the geographic hierarchy defined in the Navigation Tree. No further operator intervention would be required and every control module in the system with would be automatically downloaded with the ‘Independence Day’ Holiday.
4. All schedules that affect the system/area/equipment highlighted in the Navigation Tree shall be shown in a summary schedule table and graph.
5. Schedules shall comply with the BACnet standard, (Schedule Object, Calendar Object, Weekly Schedule property and Exception Schedule property) and shall allow events to be scheduled based on:

    a. Types of schedule shall be Normal, Holiday or Override.
    b. A specific date.
    c. A range of dates.
    d. Any combination of Month of Year (1-12, any), Week of Month (1-5, last, any), Day of Week (M-Sun, Any).
    e. Wildcard (example, allow combinations like second Tuesday of every month).

6. Schedule Categories: The system shall allow operators to define and edit scheduling categories (different types of “things” to be scheduled; for example, lighting, HVAC occupancy, etc.). The categories shall include: Name, description, icon (to display in the hierarchy tree when icon option is selected) and type of value to be scheduled.
7. Schedule Groups: In addition to hierarchical scheduling, operators shall be able to define functional Schedule Groups, comprised of an arbitrary group of areas/rooms/equipment scattered throughout the facility and site. For example, the operator shall be able to define an ‘individual tenant’ group – who may occupy different areas within a building or buildings. Schedules applied to the ‘tenant group’ shall automatically be downloaded to control modules affecting spaces occupied by the ‘tenant group’.
8. Partial Day Exceptions: Schedule events shall be able to accommodate a time range specified by the operator (example: board meeting from 6 pm to 9 pm overrides Normal schedule for conference room).
9. Schedule Summary Graph: The schedule summary graph shall clearly show Normal versus Holiday versus Override Schedules, and the net operating schedule that results from all contributing schedules. Note: In case of priority conflict between schedules at the different geographic hierarchy, the schedule for the more detailed geographic level shall apply.
10. Schedule Distribution: For reliability and performance, instead of maintaining a single schedule in a field device that writes over the network to notify other devices when a scheduled event occurs, field devices will only keep their part of the schedule locally. The EMCS server software shall determine which nodes a hierarchical schedule applies to and will create/modify the necessary schedule objects in each field device as necessary.

J. Events and Alarms:

1. Events and alarms associated with a specific system, area, or equipment selected in the Navigation Tree, shall be displayed in the Action Pane by selecting an ‘Events’ view.
2. Events View: Each event shall display an Event Category (using a different icon for each event category), date/time of occurrence, current status, and event report. An operator shall be able to sort events, edit event templates and categories, acknowledge, or force a return to normal in the Events View as specified in this section.
3. Event Categories (Alarm Levels): The operator shall be able to create, edit or delete event categories (alarm level). An icon shall be associated with each Event category, enabling the operator to easily sort through multiple events displayed. Alarm levels shall be initially configured by the Contractor as follows:

    a. Level 1: Critical/life safety.
    b. Level 2: Significant equipment failure.
    c. Level 3: Non-critical equipment failure/operation.
    d. Level 4: Energy conservation monitor.
    e. Level 5: Maintenance indication, notification.

4. BACnet Event Templates: BACnet Event template shall define different types of alarms and their associated properties. As a minimum, properties shall include a reference name, verbose description, severity of event, acknowledgement requirements, high/low limit and out of range information.
5. Event Areas (Actions): Each Event Categories (Alarm Level) shall be configured to specific Event Reporting Actions. For example, it shall be possible for an operator to assign all HVAC Maintenance events on the 1st floor of a building to email the technician responsible for maintenance. The Navigation Tree shall be used to setup Event Areas in the Graphic Pane. For initial setup, contractor shall configure events as follows:

    a. Levels 1 and 2: Print to alarm printer and call/text two engineers.
    b. Level 3: Print to alarm printer and email engineer responsible for building/system.
    c. Levels 4 and 5: Email engineer responsible for building/system

6. Event Reporting Actions: Event Reporting Actions specified shall be automatically launched (under certain conditions) after an event is received by the EMCS server software. Operators shall be able to define these Reporting Actions using the Navigation Tree and Graphic Pane through the GUI. Reporting Actions shall be as follows:

    a. GUI dialog box: Provide visual and optional audible alarm indication. The alarm dialog box shall always become the top dialog box upon receipt of an alarm irrespective of the foreground application.
    b. Print: Alarm/Event information shall be printed to the any network accessible printer.
    c. Email: Alarm/Event information shall be via email to a POP3 address on the Owner's intranet or through this intranet to the internet.
    d. Call/Text: Alarm/Event information shall be sent via alphanumeric call/text via email to internet alphanumeric call/text services.
    e. File Write: The ASCII File write reporting action shall enable the operator to append operator defined alarm information to any alarm through a text file. The alarm information that is written to the file shall be completely definable by the operator. The operator may enter text or attach other data point information (such as AHU discharge temperature and fan condition upon a high room temperature alarm).
    f. Write Property: The write property reporting action updates a property value in a hardware module.
    g. Run External Program: The Run External Program reporting action launches specified program in response to an event.

7. Event Time/Date Stamp: All events shall be generated at the DDC control module level and comprise the Time/Date Stamp using the standalone control module time and date.
8. Event Configuration: Operators shall be able to define the type of events generated per BACnet object. A 'network' view of the Navigation Tree shall expose all BACnet objects and their respective Event Configuration. Configuration shall include assignment of event, alarm, type of Acknowledgement and notification for return to normal or fault status.
9. Event Summary Counter: The view of events in the Graphic Pane shall provide a numeric counter, indicating how many events are active (in alarm), require acknowledgement, and total number of events in the EMCS Server database.
10. Event Auto-Deletion: Events that are acknowledged and closed, shall be auto-deleted from the database, and archived to a text file after an operator defined period. The file shall be stored in file on the CSS with no limit to quantity or age of alarms, other than limitations of hard disk. The file can be archived to tape and deleted by operator to clear disk space.
11. Data Format. The system shall allow for external systems to access the event instance data. Event data shall be stored and queried in the database in a relational manner. At a minimum, the fields to be stored in the database are:

    a. Event Source.
    b. Event Generation Tie.
    c. Acknowledge Required Flag.
    d. Delivery Priority.
    e. BACnet Event Type.
    f. Event Message Text.
    g. BACnet Event Parameter.
    h. Classification of Event.
    i. Event Acknowledgement Time.
    j. Return to Normal Time.
    k. Operator Comments.
    l. Who Acknowledged the Event.

12. Event Simulator: The GUI user shall provide an Event Simulator to test assigned Reporting Actions. The operator shall have the option of using current time or scheduling a specific time to generate the Event. Utilizing the Navigation Tree and drop-down menus in the Graphic Pane, the operator shall be able to select the Event Type, Status, Notification, Priority, Message, and whether acknowledgement is required.

K. Trends:

1. Trending and trend analysis capabilities are considered critical to system performance. The system shall be designed to upload and record large amounts of point data without causing network bottlenecks or affecting proper system operation. A separate server (Historical Trend Server) shall be provided (see Section 230916) in order to reduce network traffic to and disk activity on the CSS. The system as a whole shall be designed to comply with the trending capability test defined in Section 230933.
2. Every point, both real and virtual, shall be available for data trending.
3. Trending software shall be capable of recording point values and time on a user specified regular time step and on a change-of-value (COV) basis (data is recorded when point changes by a specified amount for analog points or by changes of state for binary points), at the user's option. Sampling intervals shall be as small as one second. Each trended point shall have the ability to be trended at a different sampling interval.
4. Trend data shall be sampled and stored in control panel memory (see Section 230919). If historical trending is enabled for the BACnet object, trend data shall be uploaded from control panels to the THS on a user-defined interval, manual command, or automatically when the trend buffer becomes full. There shall be no limit to the amount of trend data stored at the THS other than hard disk limitations.
5. Trends shall conform to the BACnet Trend Log Object specification. Trends shall both be displayed and user configurable through the GUI. Trend logs may comprise analog, digital or calculated points simultaneously. A trend log's properties shall be editable using the Navigation Tree and Graphic Pane.
6. Viewing Trends:

    a. Trend data shall be displayed graphically by the GUI. This shall be a capability internal to the workstation software and not a capability resulting from download of trend data on a third-party spreadsheet program unless such transfer is automatic and transparent to the operation and the third-party software is included with the workstation software package.
    b. The software shall be capable of dynamically graphing the trend logged object data by creating two-axis (x, y) graphs that simultaneously display values relative to time for at least eight objects in different colors, even if objects have been trended at different time intervals. Where trended values are COV, software shall automatically fill the trend samples between COV entries. A graph legend shall identify each variable plotted.
    c. Multiple scales shall be possible, one for each object, with range set automatically by the software but capable of being manually adjusted by the operator.
    d. Trend format, displayed points, etc. shall be capable of being saved as a template for future trend displays.
    e. Trends shall be able to dynamically update at operator-defined intervals, including on a 1 second interval for loop tuning.
    f. It shall be possible to zoom-in on a particular section of a trend for more detailed examination and 'pan through' historical data by simply scrolling the mouse.
    g. It shall be possible to pick (or float mouse over) any sample on a trend and have the numerical value displayed.
    h. The operator shall have the ability to pan through a historical trend and copy the data viewed to the clipboard using standard Windows keystrokes.

7. Trend Data Storage

a. The database shall allow applications to access the data while the database is running. The database shall not require shutting down in order to provide read-write access to the data. Data shall be able to be read from the database without interrupting the continuous storage of trend data being carried by the EMCS.
b. Provide a single licensed copy of Microsoft SQL Server and install on the OWS.
c. Data shall be accessible to off-site SQL compliant database software through the Owner's intranet and/or internet.

L. Security Access:

1. Security access from the GUI to EMCS servers shall require a Login Name and Password.
2. Access to different areas of the EMCS shall be defined in terms of roles and geographic area of responsibility as specified.
3. Roles shall reflect the actual roles of different types of operators. Roles shall be defined in terms of View, Edit and Function Privileges.

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

4. Roles shall be geographically assigned using a similar expandable/collapsible navigation tree. For example, it shall be possible to assign two HVAC Technicians with similar competencies (and the same operator defined HVAC Role) to different areas of the system.
5. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected for an adjustable period of time. This auto logoff time shall be set individually per operator.
6. Provide an audit trail of actions taken by any user, including the username and time. Store in secure file in database format on the CSS. Provide software to view and print audit trail.

M. Report Software:

1. Provide software to create standard and custom reports of point status, alarms, etc. Report format, displayed points, time period (daily, weekly, monthly, or annual), etc. shall be capable of being saved as a template for future reports. Reports shall be time and date stamped and shall contain a report title editable by the user.
2. Reports shall be capable of being sent to a printer or export to Word or ASCII format to a file and shall be capable of being generated automatically based on date and time of day.
3. Standard reports. Prepare the following standard reports for each building and the Owner as a whole, accessible automatically without requiring definition by user:

    a. Tenant after-hour usage. System must be capable of monitoring tenant override requests and generating a monthly report showing the daily total time in hours that each tenant has requested after-hours HVAC services.
    b. Alarm events and status.
    c. Points in "hand" (operator override) via Workstation command (including name of operator who made the command) or via supervised HOA switch at output, including date and time.
    d. Position reset: Where zones or system valve or damper positions are used to reset supply air/water temperature or differential pressure setpoints:

1) EMCS shall record the following on an hourly basis: the descriptors of the zones/systems that have dampers/valves at the highest cooling/heating position, i.e., the control point that is being used in the reset loop. The information shall be accumulated in a report format for periodic printing upon operator command.
2) Configure a tabular report using real-time or trend data with the following column headings: ZONE [SYSTEM] DESCRIPTION, VALVE [DAMPER] POSITION (0 to 100%), LOOP OUTPUT %, [CHWST, CHWDP, SAT, etc.] SETPOINT. At the top of the table, list building number, floor or area description if applicable, air handling unit or HW/CHW pump system designation.

2.3 CONTROL PROGRAMMING SOFTWARE

A. Points:

1. Provide templates customized for point type, to support input of individual point information using standard BACnet Objects, including long-name field.
2. All real and virtual points shall be accessible to any control panel for use in any control sequences regardless of physical location.

B. Programming Language:

1. All controllers must be fully user-programmable using a single programming language for all control devices. Use of “canned” (preprogrammed, burned-in) software is not acceptable.
2. The control programming language must allow virtually any control sequences to be written. Software shall be capable of the sequences specified on drawings without exception.
3. All custom programs shall be modifiable from Operator Workstations without having to “burn chips”. Software shall allow the user to modify and input control sequence software and to download to panels via the control network.
4. The programming language shall support floating point arithmetic using the following operators and functions: +, -, /, x, square root, and x-to-the-y-power, natural log, log, trigonometric functions (sine, cosine, etc.), absolute value, minimum/maximum value from a list of values, and psychrometric parameters (wet-bulb, dewpoint, and enthalpy) from temperature and relative humidity.
5. The programming language shall have predefined variables that represent time of day, day of the week, month of the year, and the date. Other predefined variables shall provide elapsed time in seconds, minutes, hours, and days. These elapsed time variables shall be able to be reset by the language so that interval timing functions can stopped and started within a program.
6. The system must be capable of supporting software (“virtual”) points to be used in control sequences and monitored, just as if they were real digital or analog points.
7. Control programming shall employ the BACnet protocols for Standard Command Priorities.
8. A PID (proportional-integral-derivative) algorithm with adjustable gains and anti-windup shall be included as an integral part (subroutine) of the programming language, not requiring special programming or hardware.
9. The programming language shall be graphical. BASIC-like or other line- or block-type programming languages are not acceptable. With the graphical programming language, a sequence of operations shall be created by drag-and-drop assembling on screen of graphic blocks that represent each of the commands or functions necessary to complete a control sequence. Blocks represent common logical control devices such as relays, switches, high signal selectors, PID loops, optimum start, etc. Blocks are then

interconnected on screen using graphic "wires," each forming a logical connection. Once assembled, each logical grouping of graphic blocks and their interconnecting wires then forms a graphic function block which may be used to control any piece of equipment with a similar point configuration and sequence of operation.

10. The graphic programming software shall support a ‘live’ mode, where all input/output data, calculated data, and setpoints shall be displayed in a ‘live’ real-time mode. For each piece of HVAC equipment, the entire graphic program shall be displayed through the GUI. The operator must have the ability to scroll through the entire ‘live’ graphic program as necessary.

C. Debugging Software:

1. Provide a search capability that will search all control sequences for a given point name to determine all sequences that use or control the point.
2. The control programs shall be capable of being tested on-line or off-line (prior to installation in field panels). The program and results of programming tests shall be displayed graphically using graphical programming language with parameter values displayed in appropriate locations. Simulation capabilities shall include step-by-step, accelerated time, and operator defined simulation criteria like outside weather, demand, and communication status.

2.4 MISCELLANEOUS SOFTWARE

A. Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide relevant data for the application or object that help is being called from.

B. Provide software for viewing (but not editing) electronic versions of as-built shop drawings of:

1. Mechanical, electrical, and plumbing systems in AutoCAD Release 14 or 2000+ format.
2. EMCS drawings in format selected by contractor (see limitations in Section 230900).

PART 3 - EXECUTION

3.1 SYSTEM CONFIGURATION

A. Contractor shall thoroughly and completely configure EMCS system software, supplemental software, network software etc. on CSS, POTs, and servers.

3.2 POINT STRUCTURING AND NAMING

A. The intent of this section is to require a consistent means of naming points across the Campus EMCS. Contractor shall configure the systems from the perspective of the Campus EMCS, not solely the local project. The following requirement establishes a standard for naming points and addressing Buildings, Networks, Devices, Instances, etc.

B. Point Summary Table:

1. The term ‘Point’ includes all physical I/O points, virtual points, and all application program parameters.
2. With each schematic, Contractor shall provide a Point Summary Table listing:

a. Building number and abbreviation.
b. System type.
c. Equipment type.
d. Point suffix.
e. Full point name (see Point Naming Convention paragraph).
f. Point description.
g. Ethernet backbone network number.
h. Network number.
i. Device ID.
j. Device MAC address.
k. Object ID (object type, instance number).
l. Engineering units.
m. Device make and model #. Include range of device if model number does not so identify.
n. Device physical location description. Include floor and column line intersection to one decimal place (e.g., line 6.2 and line A.3)

3. Point Summary Table shall be provided in both hard copy and in a relational database electronic format (ODBC-compliant).
4. The EMCS Contractor shall coordinate with the Owner's representative and compile and submit a proposed Point Summary Table for review prior to any object programming or project startup.
5. The Point Summary Table shall be kept current throughout the duration of the project by the Contractor as the Master List of all points for the project. Project closeout documents shall include an up-to-date accurate Point Summary Table. The Contractor shall deliver to the Owner the final Point Summary Table prior to final acceptance of the system. The Point Summary Table shall be used as a reference and guide during the commissioning process.

C. Point Naming Convention:

1. All point names shall adhere to the format as established below, unless otherwise agreed to by the Owner. New categories and descriptors may be created with approval of the Owner.
2. Format:

a. Building.Category.System.Equipment Tag.Component.Property.
b. Example: 001LIB.HVAC.Heatplant.B-1.HWS.Temperature.

Building	Category	System	Equipment Tag	Component	Property	Typical units
Building number	ELCT	Lighting Plug Generator Misc.	(From equipment schedules)	SWITCH PHOTO CB	Command Status Light Power	On/off On/off Footcandles Watts
	HVAC	Air handling Exhaust Heatplant Coolplant Misc.		CWS CWR HWS HWR CHWS	Voltage Current ValvePos DamperPos Temperature	Volts Amps % Open % Open °F
	PLMB	Dom water Air Nat gas		CHWR OA SA	Humidity Pressure Flow	%RH Psig, " H_2O Cfm, gpm

Building	Category	System	Equipment Tag	Component	Property	Typical units
		N2 O2 Irrigation Waste Misc.		RA EA GAS FLUID	Energy Speed Signal	Btu %, Hz Hz
	MISC	Weather				

D. Device Addressing Convention:

1. BACnet network numbers and Device Object IDs shall be unique throughout the network.
2. All assignment of network numbers and Device Object IDs shall be coordinated with the Owner.
3. Each Network number shall be unique throughout all facilities and shall be assigned in the following manner unless specified otherwise:

   BBBFF, where: BBB = 1-655 assigned to each building, FF = 00 for building backbone network, 1-35 indicating floors or separate systems in the building.

4. Each Device Object Identifier property shall be unique throughout the system and shall be assigned in the following manner unless specified otherwise:

   XXFFBBB, where: XX = number 0 to 40, FF = 00 for building backbone network, 1-35 indicating floors or separate systems in the building. BBB = 1-655 assigned to each building.

5. The EMCS Contractor shall coordinate with the Owner or a designated representative to ensure that no duplicate Device Object IDs occur.
6. Alternative Device ID schemes or cross project Device ID duplication if allowed shall be approved before project commencement by the Owner.

E. I/O Point Physical Description:

1. Each point associated with a hardware device shall have its BACnet long-name point description field filled out with:

   a. The device manufacturer and model #. Include range of device if model number does not so identify.
   b. For space sensors (temperature, CO_2, etc.), include room number in which sensor is located.

3.3 POINT PARAMETERS

A. Provide the following minimum programming for each analog input:

1. Name.
2. Address.
3. Scanning frequency or COV threshold.
4. Engineering units.
5. Offset calibration and scaling factor for engineering units.
6. High and low alarm values and alarm differentials for return to normal condition
7. High and low value reporting limits (reasonableness values), which shall prevent control logic from using shorted or open circuit values.

8. Default value to be used when the actual measured value is not reporting. This is required only for points that are transferred across the primary and/or secondary controlling networks and used in control programs residing in control units other than the one in which the point resides. Events causing the default value to be used shall include failure of the control unit in which the point resides, or failure of any network over which the point value is transferred.
9. Selectable averaging function that shall average the measured value over a user selected number of scans for reporting.

B. Provide the following minimum programming for each analog output:

1. Name.
2. Address.
3. Output updating frequency.
4. Engineering units.
5. Offset calibration and scaling factor for engineering units.
6. Output range.
7. Default value to be used when the normal controlling value is not reporting.

C. Provide the following minimum programming for each digital input:

1. Name.
2. Address.
3. Engineering units (on/off, open/closed, freeze/normal, etc.)
4. Debounce time delay.
5. Message and alarm reporting as specified.
6. Reporting of each change of state, and memory storage of the time of the last change of state.
7. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.

D. Provide the following minimum programming for each digital input:

1. Name.
2. Address.
3. Output updated frequency.
4. Engineering units (on/off, open/closed, freeze/normal, etc.)
5. Direct or Reverse action selection.
6. Minimum on-time.
7. Minimum off-time.
8. Status association with a DI and failure alarming (as applicable).
9. Reporting of each change of state and memory storage of the time of the last change of state.
10. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.
11. Default value to be used when the normal controlling value is not reporting.

3.4 SITE-SPECIFIC APPLICATION PROGRAMMING

A. All site-specific application programming shall be written in a manner that will ensure programming quality and uniformity among the various buildings. The EMCS Contractor will ensure:

1. Programs for all buildings are developed by one programmer, or a small group of programmers with rigid programming standards, to ensure a uniform style.
2. Programs for like functions are identical, to reduce debugging time and to ease maintainability.
3. Programs are thoroughly debugged before they are installed in the field.

B. Massage and tune application programming for a fully functioning system. It is the Contractor's responsibility to request clarification on sequences of operation that require such clarification.

C. All site-specific programming shall be fully documented and submitted for review and approval:

1. Prior to downloading into the panel (see Submittal Package 2 in Section 230900.)
2. At the completion of functional performance testing, and.
3. At the end of the warranty period (see Warranty Maintenance in Section 230900).

D. All programming, graphics and data files must be maintained in a logical system of directories with self-explanatory file names. All files developed for the project will be the property of the Owner and shall remain on the workstations/servers at the completion of the project.

3.5 GRAPHIC SCREENS

A. All site-specific graphics shall be developed in a manner that will ensure programming quality and uniformity among the various buildings.

B. Schematics of MEP systems.

1. Schematics shall be 3-D and shall be based substantially on the schematics provided on design drawings.
2. All relevant I/O points and setpoints being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation or color changes shall be used to indicate on/off status of mechanical components. Include appropriate engineering units for each displayed point value. Verbose names (English language descriptors) shall be included for each point on all graphics; this may be accomplished by the use of a pop-up window accessed by selecting the displayed point with the mouse.
3. Animation or equipment graphic color changes shall be used to indicate on/off status of mechanical components.
4. Indicate all adjustable setpoints and setpoint high and low limits (for automatically reset setpoints), on the applicable system schematic graphic or, if space does not allow, on a supplemental linked-setpoint screen.

C. Displays shall show all points relevant to the operation of the system, including setpoints and setpoint limits for setpoints that are automatically reset.

D. The current value and point name of every I/O point and setpoint shall be shown on at least one graphic and in its appropriate physical location relative to building and mechanical systems.

E. Show weather conditions (local building outside air temperature and humidity, wind speed, and wind direction) in the upper left-hand corner of every graphic.

F. CAD Files: The contract document drawings will be made available to the Contractor in AutoCAD 2010+ format upon request for use in developing backgrounds for specified graphic screens, such as floor plans and schematics. However, the Owner does not guarantee the suitability of these drawings for the Contractor's purpose.

G. Provide graphics for the following as a minimum:

1. Homepage (Campus, District or Facility Homepage). Background shall be a campus map, approximately to scale. Include links to each building, central plant, domestic water pumping station, etc. Include real-time site utility data such as: building electrical demand, domestic cold-water flow, and natural gas demand shown roughly on the map where the utilities connect to the site. Also include kW demand limit values and demand limit level.
2. Building homepage. Background shall be a bldg. footprint, approximately to scale, oriented as in the campus homepage. Include links to each floor and mechanical room/roof, and to summary graphics described below. Include real-time building utility data such as: building electrical demand, chilled water demand (flow and Btu/h), hot water demand (flow and Btu/h), domestic cold-water demand, steam demand (if applicable), and natural gas demand (if applicable) shown roughly on the building footprint where the utilities connect to the building.
3. Each occupied floor plan, to scale.

    a. HVAC. Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, which provide a visual display of temperature relative to their respective setpoints (see paragraph 2.2G.8). The colors shall be updated dynamically as a zone's actual comfort condition changes. In each zone, provide links to associated terminal equipment.
    b. Lighting. Floor plan graphics shall show lighting control zones throughout the buildings in a range of colors, which provide a visual display of temperature relative to their respective setpoints (see paragraph 2.2G.9). The colors shall be updated dynamically as a zone's actual lighting condition changes. In each zone, provide links to associated lighting panel screen to allow manual overrides.
    c. If multiple floor plans are necessary to show all areas, provide a graphic building key plan. Use elevation views and/or plan views as necessary to graphically indicate the location of all of the larger scale floor plans. Link graphic building key plan to larger scale partial floor plans. Provide links from each larger scale graphic floor plan screen to the building key plan and to each of the other graphic floor plan screens.

4. Each equipment floor/roof plan, to scale, with links to graphics of all DDC controlled/monitored equipment.
5. Each air handler and fan-coil. Provide link to associated HW and CHW pumping stations where applicable.
6. Each zone terminal. Provide link to associated air handling unit where applicable and to floor plan where terminal is located.
7. Each building pumping station. Provide link to central plant for heating and cooling systems.
8. Plumbing, potable water pumping and domestic water heating system.
9. Potable water, irrigation and natural gas meter.
10. Lighting panels. Indicate status of each relay and provide links to allow override.
11. Electrical power monitoring system.

    a. Site: Show site single line diagram up to each building ATS, in order to illustrate the 12 KV power distribution and connection of each building to one of the two site circuits. The power flow would change on the diagram (by changing line color and/or width) to show which power line is active into each building as the ATS position is changed. Show ATS status at each building and a link to each building’s electrical system graphic.
    b. For each building: Show a schematic of the electrical system based on one-line diagrams. Show status and power of each switch, breaker, meter, etc. and override buttons for overriding switch positions.

12. Central plant equipment including chilled water system, cooling tower system, hot water system, steam system, generators, etc. The flow path shall change on the diagram (by changing piping line color and/or width) to show which piping has active flow into each boiler, chiller, tower, etc. as valve positions change.
13. Weather station. Show actual, daily, month-to-date, year-to-date, and historical high and low peaks and average temperature, humidity, wind speed, wind direction (average only), and solar radiation.
14. Summary graphics. Provide a single text-based page (or as few as possible) for each of the following summary screens showing key variables listed in columns for all listed equipment:

    a. For each building:

        1) Air handling units: operating mode, on/off status, supply air temperature, supply air temperature setpoint, fan speed, duct static pressure, duct static pressure setpoint, outdoor air damper position, coil valve positions
        2) Zone terminal units: operating mode, airflow rate, zone temperature, zone temperature setpoint, damper position, supply air temperature (reheat boxes), supply air temperature setpoint (reheat boxes), fan status (fan-powered boxes), fume hood status and exhaust airflow rate (laboratory).
        3) Electrical meters and switches: Volts, current, kW, switch positions.

15. All other DDC controlled/monitored equipment.

H. Alarms: Each programmed alarm shall appear on at least one graphic screen. In general, alarms shall be displayed on the graphic system schematic screen for the system that the alarm is associated with (for example, chiller alarm shall be shown on graphic cooling system schematic screen). For all graphic screens, display analog values that are in a ‘high alarm’ condition in a red color, ‘low alarm’ condition in a blue color. Indicate digital values that are in alarm condition in a red color.

3.6 POT SOFTWARE

A. Direct Panel Access:

1. One of the POTs shall be configured to access BCs and AACs by directly connecting to these panels without having to connect to the CSS via the network. The purpose of this requirement is to provide access to building EMCS panels in case the Supervisory LAN is down.
2. At the end of commissioning and then again at the end of the warranty period, fully synchronize the database on this POT with that on the CSS.

B. Temporary Interface prior to Acceptance:

1. Point database and control programming shall not be installed on and merged with that on the CSS until the system is fully commissioned and accepted by the Owner. During this phase, the Contractor shall provide a temporary POT configured with proper software for this purpose, connected to the EMCS locally at the building.
2. Once the EMCS has been accepted by the Owner, merge the database and control programming with existing systems on the CSS.

C. TAB Coordination:

1. Software shall be provided free of charge on at least a temporary basis to the TAB contractor to allow them to calibrate terminal box airflow controls and other work specified under Section 230593 Testing, Adjusting, and Balancing for HVAC.
2. Software may be provided for installation on POT provided by TAB contractor or Contractor shall loan a POT or hand-held device with software installed to the TAB contractor for the duration of TAB work.
3. Provide sufficient training to the TAB contractor to allow them to use the software for balancing and airflow calibration purposes. Contractor shall include a single training session; additional training due to changes in TAB personnel shall be paid for by the TAB contractor.

END OF SECTION 230926

SECTION 230933 – EMCS COMMISSIONING

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 WORK INCLUDED

A. Provide the following:

1. EMCS and equipment testing and start-up.
2. Validation of proper and thorough installation of EMCS and equipment.
3. Functional testing of control systems.
4. Demonstration testing of control systems.
5. Documentation of tests, procedures, and installations.
6. Coordination of EMCS training.
7. Documentation of EMCS Operation and Maintenance materials.

B. Refer to Section 230900 for general requirements.

1.3 RELATED WORK AND REQUIREMENTS

A. Other EMCS Sections:

1. Section 230900 Energy Management and Control System (EMCS) - General
2. Section 230913 EMCS Basic Materials and Devices
3. Section 230916 EMCS Operator Interfaces
4. Section 230919 EMCS Field Panels
5. Section 230923 EMCS Communication Devices
6. Section 230926 EMCS Software and Programming

1.4 COORDINATION

A. Assist Architect (or Commissioning Coordinator), including attending commissioning meetings.

B. Testing, Adjusting, and Balancing:

1. Coordinate with TAB contractors in test and balance work as specified in Section 230593 Testing, Adjusting, and Balancing. A significant number of balancing procedures require the EMCS to be operational and require Contractor time to assist the TAB contractor in their work.
2. Terminal unit calibration:

a. Provide software and/or portable devices for terminal unit calibration per Section

230926.

b. Connections shall be provided local to the device being calibrated. For instance, for VAV boxes, connection of the operator's terminal shall be either at the sensor or at the terminal box.

C. Coordinate with Division 23 and 26 contractors in the performance of pre-functional, functional, and post-occupancy commissioning activities.

1.5 SEQUENCING

A. The following list outlines the general sequence of events for submittals and commissioning:

1. Submit Submittal Package 1 (Hardware and Shop Drawings) and receive approval.
2. Initiate installation of EMCS hardware, devices and wiring.
3. Develop point database and application software.
4. Simulate sequencing and debug programming off-line to the extent practical.
5. Submit Submittal Package 2 (Programming and Graphics) and receive approval.
6. Complete installation of EMCS hardware, devices and wiring.
7. Install point database and application software in field panels.
8. Submit Submittal Package 3 (Functional Testing) and receive approval.
9. Perform EMCS Pre-functional Tests (start up, calibration and tuning) and submit Pre-functional Tests for approval.
10. Field test application programs prior to functional testing.
11. Receive EMCS Pre-functional Test Report approval and approval to schedule Functional Tests.
12. Prepare and initiate commissioning Trend Logs.
13. Assist TAB contractor in TAB tests and determining setpoints as specified in Section 230593.
14. Perform and record functional tests and submit Functional Test Report for approval.

    a. Some tests may not be possible due to weather conditions. These tests may be deferred to post-occupancy period.

15. Submit Package 4 (Training Materials) and receive approval.
16. Receive EMCS Functional Test Report approval and approval to schedule Demonstration Tests.
17. Perform Demonstration Tests to Commissioning Coordinator and Architect and submit Demonstration Test Report.
18. Receive acceptance of Demonstration Tests.
19. Train Owner personnel on EMCS operation and maintenance.
20. Substantial Completion.
21. Submit Package 5 (Post-Construction Trend Logs) in format specified for review and approval.
22. Receive approval of successful Trend Log tests, or retest as required.
23. Complete all items in Completion Requirements per Section 230900.
24. Provide administration level password access to the Owner.
25. Final Acceptance.
26. Begin Warranty Period.
27. Prepare and initiate post-occupancy Trend Logs.
28. Perform deferred alternate season functional tests and submit amended Functional Test Report for approval.

29. Receive amended EMCS Functional Test Report approval.
30. Two months prior to end of Warranty Period, submit Package 6 (End-of-Warranty Trend Logs) in format specified for review and approval.
31. Receive approval of successful Trend Log tests, or retest as required.
32. Revise and submit record documents and O&M Manuals.
33. Update all software as specified.
34. End of Warranty Period.

1.6 FUNCTIONAL TEST DOCUMENTATION

A. Pre-functional Tests:

1. Prepare forms to document the proper startup of the EMCS.
2. All equipment shall be included test forms including but not limited to:

    a. Wiring: End-to-end checkout of all wiring at terminations. Power to all controllers and actuators. Confirmation of emergency power where specified.
    b. Digital Outputs: proper installation, normal position, response to command at CU
    c. Digital Inputs: proper installation, device test, response at CU.
    d. Analog Outputs: proper installation of devices, verification of maximum and minimum stroke.
    e. Analog Inputs: proper installation of sensors, calibration.
    f. Panels: Confirmation of location, power source (electrical circuit used), confirmation of emergency power where specified.
    g. Alarms and Safeties: Verification of alarm routing to all specified devices and correct hierarchy. Example: confirm alarm routing to cell phones, email, servers, remote workstations. Confirm that appropriate alarm levels are routed to appropriate devices.
    h. Loop Tuning: Document setting of P/I parameters for all loops, chosen setpoints, time delays, loop execution speed.
    i. Network Traffic: Document speed of screen generation, alarm and signal propagation in system with all required commissioning trends active.

3. Each form shall have a header or footer where the technician performing the test can indicate his/her name and the date of the test.
4. Submit forms for approval in Submittal Package 3.
5. Complete work, document results on forms, and submit for approval as Pre-Functional Test Report.

B. Functional Tests:

1. Architect will prepare functional testing forms after Submittal Package 2 has been reviewed and approved. Tests will be designed to test all sequences in a formal manner with simulations and expected outcomes.
2. Review tests and recommend changes that will improve ease of testing or avoid possible system damage, etc.
3. Adapt forms from Architect into electronic format. Each form shall have a header or footer where the technician performing the test can indicate his/her name and the date of the test.
4. Complete work, document results on forms, and submit for approval as Functional Test Report.

C. Assist Commissioning Coordinator/Architect as specified including attending commissioning meetings.

PART 2 - PRODUCTS

2.1 INSTRUMENTATION

A. Instrumentation required to verify readings, calibrate sensors, and test the system and equipment performance shall be provided by Contractor.

B. All equipment used for testing and calibration shall be NIST/NBS traceable and calibrated within the preceding 6-month period. Certificates of calibration shall be submitted.

C. Test equipment used for testing and calibration of field devices shall be at least twice as accurate as respective field device (e.g., if field device is ±0.5% accurate, test equipment shall be ±0.25% accurate over same range).

PART 3 - EXECUTION

3.1 PRE-FUNCTIONAL TESTS

A. General:

1. Inspect the installation of all devices. Review the manufacturer's installation instructions and validate that the device is installed in accordance with them.
2. Verify proper electrical voltages and amperages and verify that all circuits are free from faults.
3. Verify integrity/safety of all electrical connections.
4. Verify that shielded cables are grounded only at one end.
5. Verify that all sensor locations are as indicated on drawings and are away from causes of erratic operation.
6. Ensure that minimum speed settings programmed into variable speed drive are at or below the minimum speed settings in control sequences.

B. Digital Outputs:

1. Verify that all digital output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.

C. Digital Inputs:

1. Adjust setpoints, where applicable.

    a. For current switches used as status on fans, adjust current setpoint so that fan status is "off" when fan discharge damper (if present) is fully closed and when belt is broken (temporarily remove belt).
    b. For current switches used as status on pumps, adjust current setpoint so that

pump status is “off” when pump is dead-headed (temporarily close discharge valve).

c. For differential pressure sensors on pumps and fans, set so that status is on when pump operating with all valves open (out on its curve).

D. Analog Outputs:

1. Verify start and span are correct and control action is correct.
2. Check all control valves and automatic dampers to ensure proper action and closure. Make any necessary adjustments to valve stem and damper blade travel.
3. Check all normal positions of actuators with spring return.
4. For outputs to reset other manufacturer’s devices (for example, chiller setpoint) and for feedback from them, calibrate ranges to establish proper parameters.

E. Analog Input Calibration:

1. Sensors shall be calibrated as specified on the points list. Calibration methods shall be one of the following:

   a. Factory. Calibration by factory, to standard factory specifications. Field calibration is not required.
   b. Handheld. Field calibrate using a handheld device with accuracy meeting the requirements of Paragraph 2.1.
   c. Drywell Bath. Field calibrate using a 2-point procedure, using a drywell calibrator block constructed for that purpose, or an ice bath with a reference standard.

2. The calibrating parameters in software (e.g. slope and intercept) shall be adjusted as required. A calibration log shall be kept and initialed by the technician showing date and time, sensor and hand-held readings, and calibration constant adjustments and included in the Pre-functional Test Report.
3. Inaccurate sensors must be replaced if calibration is not possible.

F. Alarms and Interlocks:

1. A log shall be kept and initialed by the technician showing date and time, alarm/interlock description, action taken to initiate the alarm/interlock, and resulting action, and included in the Pre-functional Test Report.
2. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
3. Coordinate with Division 26 to test fire and life safety systems alarm contacts.
4. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
5. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

G. Variable Frequency Drive Minimum Speed:

1. Minimum speed for VFD-driven fans and pumps shall be determined in accordance with this Paragraph. Tests shall be done for each piece of equipment, except that for multiple pieces of identical equipment used for identical applications, only one piece of equipment need be tested with results applied to all. Note that for fans and pumps, there is no minimum speed required for motor cooling. Power drops with cube of speed, causing

motor losses to be minimal at low speeds.

2. The work shall be done only after fan/pump system is fully installed and operational.
3. Determine the minimum speed setpoint as follows:

    a. Start the fan or pump.
    b. Manually set speed to 6 Hz (10%) unless otherwise indicated in control sequences. For cooling towers with gear boxes, use 20% or whatever minimum speed is recommended by tower manufacturer.
    c. Observe fan/pump in field to ensure it is visibly rotating.

        1) If not, gradually increase speed until it is.

    d. The speed at this point shall be the minimum speed setpoint for this piece of equipment.
    e. Record minimum speeds in log and store in software point as indicated on drawings.

H. Tuning:

1. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop in the Pre-functional Test Report. Except from a startup, maximum allowable variance from set point for controlled variables under normal load fluctuations shall be as follows. Within 3 minutes of any upset (for which the system has the capability to respond) in the control loop, tolerances shall be maintained (exceptions noted):

Controlled Variable	Control Accuracy
Duct Pressure	±0.1" w.g.
Building and relief plenum	±0.01" w.g.
Airflow and waterflow	±10%
Space Temperature	±1.5ºF
Chilled Water Temperature	±1ºF
Hot Water Temperature	±3ºF
Duct Temperature	±2ºF
Water Differential Pressure	±1.5 psi
Others	±2 times reported accuracy

I. Interface and Control Panels:

1. Ensure devices are properly installed with adequate clearance for maintenance and with clear labels in accordance with the Record Drawings.
2. Ensure that terminations are safe, secure and labeled in accordance with the Record Drawings.
3. Check power supplies for proper voltage ranges and loading.
4. Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.
5. Check for adequate signal strength on communication networks.
6. Check for standalone performance of controllers by disconnecting the controller from the LAN. Verify the event is annunciated at Operator Interfaces. Verify that the controlling

LAN reconfigures as specified in the event of a LAN disconnection.

7. Ensure that buffered and/or volatile information is held through power outage.
8. With all system and communications operating normally, sample and record update/annunciation times for critical alarms fed from the panel to the Operator Interface.
9. Check for adequate grounding of all DDC panels and devices.

J. Operator Interfaces:

1. Verify that all elements on the graphics are functional and are properly bound to physical devices and/or virtual points, and that hot links or page jumps are functional and logical.
2. Verify that the alarm printing, logging, paging, emailing etc. is functional and per requirements.

K. Trending/Network Traffic Test. Perform this test to verify that system has been design adequately to simultaneously capture trends and allow proper operation of the control system.

1. The test shall be performed after the verification trends (see paragraph 3.5A) have been set up and are operational.
2. Test 1:

   a. Randomly select a device whose failure will generate a Level 1 or 2 alarm and manually shut it off. The status points for the device must indicate the change of state of the device at the Operator Workstation within 5 seconds.
   b. The test shall be repeated for four devices in each building.

3. Test 2:

   a. A clock signal from a field controller randomly selected will be sent as a programmable point to up to 3 BCs. The clock signal stored in BCs shall be sampled with the rest of the trend data. The system shall be considered acceptable if these clock signals are no more than 2 seconds off of the system clock as sampled concurrently during data collection.

4. If the system fails any test, the system architecture shall be revised as required (e.g. more trend memory, more controllers with trend storage capability, network repeaters to allow an increase in network speed, etc.) followed by additional tests.

3.2 TESTING, ADJUSTING, AND BALANCING (TAB) COORDINATION

A. Coordinate with Work performed under Section 230593 Testing, Adjusting, and Balancing. Some balancing procedures require the EMCS to be operational and require Contractor time and assistance.

B. Calibration Software:

1. Software shall be provided free of charge on at least a temporary basis to allow calibration of terminal box airflow controls and other Work specified under Section 230593 Testing, Adjusting and Balancing for HVAC.
2. Software shall be provided for installation on POT(s) provided by Others or Contractor shall loan a POT or handheld device with software installed for the duration of Work specified under Section 230593 Testing, Adjusting, and Balancing.

3. Provide sufficient training to those performing Work specified under Section 230593 Testing, Adjusting, and Balancing to allow them to use the software for balancing and airflow calibration purposes. Contractor shall include a single training session for this purpose.

C. Setpoint Determination:

1. Perform pre-functional tests described in the specifications before assisting in setpoint determination.
2. Coordinate with Work performed under Section 230593 Testing, Adjusting, and Balancing to determine fan and pump differential pressure setpoints, outdoor air damper minimum positions and DP setpoints, etc. as indicated in Section 230593 Testing, Adjusting and Balancing for HVAC.

3.3 FUNCTIONAL TESTS

A. Test schedule shall be coordinated with the Commissioning Authority, Commissioning Coordinator and/or Architect.

B. Functional tests may be witnessed by the Architect at the Owner's option.

C. All approved Functional Tests shall be conducted by the Contractor with results confirmed and signed by the Contractor's start-up technician.

1. Seasonal Impacts: It shall be assumed that not all tests will be possible due to weather conditions. Those that are not possible shall be deferred until the next season, performed during the warranty period.

D. Test documentation shall be submitted to the Owner for review and approval.

3.4 DEMONSTRATION TEST

A. Demonstration tests consist of a small representative sample of functional tests and systems randomly selected by the Owner. Tests will be designed to occur over no longer than ***2*** days.

B. Schedule the demonstration with the Architect 1 week in advance. Demonstration shall not be scheduled until the Functional Test Report has been approved.

C. The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, instruments, ladders, etc. Contractor-supplied personnel shall be those who conducted the Functional tests or who are otherwise competent with and knowledgeable of all project-specific hardware, software, and the HVAC systems.

D. The system will be demonstrated following procedures that are the same or similar to those used in the Pre-Functional and Functional Tests. The Architect will supply the test forms at the site at the start of the tests.

E. Demonstration tests may be witnessed by the Architect at the Owner's option.

F. Contractor shall conduct tests as directed by and in the presence of the Architect and complete

test forms. Completed forms shall be submitted as the Demonstration Test Report to the Owner and Commissioning Coordinator after tests are complete.

G. Demonstration Tests shall be successfully completed and approved prior to Substantial Completion.

3.5 TREND LOG TESTS

A. Trends shall be fully configured to record and store data to the OWS or server for the points and at the interval listed on drawings as follows:

1. Commissioning: Configure trends prior to functional testing phase. Retain configuration until post-construction trend review has been completed successfully and accepted by the Architect. Trends shall be deactivated after acceptance.
2. Continuous: After system acceptance, configure trends for the purpose of long term future diagnostics. Configure trends to overwrite the oldest trends at the longest interval possible without filling the server hard disk beyond 80%.

B. Commissioning (Post Construction) Trend Test.

1. Trend logging shall not commence until Demonstration Tests are successfully completed.
2. Hardware Points: Contractor shall configure points to trend as indicated in the Commissioning Trend column listed on drawing points list with the following qualifications.

    a. For equipment of identical function, such as VAV zones and AHUs with identical components and control sequences, only a sample of such equipment need be trended. The sampling shall be 10% of the identical components, but no more than 10 and no less than three. Review with Architect before setting up trends.
    b. All points trended for one HVAC subsystem (e.g. air handling unit, chilled water system, etc.) shall be trended during the same trend period and the same time intervals so that data may be easily plotted using a spreadsheet.

3. Software Points: Include the following in trends of systems and zones whose hardware points are being trended as called for above. Time interval shall be the same as associated hardware point.

    a. All setpoints and limits that are automatically reset, such as supply air temperature and fan static pressure setpoints, plus the points that are driving the reset, such as zone level cooling and static pressure requests.
    b. All setpoints that are adjustable by occupants.
    c. Outputs of all control loops, other than those driving a single AO point that is already being trended.
    d. System mode points (e.g. Warm-up, Occupied, etc.).
    e. Global overrides such as demand shed signals.
    f. Calculated performance monitoring points, such as chiller efficiency.

4. Submit for review and approval by the Commissioning Authority and/or Architect a table of points to be trended along with trend intervals or change-of-value a minimum of 14 days prior to trend collection period.
5. Trends shall be uploaded to the OWS or Server in data format specified in Section

230926.

6. Trend logs of all points indicated above shall be collected for a 3 week Trend Period.
7. At the completion of the Trend Period, data shall be reviewed by the Contractor to ensure that the system is operating properly. If so, data shall be submitted to the Architect in an electronic format agreed to by the Owner and Contractor (e.g. CD-ROM or via direct access to the OWS or server via the internet).
8. Data will be analyzed over approximately a two- to three-week period by the Commissioning Authority and/or Architect.
9. The system shall be accepted only if the trend review indicates proper system operation without malfunction, without alarm caused by control action or device failure, and with smooth and stable control of systems and equipment in conformance with these specifications. If any but very minor glitches are indicated in the trends, steps 4 to 6 above shall be repeated for the same Trend Period until there is a complete Trend Period of error free operation.

C. Post Occupancy Trend Tests.

1. After successfully completing the Commissioning Trend Tests, the Contractor shall configure all points to trend as indicated in the Continuous Trend column listed on drawing points list.
2. Archive trends up to the OWS or server without overwriting stored data for the entire Warranty Period.
3. The system shall be accepted, and warranty period considered complete only if the trend review indicates proper operation without malfunction without alarm caused by control action or device failure, and with smooth and stable control of systems and equipment in conformance with these specifications. If any but very minor glitches are indicated in the trends, steps above shall be repeated until there is a complete Trend Period of error free operation.

3.6 REMEDIAL WORK

A. Repair or replace defective Work, as directed by Architect in writing, at no additional cost to the Owner.

B. Restore or replace damaged Work due to tests as directed by Architect in writing, at no additional cost to the Owner.

C. Restore or replace damaged Work of others, due to tests, as directed by Architect in writing, at no additional cost to the Owner.

D. Remedial work identified by site reviews, review of submittals, demonstration test, trend reviews, etc. shall be performed to the satisfaction of the Architect, at no additional cost to the Owner.

E. Contractor shall compensate Architect and Commissioning Authority on a time and material basis at standard billing rates for any additional time required to witness additional demonstration tests or to review additional EMCS trends beyond the initial tests, at no additional cost to the Owner.

3.7 TRAINING

A. Coordinate schedule and materials with Architect and/or Commissioning Authority.

B. Interim Training:

1. Provide minimal training so the operating staff can respond to occupant needs and other operating requirements during start-up and commissioning phase.

C. Formal Training:

1. Provide training sessions at locations and for personnel indicated below.
2. Training shall be conducted after all commissioning is complete and systems are fully operational.
3. The length of each training period will depend on the complexity of the system and the audience, described below. Minimum training shall be as listed below, but period shall be longer if required to complete the training tasks described below.

    a. On site job training: Include 40 hours total of on-site training to assist personnel in becoming familiar with site-specific issues, systems, control sequences, etc. (including general EMCS system training).

4. Training may be in non-contiguous days at the request of the Owner.
5. Contractor shall be video training sessions, see Section 230010 Mechanical General Provisions.
6. During the warranty period, provide unlimited telephone support for all trained operators.

D. Operators are divided into three categories and shall receive training including but not limited to the tasks listed.

1. Day-to-day Operators shall be trained to:

    a. Proficiently operate the system.
    b. Understand control system architecture and configuration.
    c. Understand EMCS system components.
    d. Understand system operation and control sequences.
    e. Operate the workstation and peripherals.
    f. Log on and off the system.
    g. Access graphics, point reports and logs.
    h. Adjust and change system set points, time schedules, and holiday schedules.
    i. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals.
    j. Understand and acknowledge alarms.
    k. Understand system drawings, and Operation and Maintenance manual.
    l. Understand the Project layout and location of control components.
    m. Print point and predefined reports.

2. Advanced Operators shall be trained to do all items for Day-to-day operators plus:

    a. Make and change graphics on the workstation.
    b. Create, delete, and modify alarms, including annunciation and routing.
    c. Create, delete, and modify point trend logs, and graph or print these both on an

ad-hoc basis and at user-definable time intervals.

d. Create, delete, and modify reports.
e. Add, remove, and modify system's physical points.
f. Create, modify, and delete programming.
g. Add control panels.
h. Add Operator Workstations.
i. Create, delete, and modify system displays — both graphical and otherwise.
j. Perform EMCS system field checkout procedures.
k. Perform EMCS controller unit operation and maintenance procedures.
l. Perform workstation and peripheral operation and maintenance procedures.
m. Perform EMCS system diagnostic procedures.
n. Configure hardware including PC boards, switches, communication, and I/O points.
o. Maintain, calibrate, troubleshoot, diagnose, and repair hardware.
p. Adjust, calibrate, and replace system components.
q. Maintain software and prepare backups.

3. System Managers/Administrators shall be trained to do all items for Day-to-day operators plus:

a. Maintain software and prepare backups.
b. Create and print custom reports, including tenant billing summaries.
c. Interface with job-specific, third-party operator software.
d. Add new users and understand password security procedures.

E. Training materials shall include step-by-step instructions (including illustrations, screen captures, etc.) for how to perform all task identified in herein such that a new Operator, who has not attended the training in person and has minimal familiarity with this EMCS system, can easily follow the instructions and successfully perform all of the identified tasks. One copy of training material shall be provided per student. An electronic copy of the materials shall be stored on the OWS.

F. The instructor(s) shall be factory-trained instructors experienced in presenting this material.

G. The type and number of personnel and location for training shall include.

1. Day-to-day Operator: 2.
2. Advanced Operator: 1.
3. System Managers/Administrators: 1.

END OF SECTION 230933

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 materials, equipment, fabrication, special-duty valves, specialties, and installation for the following:

1. Natural gas piping.

1.3 PROJECT CONDITIONS

A. Site Gas System Pressure: (CONTRACTOR SHALL VERIFY).

B. Building Gas System Pressure: Primary pressure is 2 psig reduced to secondary pressure of 8 Inch of Water Column. (CONTRACTOR SHALL COORDINATE WITH SUBMITTED GAS-FIRED EQUIPMENT).

C. Contractor shall replace or adjust existing gas meter and pressure regulator as required to serve new and existing gas fired equipment. Contractor shall include cost to replace or adjust existing gas meter and pressure regulator in their bid.

1.4 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Piping (below ground and above ground	R			R
Valves, all types	R			R
Meters	R	R		R
Pressure regulators	R			R
Specialties	R	R		R

1.5 QUALITY ASSURANCE

A. FM Standard: Provide components listed in FM's Fire Protection Approval Guide if specified to be FM approved.

B. IAS Standard: Provide components listed in IAS's Directory of AGA and CGA Certified Appliances and Accessories if specified to be IAS listed.

C. UL Standard: Provide component listed in UL's Gas and Oil Equipment Directory if specified to be UL listed.

D. ANSI Standard: Comply with ANSI Z223.1 and NFPA 54 (2009 Edition), "National Fuel Gas Code."

1.6 COORDINATION

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Using Agency or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Owner not less than seven days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect's written permission.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Appliance Connector Valves.

a. Conbraco Industries, Inc.: Apollo Div.
b. Mueller Co.: Mueller Gas Products Div.
c. Watts Industries, Inc.: Water Products Div.
d. Brass Craft Manufacturing Co.
e. American Valve.

2. Gas Valves, NPS 2 and smaller.

a. Nibco, Inc.
b. Flow Control Equipment, Inc.
c. Grinnell Corp.
d. Honeywell, Inc. Co.
e. Crane Valves.
f. McDonald: A.Y. McDonald Mfg. Co.
g. Milwaukee Valve Co., Inc.
h. Mueller Co.: Mueller Gas Products Div.
i. Watts Industries, Inc.: Water Products Div.

3. Plug Valves, NPS 2-1/2 and larger.

a. Walworth Co.
b. Olson Technologies, Inc.; Homestead Valve Div.
c. Milliken Valve Co., Inc.

4. Service Meters: As approved by the Utility Provider or Owner.
5. Line Pressure Regulators.

a. American Meter Co.
b. Equimeter, Inc.
c. Fisher Controls International, Inc.
d. Schlumberger Industries: Gas Div.

6. Appliance Pressure Regulators.

a. Eaton Corp.: Controls Div.
b. Harper Wyman Co.
c. Maxitrol Co.

2.2 PIPING MATERIALS

A. Steel Pipe: ASTM A 53; Type E or S; Grade B (Grade A for pipe 1-1/2 inch and smaller) Schedule 40; black.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern, with threaded ends according to ASME B1.20.1.
2. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends according to ASME B1.20.1.
3. Cast-Iron Flanges and Flanged Fittings: ASME B16.1, Class 125.
4. Steel Welding Fittings: ASME B16.9, wrought steel or ASME B16.11, forged steel.
5. Steel Threaded Fittings: ASME B16.11, forged steel with threaded ends according to ASME B1.20.1.
6. Joint Compound and Tape: Suitable for natural gas.
7. Steel Flanges and Flanged Fittings: ASME B16.5.
8. Gasket Material: Thickness, material, and type suitable for natural gas.

B. Polyethylene Pipe: All polyethylene pipe used in the Project must comply with ASTM D-2513 and be manufactured in the United States.

1. Pipe and Fitting Material. All pipes shall conform to the requirements of the currently approved ASTM D-25 13 specification “Thermoplastic Gas Pressure Pipe, Tubing and Fittings.” All fittings shall conform to the requirements of ASTM D-2683 specification “Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe” or ASTM D3261 “Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.” All pipes shall be manufactured of virgin material, with the exception of the clean rework material that is generated from the manufacturer’s own production, as long as the pipe and/or fittings meet the required specifications. All pipe formulation must have suitable outdoor weather resistance. The color of all polyethylene pipes shall be either orange or yellow.
2. Pipe Design. All pipe shall be designed for direct burial as specified in D.O.T. Title 49, Part 192, “Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards,” through current Amendment, for natural gas mains and services operated at 60 psig. or less. The pipe must also be suitable for replacing old steel mains and services. The pipe must be homogeneous and be free of holes, cracks, foreign

material, blisters, or other deleterious faults. The minimum design stress must comply with the requirements of ASTMD-2513.

3. Any defect such as a groove, notch, or gouge, greater than ten percent (10%) of the wall thickness of the pipe, shall not be used.

C. Transition Fittings: Type, material, and end connections to match piping being joined.

2.3 SPECIALTY VALVES

A. Valves, NPS 2 and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.

B. Valves, NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

C. Appliance Connector Valves: ANSI Z21.15 and IAS listed.

D. Gas Stops: Bronze body with AGA stamp, plug type with bronze plug and flat or square head, ball type with chrome-plated brass ball and lever handle, or butterfly valve with stainless-steel disc and fluorocarbon elastomer seal and lever handle; 2-psig minimum pressure rating.

E. Gas Valves, NPS 2 and Smaller: ASME B16.33 and IAS-listed bronze body and 125-psig pressure rating.

1. Tamperproof Feature: Include design for locking.

F. Plug Valves, NPS 2-1/2 and Larger: ASME B16.38 and MSS SP-78 cast-iron, lubricated plug valves, with 125-psig pressure rating.

1. Tamperproof Feature: Include design for locking.

G. Automatic Gas Valves: ANSI Z21.21, with electrical operator for actuation by appliance automatic shutoff device.

2.4 PRESSURE REGULATORS

A. Description: Single stage and suitable for fuel gas service. Include steel jacket and corrosion-resistant components, elevation compensator, and atmospheric vent.

1. NPS 2 and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
2. NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
3. Line Pressure Regulators: ANSI Z21.80.
4. Appliance Pressure Regulators: ANSI Z21.18. Regulator may include vent limiting device, instead of vent connection, if approved by Architect.

B. Pressure Regulator Vents: Factory- or field-installed, corrosion-resistant screen in opening if not connected to vent piping.

2.5 METERS

A. Natural gas meter: Provide outside adjacent to mechanical room entrance, a meter for the Owner's use in determining the gas usage for this building. Meter shall be pipe or pedestal

mounted, rotary style, enamel coated steel case. Provide combined register totalizer, water escape hole in housing and means for sealing against tampering. Provide with a pulse sensor so the building meter reading system can connect to the gas meter.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Division 31.

3.2 INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping adjacent to machines to allow service and maintenance.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Select system components with pressure rating equal to or greater than system operating pressure.

I. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

J. Arrange piping to allow inspection and service of equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels if valves or equipment requiring maintenance is concealed behind finished surfaces.

K. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

L. Install sleeve seals for piping penetrations of concrete walls and slabs.

M. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.3 PREPARATION

A. Close equipment shutoff fuel gas to premises or section of piping. Perform leakage test as specified in Article entitled, Field Quality Control, to determine that all equipment is turned off in affected piping section.

B. Comply with ANSI Z223.1, paragraph entitled, Prevention of Accidental Ignition.

3.4 SERVICE ENTRANCE PIPING

A. Extend fuel gas piping and connect to fuel gas distribution for service entrance to building.

B. Install dielectric fitting downstream from and adjacent to each service meter unless meter is supported from service-meter bar with integral dielectric fitting. Install shutoff valve downstream from and adjacent to dielectric fitting.

C. Provide Schedule 40 black steel riser (from underground) at building or equipment, extending minimum 2' horizontal to connect with underground piping.

3.5 PIPING APPLICATIONS

A. Flanges, unions, transitions, and special fittings with pressure ratings same as or higher than system pressure rating may be used in applications below, provided compliance with the IFGC is maintained.

B. Fuel Gas Piping above ground: Use the following:

1. NPS 2 and Smaller: Steel pipe, malleable-iron threaded fittings, and threaded joints.
2. NPS 2-1/2 and Larger: Steel pipe, steel welding fittings, and welded joints.

C. Fuel-Gas Piping below ground: Use the following:

1. Thermoplastic gas pressure pipe, tubing and fittings, ASTM D2513 with transition riser.

3.6 VALVE APPLICATIONS

A. Appliance Shutoff Valves for Pressure 0.5 psig or less. Appliance connector valve or gas stop.

B. Appliance Shutoff Valves for Pressure 0.5 to 2 psig: Gas stop or gas valve.

C. Appliance Shutoff Valves for Pressure 2 to 5 psig: Gas valve.

D. Piping Line Valves, NPS 2 and Smaller: Gas valve.

E. Piping Line Valves, NPS 2-1/2 and Larger: Plug valve or general-duty valve.

3.7 PIPING INSTALLATION

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 dry-seal 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. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

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

G. 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.

H. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

I. PE Piping Install regulator assemblies aboveground. Include gas valve or plug valve for each assembly.

1. Install gas valve or plug valve and strainer upstream from each service pressure regulator.
2. Install service pressure regulators with vent outlet turned down and with corrosion-resistant-metal insect screen.

J. Service Entrance Piping: Extend fuel gas piping and connect to fuel gas distribution for service entrance to building.

1. Exterior service meter will be provided by gas utility.

K. Concealed Locations: Except as specified below, install concealed gas piping in airtight conduit constructed of Schedule 40, seamless, black steel pipe with welded joints. Vent conduit to outside and terminate with screened vent cap.

1. Above-Ceiling Locations: Gas piping may be installed in accessible spaces, subject to approval of authorities having jurisdiction, whether or not such spaces are used as plenums. Do not locate valves above ceilings.
2. In Partitions: Do not install concealed piping in solid partitions. Protect tubing from physical damage when installed inside partitions or hollow walls.
3. In Walls: Gas piping with welded joints and protective wrapping specified in "Protective Coating" Article in Part 2 may be installed in walls, subject to approval of authorities having jurisdiction.
4. Prohibited Locations: Do not install gas piping in or through circulating air ducts, chimneys or gas vents (flues), ventilating ducts, or elevator shafts.

    a. Exception: Accessible above-ceiling space specified above.

L. Drips and Sediment Traps: Install drips at points where condensate may collect. Include outlets of service meters. Locate where readily accessible for cleaning and emptying. Do not install where condensate would be subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use minimum-length nipple of 3 pipe diameters, but not less than 3 inches long, and same size as connected pipe. Install with space between bottom of drip and floor for removal of plug or cap.

M. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings and in floor channels, unless indicated to be exposed to view.

N. Install fuel gas piping at uniform grade of 0.1 percent slope upward toward risers.

O. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

P. Connect branch piping from top or side of horizontal piping.

Q. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.

R. Install strainer on inlet of each line pressure regulator and automatic and electrically operated valve.

S. Install pressure gage upstream and downstream from each line pressure regulator.

T. Install flanges on valves, specialties, and equipment having NPS 2-1/2 and larger connections.

U. Install vent piping for gas pressure regulators and gas trains, extend outside building, and vent to atmosphere. Terminate vents with turned-down, reducing-elbow fittings with corrosion-resistant insect screens in large end.

V. Purging Pipes and Fittings: A combustible gas indicator shall be used when purging mains and piping. When purging gas from abandoned lines, the air and the gas must be discharged aboveground and directed away from power lines or structures. When purging air from new lines, installation of a 3/4 service saddle and non-corrodible riser is required four (4) feet from each dead-end on all new installations of pipe in order to purge air from all dead-ends simultaneously. Release gas into new lines at a rate that will prevent formation of a hazardous mixture of gas and air or precede natural gas with a slug of inert gas.

W. Pipe Placement and Backfill.

1. When installing polyethylene pipe, sufficient slack shall be provided to allow for possible contraction. The polyethylene pipe shall not have a bend that is less than 25 times the outside diameter of the pipe. If a bend is required that is less than 25 times the outside diameter of the pipe, then an approved polyethylene elbow fitting is required. A fusion joint shall not be placed at a bend. During extremely high temperature conditions it may be necessary to cool the pipe before the last connection.
2. No polyethylene gas line shall be installed above ground. During maintenance, repair, and tie-in work, temporary polyethylene gas lines may be used above ground.
3. The minimum clearance required between the distribution piping and other underground structures is twelve (12) inches. Trench width and minimum cover shall comply with another Section of specification, Excavation, Trenching and Backfilling for Utilities. Unless otherwise shown on plans, pipe embedment shall be select material and remainder of trench may be backfilled with spoil from trenching operation.

3.8 VALVES AND VALVE BOXES

A. Provide valves and valve boxes plumb. All boxes shall be installed flush with the finished grade. Support box with brick or other approved material. Adequate backfill shall be placed around the valve boxes and valve extension boxes to prevent any damage or settlement to the pipeline that may be transferred to the pipe through the valve box. Protective sleeves shall be installed over fusion joints and extend through the valve boxes on the polyethylene valve installations.

3.9 HANGERS AND SUPPORTS

A. Refer to Section 230529 – Hangers and Supports.

3.10 CONNECTIONS

A. Install piping adjacent to appliances to allow service and maintenance. Connect piping to appliances using gas with shutoff valves and unions. Install valve upstream from and within 72 inches of each appliance. Install union downstream from valve.

B. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance using gas.

C. Ground equipment.

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
2. Do not use gas pipe as grounding electrode.

3.11 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each service meter, pressure regulator and specialty valve.

1. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each service meter, pressure regulator and specialty valve.
2. Refer to 230553 – Mechanical Identification.

B. Label piping per 230553 – Mechanical Identification.

3.12 PAINTING

A. Use materials and procedures in Division 09 – Painting.

B. Paint exterior pipe, fittings, pressure regulators, specialty valves, etc.

1. Pipe and Fittings, Color: Yellow (Confirm color with Architect prior to painting).
2. Pressure Regulators, Specialty valves, Etc., Color: Red (Confirm color with Architect prior to painting).

C. Paint exposed interior pipe, fittings, pressure regulators, specialty valves, etc.

1. Pipe and Fittings, Color: Yellow (Confirm color with Architect prior to painting).
2. Pressure Regulators, Specialty valves, Etc., Color: Red (Confirm color with Architect prior to painting).

3.13 FIELD QUALITY CONTROL

A. Inspect, test, and purge piping according to ANSI Z223.1, Part 4 "Inspection, Testing, and Purging" and requirements of authorities having jurisdiction. Isolate pressure reducing valves and equipment controls during testing. Test pressure to be 100 psi for a period of 24 hours with no drop in pressure.

B. Repair leaks and defects with new materials and retest system until satisfactory results are obtained.

C. Report test results promptly and in writing to Architect.

D. Verify capacities and pressure ratings of pressure regulators, valves and specialties.

E. Verify correct pressure settings for pressure regulators.

F. Verify that specified piping tests are complete.

3.14 ADJUSTING

A. Adjust controls and safety devices. Replace damaged and malfunctioning controls and safety devices.

Natural Gas Piping Test Log						
Date	System	Description of Piping Section Tested	Test Press. (psig)	Test Duration (hours)	Results Pass/ Fail	Witness (Contractor) Initials
This form stall be completed and submitted with the project closeout documents. Contractor shall copy this form if more sheets are required. Piping pressure test log shall be kept at project site and shall be made available to the Architect upon request.						

END OF SECTION 231123

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes special-duty valves and specialties for the following:

1. Hot-water heating piping.
2. Chilled water piping.
3. Auxiliary and intermediate drain pan piping.

1.3 REFERENCE STANDARDS

A. ASME B31.1 or B31.9 as applicable for shop and project site welding of piping work.

B. ASTM A53 – Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless.

C. ASTM A120 – Pipe, Steel, Black, Welded and Seamless, for Ordinary Uses.

D. ASTM A234 – Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.

E. ANSI/ASME SEC 9 – Welding and Brazing Qualifications.

F. ANSI/ASME B16.3 – Malleable Iron Threaded Fittings Class 150 and 300.

G. ANSI/ASME B16.22 – Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

H. ANSI/ASME B16.26 – Cast Copper Alloy Fittings for Flared Copper Tubes.

I. ANSI/ASTM B32 – Solder Metal.

J. ANSI/ASTM B88 – Seamless Copper Water Tube.

K. ASTM B280 – Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.

L. ANSI/AWS A5.8 – Brazing Filler Metal.

M. ANSI/AWS D1.1 – Structural Welding Code.

1.4 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Piping materials	R			R
Pipe fittings	R			
Solder	R2			

1.5 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

B. Welding materials and labor to conform to ASME Code and applicable state Labor Regulations.

C. Use welders fully qualified and licensed by state authorities.

D. Each length of pipe, fitting, trap, fixture, or device used in any piping system shall be stamped or indelibly marked with.

1. Weight or quality.
2. Maker's name or mark.

E. Examine piping layouts and determine requirements for piping offsets, loops or expansion joints to adequately protect systems.

1. Determine locations and design of anchors and pipe guides to maintain proper piping alignment.
2. Determine anchor reaction forces and coordinate locations of anchors with Architect.

F. Conform to ANSI/ASME B31.1

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Welding Fittings.

1. Babcock and Wilcox Tubular Products Division.

2. Bonney Forge Foundry, Inc.
3. Landish Company.
4. Or equal.

C. Flange Gaskets.

1. John Crane Company.
2. Garlock Mechanical Packing Division.
3. Goodrich.
4. Or equal.

D. Copper Press Fittings.

1. Viega Propress.
2. Apolloxpress.
3. Or equal.

E. Solder.

1. Westinghouse.
2. J.W. Harris Co., Inc.
3. Engelhard.
4. Or equal.

F. Pipe Joint Compound.

1. Rectorseal.
2. Permatec.
3. John Crane.
4. Or equal.

2.2 PIPING AND FITTINGS

A. General.

1. Piping shall.

a. Be commercially round and straight.
b. Be of uniform quality and workmanship.
c. Be free from all defects.
d. Be identified.

B. Pressure Piping.

1. Pressure piping shall conform to requirements of ANSI Safety Code for Pressure Piping, B31.1.

2. Type PP-1: Black Steel: Schedule 40 or Standard Weight, ASTM A53 Type E Grade B (electric resistance welded).

a. 2-1/2 inches and larger.
b. Butt-welded joints.
c. Fittings.

1) Steel welding-neck flanges and flanged fittings, ANSI B16.5, Class 150 forged carbon steel.
2) ASTM A234 carbon steel welding type, long radius type elbows unless specified otherwise on the Drawings.

d. 0.375-inch wall for sizes 12 inch and larger.

3. Type PP-2: Copper Tubing.

a. 2 inches and smaller.
b. ASTM B 88; Type L, hard drawn.
c. Wrought-copper, solder joint fittings, ANSI B16.22, in sizes available.
d. Cast-bronze solder-joint fittings, ANSI B16.18, only in sizes not available in wrought copper.
e. Cast-bronze, threaded, ground-joint unions, ANSI B16.15, 2 inches and smaller.
f. Cast bronze, flanged unions, ANSI B16.24, 150 pounds per square inch class, 2-1/2 inches and larger.
g. Joints:

1) ASTM B 32, solder, Grade 95TA (lead free).
2) ASTM B 88 Type L Press Fittings and Joints. Press fittings and joints shall be feature leak before press technology. The O-ring shall be constructed out of EPDM. The fittings shall be rated for working pressure of 200 psi and temperature range from 32°F to 250°F. Press fittings are not acceptable for underground installations.

C. Fittings and Flanges: Standard products of respective manufacturer of piping as hereinbefore specified.

D. Flange Gaskets.

1. Full faced or flat ring type to suit flange facings, selected from one of following materials.
2. Gaskets for flanged joints shall comply with ANSI B16.21.
3. Full faced for cast iron flanges.
4. Raised face for steel flanges.

a. Red rubber, ASTM D1330.
b. 1/16 inch thick.
c. Equal to Crane Style 555.

5. Gaskets coated with thread lubricant when being installed.

E. Flange Bolts: Open-hearth bolt steel.

F. Unions.

1. Steel Piping 2 inches and smaller.

a. 250 pounds per square inch: ground joint.
b. Equal to Grinnell Fig. 554.

2. Steel Piping Larger than 2 inches: Welding flanges.
3. Copper Piping: Equal to Nibco No. 633.

G. Dielectric Connections.

1. Unions.

    a. Only allowed where union is required elsewhere in specifications or on drawings. Use nipple specified below otherwise.
    b. 2 inches and smaller.

        1) 250 pounds per square inch water on gage (WOG).
        2) Standard gaskets for plumbing.
        3) High temperature gaskets for heating.
        4) Equal to EPCO Model FX.

    c. 2-1/2 inches and larger.

        1) Brass.

            a) Brass half-union, ANSI B16.1, 1989, 175 pounds per square inch water on gage (WOG).
            b) To welding flange as hereinbefore specified.
            c) Equal to EPCO Model X.

        2) Copper.

            a) Half union with EPDM insulator gasket.
            b) 150 pounds per square inch water on gage (WOG).
            c) The Copper component of the flange adapter shall be Third Party Classified by Underwriters Laboratories Inc.

2. Nipples.

    a. Applicable to all hydronic systems.

        1) Minimum 4-inch-long stainless steel, brass, or copper nipple with non-conducting thermo-plastic internal lining.
        2) ASTM Standard F-492 for continuous use at temperatures up to 225°F.
        3) ClearFlow or equal.

    b. Allowed for closed-circuit hydronic systems only: minimum 6-inch-long brass nipple.

2.3 PIPING SPECIALTIES

A. See Section 232116 “Hydronic Piping Specialties”.

2.4 SOLDER

A. S-1: Silfos or Silvaloy 15 silver solder (brazing) with 15 percent silver, 80 percent copper and 5 percent phosphorous.

B. S-1A: Safety Silv 56 cadmium-free silver solder (brazing) with 55 to 57 percent silver, 21 -23 percent copper, 15 to 19 percent zinc, 4 to 6 percent tin, and 0.15 percent other metals.

C. S-2, either.

1. 95 percent tin 5 percent antimony solder, lead free, or.
2. 95.6 percent tin, 4 percent copper, 0.4 percent silver, lead free.

PART 3 - EXECUTION

3.1 PIPE SERVICES

Service	Type of Pipe	Remarks
Above Ground Hydronic (HW, CHW)	PP-1; PP-2 Type L Hard; PP-3	to 250 degrees Fahrenheit

3.2 INSTALLATION

A. Coordinate with work of other trades.

B. Install pipes and pipe fittings in accordance with recognized industry practices which will achieve permanently leak resistant piping systems, capable of performing each indicated service without piping failure. Install each run with minimum joints and couplings but with adequate and accessible unions for disassembly and maintenance/replacement of valves and equipment. Reduce sizes, where indicated by use of reducing fittings. Align piping accurately at connections, within 1/16-inch misalignment tolerance.

C. Contractor shall add hydronic, closed-loop water treatment chemicals once system has been refilled and in operation.

D. Arrangement.

1. Except for large scale details piping is diagrammatically indicated. Install generally as shown.
2. Do not scale drawings for exact location of piping.
3. Install piping to best suit field conditions, in coordination with other trades.
4. Piping Arrangement.

    a. Arrange piping neatly along walls.
    b. In neat, horizontal groups.
    c. Each group to be in one plane, insofar as possible.
    d. Maintain required slope.

5. Do not sleeve structural members without consent of the Architect.
6. Maintain maximum 1-inch clearance from adjacent work, including insulation, except as noted.
7. Install piping concealed above ceilings or in walls unless otherwise indicated.
8. Installation of piping shall be made with use of appropriate fittings. Bending of piping will not be allowed.
9. Unions installed shall be accessible.
10. Locate piping runs vertically and horizontally; avoid diagonal runs wherever possible. Orient horizontal runs parallel with walls and column lines. In finished and occupied spaces, conceal piping from view by locating in column enclosures, in hollow wall construction, or above suspended ceilings; do not encase horizontal runs in solid partitions, except as indicated.

11. Electrical equipment spaces: Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures unless the piping serves equipment in the room.
12. Use tapered reducers where any change in pipe size occurs. Bushings shall not be used.
13. Conceal piping in finished portions of building, above the floor line. Cutting of walls and floors shall be held to the minimum possible to secure the proper installation.
14. Provide concealed high points with air chambers with 1/4-inch copper tube vent line and stop cock carried to accessible point.
15. Install piping subject to expansion or contraction in a manner permitting strains to be evenly distributed and alleviated.
16. Pipe the discharge of each relief valve, air vent, backflow preventer, and similar device to floor sink or drain.

E. Installation of Protective Pipe Wrap.

1. Wrap pipe and fittings with two layers of protective wrap according to manufacturer's instructions. Over-lap each layer of warp minimum 1/2 inch. Extend wrap three feet beyond section underground.
2. Protect all steel pipe buried in ground from corrosion by the application of protective pipe wrap. Clean and prime piping before application of the wrapping material.
3. No rocks or sharp edges shall be backfilled against the wrap. When backfilling with other than sand, protect wrap with an outer wrapping of Kraft paper; leave in place during backfill.
4. Wrap all copper piping below grade or concrete with plastic sleeve.

3.3 EXPANSION CONTROL

A. General.

1. Install piping to permit free expansion and contraction without damaging piping or construction.
2. Provide offsets, expansion loops, anchors, guides, and supports to permit expansion, within stress limits of ANSI 31.1 Pressure Piping for temperature ranges specified.
3. Where pipe loops or changes in direction of piping cannot be employed to absorb expansion and contraction, provide expansion joints.
4. Install pipe guides so that movement takes place along axis of pipe only. Pipe moves laterally at expansion elbows.
5. Make riser offsets in manner to avoid pocket forming due to expansion.

B. Expansion Calculations.

1. Thermal Expansion.

a. Determine thermal linear expansion of each segment of piping systems.
b. Base expansion calculations on following temperatures, plus 30 percent safety factor.

1) Hot Water Heating.

a) Idle temperature: 50 degrees Fahrenheit.
b) Maximum temperature: 210 degrees Fahrenheit.

2) Chilled Water.

a) Operating temperature: 40 degrees Fahrenheit.
b) Maximum temperature: 100 degrees Fahrenheit.

c. Determine effect of linear expansion upon piping layout in building.

1) If resulting stresses exceed maximum allowable limits introduce additional loops and/or offsets.
2) Where space limitations preclude installation of loops and/or offsets provide expansion joints.

2. Structural Considerations

a. Install pipe anchors to provide required restraints on expanding piping systems.
b. Install pipe guides to provide required restraints against lateral action of expanding piping systems.

1) Spacing for expansion joints: per manufacturer's recommendations.
2) Spacing for pipe loops and/or offsets: as required to maintain alignment within allowable stress limits.

c. Locate anchors and guides only at building structural members capable of taking imposed reaction loads.
d. Determine horizontal and vertical reaction loads of anchors and guides to building structure.

1) Coordinate details and reaction loads with structural engineer for building.
2) If necessary, revise location and number of anchors and guides as recommended by structural engineer to result in allowable reaction loads to building.

C. Provision for Expansion.

1. Loops, bends, offsets.

a. As indicated or because of job required relocation of piping and equipment.
b. Design as follows:

1) Use spring type loop U-bend or offset U-bend.
2) Corner radii five to six times pipe diameters.
3) Join bends only by welding.

a) Welding-steel piping.
b) Brazing-copper or bronze piping.

D. Sloping, Air Venting and Draining.

1. Slope piping as indicated, true to line and grade, and free of traps and air pockets.
2. Reducers/increasers.

a. Eccentric.

1) At pump suction where reducer is required.
2) Top side flat.

b. Concentric: All other locations.

3. Connect branch piping to bottom of mains in closed systems.
4. Provide drain valves and hose adapters as indicated on drawings and at the bottom of all risers.
5. Vents: See Section 232116 “Hydronic Piping Specialties.”

E. Piping Specialties: See Section 232116 “Hydronic Piping Specialties.”

F. Pipe Hanging and Supports: See Section 230529 “Hangers and Supports.”

G. Copper.

1. Crimping of copper tubing prohibited.
2. Isolate copper tubing from ferrous materials and hangers with two thicknesses of 1 inch wide 10 mil polyvinyl tape, spiral-wrapped around pipe. Total width shall be a minimum of 3 inches.

H. Coatings: Reapply coal-tar coating on buried piping, after installation, to surfaces from which coating has been removed or scraped.

I. Pipe Identification: See Section 230553 “Mechanical Identification.”

J. Care of Floors.

1. Do not set pipe vises or threading machines on unprotected concrete floors.
2. Cover floor when making plumbing connections to avoid staining floors with oil, white or red lead or other substances.
3. Remove any stains at no additional cost to the Owner.

3.4 PIPE JOINTING

A. This section does not apply to refrigerant piping.

B. Fittings.

1. Provide standard, manufacturing fittings in all cases.
2. Prohibited fittings.

    a. Field fabricated.
    b. Bushings on pressure piping.
    c. Clamp-on branch connections.

3. Provide insulating couplings or dielectric unions at all connections of ferrous piping to non-ferrous piping.
4. Branch connections, steel piping.

    a. Equal to main and to two pipe sizes smaller: weld tees, same weight as piping.
    b. Three or more pipe sizes smaller than main, but 2-1/2 inches and larger: Bonney Weld-o-lets.
    c. Two inches and smaller: Bonney Weld-o-lets, Thread-o-lets, threaded Nip-o-lets, or steel couplings.

C. Unions: Provide unions or flanges to render all items in systems easily removable, including.

1. Control valves.

2. Both sides of pumps and equipment.
3. Where indicated on drawings.
4. Exceptions.

    a. Copper water piping 1-inch or less, at Contractor’s options, since the copper can be easily cut, and the union is a less secure joint than a soldered joint.
    b. Where unions are not allowed by code: Unions not allowed.

D. Pipe Ends.

1. Perform pipe cutting and end preparation to result in clean ends with full inside diameter.
2. Grind and ream as necessary.

E. Nipples.

1. Close nipples not permitted.
2. Provide extra heavy pipe for nipples where unthreaded portion is less than 1-1/2 inch long.

F. Threaded Joints: not allowed other than unions.

G. Welded Joints.

1. Weld pipe joints in accordance with recognized industry practice and as follows:

    a. Welding shall be done by qualified welders in a first-class, workmanlike manner, conforming to the American Standard Code for Pressure Piping USA B-31.1 and B-31.1A.
    b. Bevel pipe ends at a 37.5-degree angle where possible, smooth rough cuts, and clean to remove slag, metal particles, and dirt.
    c. Do not weld-out piping system imperfections by tack-welding procedures; re-fabricate to comply with requirements.
    d. Standards: Conform to Section UI, Chapter 4, "Welding of Pipe Joints", ANSI B31.1 and applicable portion of ASME Boiler and Pressure Vessel Code, Section IX.
    e. Operator's qualifications: All welders engaged in work under this Section shall be qualified in accordance with State requirements. Each operator's certificate shall be on file at site and made available to State upon request. Welding of pressure piping shall be done by-welders who have been qualified by recognized agency within 6 months prior to date of Contract.
    f. Preparation for welding: Bevel piping on both ends before welding; both ends shall have 1-1/6-inch land at bottom of bevel. Pipe with a 3/4-inch wall thickness or less shall be beveled to a standard 37.5 degrees.
    g. Use backing rings on all butt-welding joints 6-inches and larger.
    h. State employed Inspector will visually inspect welds. Any weld judged defective by visual inspection shall be cut out and tested in presence of Inspector. If percentage of defective coupons is deemed excessive, contractor shall cut additional coupons as directed by the Architect or the State Inspector. Removal and replacement of test coupons and samplings shall be done at no additional cost to the Owner. At the option of the State Inspector or the Architect, certain welds may be required to be radiographed.

2. Where required, peen and wheel-grind welds.
3. Ends of pipe may be burned for welding.

a. Grind bevel and remove scale between welding joint.
b. Ragged edges with metal beads, poor alignment other inferior work will be rejected.

4. Perform welding with oxyacetylene or electric arc process.

H. Soldered and Brazed Joints.

1. Solder.

a. Use Solder S-1 for underground copper piping.
b. Use Solder S-2 other than above.

2. Clean surfaces to be jointed, of oil, grease, rust, and oxides.

a. Remove grease from fittings by washing in solution of 1/16 sodium carbonate and three gallons hot water (except as otherwise specified for medical gas piping).
b. Clean socket of fitting and end of pipe thoroughly with emery cloth to remove rust and oxides.
c. Wipe excess solder from joint before it hardens.

3. When soldering or brazing materials that could be damaged by heat, remove sensitive parts and protect parts from heat. Joints shall be cool before reassembling valve.
4. Cut tubing square, reamed, and burrs removed.
5. Prevent annealing of fittings and tubing when making connections.

3.5 FLASHING AND SLEEVES

A. See Section 230529 “Hangers and Supports.”

3.6 CLEANING

A. General.

1. During Construction.

a. Keep openings in piping closed to prevent entrance of foreign matter.
b. Clean pipe, fittings, and valves internally.
c. Hammer welds to remove slag and weld beads.

2. Clean system after pressure test. Do NOT let system sit filled with un-chemically treated water for more than 4-hours.

B. Cleaning Procedure.

1. Upon start-up fill with clean water.
2. Add alkaline detergent.

a. Sodium silicate and/or sodium phosphate with non-foaming wetting agent.
b. Phenolphthalein alkalinity to 2000 to 5000 parts per million as CaCo/3.
c. Supplied and supervised by water treatment company.

3. Install temporary filter bags in line strainers during start-up.

4. Circulate water of each system at respective design flow rates or greater.

    a. Three 8-hour periods.
    b. At end of each 8-hour period remove and clean strainers and blow off low points.
    c. After third period, completely drain out entire systems of cleaning solution and removed filters at strainers.
    d. Refill systems with clean water and circulate for additional 8-hour period at end of which interval, completely drain systems.
    e. Drain, refill with clear water; circulate.
    f. Test for alkalinity.

        1) Not more than 200 parts per million in excess of alkalinity of rinsing water.
        2) Repeat flushing of water of each system at respective minimum design flow rate as described above, until 200 parts per million or less.

5. Protect against damage from freeze up or discharge of water.
6. Should any pipe be plugged or should foaming of water systems occur, disconnect piping, clean again, and reconnect at no additional cost to the Owner.

C. Upon completion of cleaning, dose system with chemicals to obtain corrosion inhibition conditions as recommended by water treatment company.

3.7 FIELD QUALITY CONTROL

A. Testing of Water Piping.

1. Test water piping at completion of roughing in, in accordance with the following schedule and show no loss in pressure or visible leaks after a minimum duration of four hours, or time as indicated, at the test pressures indicated.
2. Make connections to existing systems with flanged connection. During testing of the new work, provide a slip-in plate to restrict test pressure to new systems only. Remove plate and complete connection to existing system at completion of testing.
3. Inspect pressure piping in accordance with procedures of ANSI B31.
4. Less than 100 pounds per square inch operating pressure: Test hydrostatically to 150 pounds per square inch.
5. Over 100 pounds per square inch operating pressure.

    a. Test hydrostatically to 1-1/2 times operating pressure.
    b. Never exceed test pressure ANSI B16.1 basis.

6. Duration: 4 hours.

    a. With system valves capped and pressure apparatus disconnected.

        1) Pressure change: none.
        2) Compensate for temperature change.

7. Leaks and defects.

    a. Repair or replace as directed by the Architect.
    b. At no additional cost to the Owner.

8. Notify Architect in writing one week before test.

9. Furnish written report and certification that tests have been satisfactorily completed to the Architect.
10. Include written report and certification that tests have been satisfactorily completed.
11. Final connection to system shall be witnessed by Architect.

Hydronic Piping Test Log						
Date	System	Description of Piping Section Tested	Test Press. (psig)	Test Duration (hours)	Results Pass/ Fail	Witness (Contractor) Initials
This form stall be completed and submitted with the project closeout documents. Contractor shall copy this form if more sheets are required. Piping pressure test log shall be kept at project site and shall be made available to the Architect upon request.						

END OF SECTION 232113

SECTION 232300 - REFRIGERANT 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 materials, equipment, fabrication, special-duty valves, specialties, and installation for the following:

1. Refrigerant Piping

1.3 REFERENCE STANDARDS

A. ANSI/ASHRAE 34 – Number Designation of Refrigerants.

B. ANSI/ASTM B32 – Solder Metal.

C. ANSI/ASTM B88 – Seamless Copper Water Tube.

D. ASTM B280 – Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.

E. ANSI/AWS A5.8 – Brazing Filler Metal.

F. ANSI/AWS D1.1 – Structural Welding Code.

1.4 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Piping and fitting materials	R			R
Valves and specialties	R			R
Solder	R2			

C. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, valve arrangements and locations, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.

1. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

D. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

C. Installer Qualification: Only trained installers skilled in refrigeration pipe installation and brazing of copper tubing should be used.

D. Each length of pipe, fitting, trap, fixture, or device used in any piping system shall be stamped or indelibly marked with:

1. Weight or quality.
2. Maker's name or mark.

1.6 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A.

1. Suction (low pressure gas) Lines: 550 psig, or per equipment manufacturers recommendation.
2. Hot-Gas (high pressure gas) and Liquid Lines: 550 psig, or per equipment manufacturers recommendation.

1.7 REUTILIZE EXISTING REFRIGERANT PIPING

A. Clean piping per industry standards and new equipment manufacturer’s recommendations.

B. Pressure test and remedy all leaks.

C. Newly insulate.

D. Install with new liquid drier.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Copper Tube:

1. Straight Lengths: ASTM B 75, UNS C12200, H55 Temper (Light Drawn), ACR Bending Quality; Cleaned, Eddy Current Tested, and Plugged per ASTM B 280.

a. Reftekk “HHC”

2. Coiled: ASTM B 280, UNS C12200, O60 Temper (Soft Annealed), ACR, cleaned and capped

a. Reftekk “CCE”

B. Brazing Filler Metals: AWS A5.8.

a. Reftekk “BRG”

C. Field Swaged Brazing Cups: MSS-SP-73, ASME B 16.50

D. Field Bends (all angles): ASME B31.5

E. Wrought-Copper Fittings: ASME B16.22.

F. Wrought-Copper Unions: ASME B16.22.

2.2 VALVES AND SPECIALTIES

A. Service Valves:

1. Body: Forged brass with brass cap.
2. Core: Teflon Seal.
3. Type: Full Port Refrigeration Ball Valve with Schrader Port.
4. Working Pressure Rating: 700 psig.
5. Approved for R410
6. Provide with Ball Valve Insulation 3/4" thickness
7. NDL Ball Valve UL# SA33847 or approved equal

2.3 REFRIGERANTS

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

1. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. Or equal.

B. ASHRAE 34, R-410A

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A.

A. Suction (low pressure gas), Hot Gas (high pressure gas), and Liquid Lines for Heat Pump and Heat Recovery Applications: All sizes, Straight Lengths, Copper, Type ACR Type L, H55 (light drawn)-temper tubing and field bent fittings with brazed joints.

3.2 VALVE AND SPECIALTY APPLICATIONS.

A. Install service valves to isolate system components.

B. Install service valves at each branch selector pipe to indoor unit.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. 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.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections. Field Bend changes in direction for annealed piping.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels if valves or equipment requiring maintenance is concealed behind finished surfaces.

L. Install refrigerant piping in protective conduit, where installed belowground.

M. Install refrigerant piping in rigid or flexible conduit in locations, where exposed to mechanical injury.

N. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

O. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

P. Identify refrigerant piping and valves according to Section 230553 “Identification for HVAC Piping and Equipment.”

Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 “Sleeves and Sleeve Seals for HVAC Piping.”

R. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 “Sleeves and Sleeve Seals for HVAC Piping.”

S. Install escutcheons for piping penetrations of walls, ceilings, and floors.

T. Provide proper compensation for pipe/tube expansion and contraction per equipment manufacturers recommendations.

U. Pressure test, clean, and pull a vacuum, as recommended by equipment manufacturer, on all piping reused. Provide new filter driers in all reused system piping systems.

3.4 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or soldering, to prevent scale formation.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BcuP-5 (15% Ag, 80% Cu, 5% P), copper-phosphorus alloy pre-formed brazing rings for joining copper swage fittings and copper socket fittings with copper pipe. Do NOT use flux.
2. Use Type Bag-5 (45% Ag), cadmium-free silver alloy for joining copper with bronze or steel. Use manufacturers recommended flux.

E. Field Swaged Brazing Cups: Fabricate brazing cup on one tubing end for each coupling. Only O60 (soft annealed) and H55 (light drawn) may be swaged. Do NOT swage H58 (drawn general purpose). Use swaging tool designed to provide a minimum of 0.0015” brazing gap and a maximum of 0.005” brazing gap. Brazing cup depth for each tube size shall be as follows.

1/4"	3/8”	1/2"	5/8”	3/4"	7/8”	1-1/8”	1-3/8”	1-5/8”	2-1/8”
0.250”	0.280”	0.310”	0.390”	0.420”	0.460”	0.510”	0.560”	0.600”	0.700”

F. Field Bends: Fabricate field bends with a center-line bend radius greater than or equal to 4 times the nominal OD of the pipe or tube. Tube shall be bent with a tubing bender sized for ACR OD tube sizes and shall not cause cracks or wrinkles in the tube or pipe. Do NOT use a conduit bender for bending ACR copper. The difference between maximum and minimum diameters for pipe bends should not exceed 8% of the nominal outside diameter of the pipe. Only O60 soft annealed-temper and H55 light drawn-temper shall be field bent. Do NOT field bend H58 drawn general purpose-temper copper tube.

G. BRAZING AND JOINING PROCEDURE

1. Tube ends shall be cut with a clean sharp tubing cutter.
2. Deburr the I.D. of the cut tube end with a clean deburring tool.
3. Visually inspect the interior of each tube for obstructions and debris before assembly. Protect the joint from contamination before brazing.
4. Method of pre-cleaning: Non-shedding abrasive pads (Scotch Bright) to remove all oxides in the brazing area followed by wiping with a clean lint-free white cloth. Do not groove the surfaces while cleaning.
5. Purge all tubing with oil free nitrogen while brazing and until cool to the touch. Use an oxygen analyzer to verify the absence of oxygen prior to brazing. The oxygen content shall be less than 1% before start of brazing.
6. Use a neutral to slightly reducing flame using oxy/acetylene or oxy/propane.
7. Use the proper torch tip based on tube size as recommended by the torch manufacturer. Use of Turbo-Torch or Rosebud is permitted.
8. Post Brazing Cleaning: Exterior of all completed joints shall be washed with a water-soaked rag or sponge, followed by brushing with a stainless-steel hand wire brush to remove any residue for inspection.

3.5 HANGERS AND SUPPORTS

A. See Section 230529 “Hangers and Supports for HVAC Piping and Equipment.”

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs.
2. Rigid high compressive strength foam insulating pipe support at all support points. Comply with Section 230719 “DX Piping System Insulation”.
3. Do NOT attach hangers directly to pipe or tube.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. Up to 3/4" OD: Maximum span, 60 inches; minimum rod size, 3/8 inch.
2. Greater than 3/4" thru 1” OD: Maximum span, 72 inches; minimum rod size, 3/8 inch.
3. Greater than 1” thru 2-1/8” OD: Maximum span, 96 inches; minimum rod size, 3/8 inch.

D. Support multi-floor vertical runs every 10 feet and at least at each floor.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test as recommended by equipment manufacturers instructions.
3. Test refrigerant piping and specialties. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
    a. Fill system with 95/5 nitrogen/hydrogen to the required test pressure.
    b. System shall maintain test pressure at the manifold gage throughout duration of test.
    c. Test all joints and fittings with hydrogen leak detector, at test pressure.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures and per equipment manufacturers instructions.

1. Evacuate (triple evacuation procedure) entire refrigerant system with a vacuum pump to obtain a steady state vacuum of less than 500 micrometers. If vacuum holds for 12 hours, system is ready for charging. Do NOT evacuate the system through a charging manifold. Use only suction rated hoses and core removal tools.
2. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
3. Charge system as recommended by equipment manufacturer.

Refrigerant Piping Test Log						
Date	System	Description of Piping Section Tested	Test Press. (psig)	Test Duration (hours)	Results Pass/ Fail	Witness (Contractor) Initials
This form stall be completed and submitted with the project closeout documents. Contractor shall copy this form if more sheets are required. Piping pressure test log shall be kept at project site and shall be made available to the Architect upon request.						

END OF SECTION 232300

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Work included in this section: materials, equipment, fabrication, installation, and tests in conformity with applicable codes and authorities having jurisdiction for the following:

1. Ductwork.
2. Plenums.
3. Fasteners, sealants, and gaskets.
4. Hangers and supports.
5. Duct air leakage tests.

1.3 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:

1. ASHRAE - Handbook of Fundamentals; Duct Design.
2. ASHRAE - Handbook of HVAC Systems and Equipment; Duct Construction.
3. ASTM A 90 - Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles.
4. ASTM E 96 - Standard Test Methods for Water Vapor Transmission of Materials.
5. ASTM A 167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
6. ASTM A 525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.
7. ASTM A 527 - Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality.
8. ASTM B209 - Aluminum and Aluminum Alloy Sheet and Plate.
9. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
10. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems.
11. NFPA 96 - Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors from Commercial Cooking Equipment.
12. NFPA 45 – Laboratory Ventilating Systems and Hood Requirements.
13. SMACNA – HVAC Duct Construction Standards.
14. SMACNA – Rectangular Industrial Duct Construction Standards.
15. SMACNA – Round Industrial Duct Construction Standards.

16. SMACNA – HVAC Air Duct Leakage Test Manual.
17. UL 181 - Factory-Made Air Ducts and Connectors.
18. Engineering Design Manual for Air Handling Systems, United McGill Corporation (UMC).
19. Assembly and Installation of Spiral Ducts and Fittings, UMC.
20. Engineering Report No. 132 (Spacing of Duct Hangers), UMC.
21. AWSD1.1 American Welding Society Structural Welding Code.

1.4 DEFINITIONS

A. Seam: locks or weld applied longitudinally to close section of duct, for example longitudinal seam, spiral seam.

B. Joint: abutting connection between duct sections for continuity of air passage, for example cross joint, transverse joint, coupling.

C. Reinforcement: hardware applied to strengthen duct, for example girth angles, tie rods, fasteners (not connectors), and the like.

D. Stiffening: folding, bending, beading, cross breaking or corrugating of sheets to achieve strength through shape, for example pocket lock secures joint and is transverse stiffener, with girth angle and fasteners applied (not connectors), joint or stiffener is reinforced.

E. Duct Classification:

1. Pressure classification: except as indicated on the Drawings:

a. Low Pressure: Ductwork systems up to 2-inch w.g. positive or negative static pressure with velocities less than or equal to 1500 fpm.
b. Medium Pressure: Ductwork systems over 2-inch w.g. and up to 6-inch w.g. positive or negative static pressure with velocities less than or equal to 2500 fpm.
c. High Pressure: Ductwork systems over 6-inch w.g. and up to 10-inch w.g. positive or negative static pressure with velocities greater than 2500 fpm.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements.

1. Entire ductwork system, including materials and installation, installed in accordance with NFPA 90A.
2. Ductwork and components shall be listed as U.L. 181, 181A and 181B, Class I air duct, flame rating not to exceed 25 and smoke rating not to exceed 50.
3. Flues shall conform to the requirements of NFPA-211. Products shall be listed to UL-103 and shall carry the appropriate UL listing mark or label.

B. Mockups:

1. Before installing duct systems, build mockups representing static-pressure classes in excess of 2inch wg. Build mockups to comply with the following requirements, using materials indicated for the completed Work:

a. Five transverse joints.
b. One access door(s).
c. Two typical branch connections, each with at least one elbow.

d. Two typical flexible duct or flexible-connector connections for each duct and apparatus.
e. One 90-degree turn(s) with turning vanes.
f. One fire damper(s).
g. Perform leakage tests specified in "Field Quality Control" Article. Revise mockup construction and perform additional tests as required to achieve specified minimum acceptable results.

2. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 SUBMITTALS

A. See Section 230010 Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop and coordination drawings according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

C. Product Data: For each type of the following products:

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

Item	Product Data	O&M Manual	Samples	Shop Drawing
Ductwork materials and fittings	R			R
Duct fasteners, sealants, and gaskets	R			
Flexible duct	R			R
Flue	R			R
Duct pressure testing reports		R		

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Spiral oval and round ducts:

1. United Sheet Metal Division, United McGill.
2. Semco Manufacturing, Inc.
3. Eastern Sheetmetal.
4. Lindab, Inc.
5. Or equal.

C. Duct Connection Systems:

1. Ductmate Industries, Inc.
2. Fabriduct Transverse Duct Connection system.
3. Ward Industries, Inc.
4. Or equal.

D. Flexible Connections:

1. Ventfabrics.
2. Duro Dyne.
3. Or equal.

E. Flexible Ducts:

1. Thermaflex.
2. Hart & Cooley.
3. Flexmaster.
4. Or equal.

F. Duct Sealants:

1. Foster Products Corporation.
2. Hardcast Corporation.
3. 3M.
4. Or equal.

G. Flexible Duct Clamps:

1. Panduit.
2. Dura-Dyne.
3. Young Regulator Company.
4. Or equal.

H. Hi-efficiency & conical Tap Fittings:

1. Flexmaster.
2. Crown.
3. Die Stamp.
4. Or equal.

2.2 APPLICATIONS

A. Ductwork systems shall be constructed in accordance with the following Materials as a minimum standard. Refer to Drawings for any deviation from this Table.

AIR SYSTEM	MATERIAL	SMACNA DUCT PRESSURE CLASS (1)	SMACNA DUCT SEAL CLASS(3)
Supply, Return, and Exhaust Systems:			
Untreated Outside Air to Indoor Units and conditioned spaces	Galvanized Steel	-2” w.g.	A
Treated Outside Air to Indoor Units and conditioned spaces	Galvanized Steel	2” w.g.	A

AIR SYSTEM	MATERIAL	SMACNA DUCT PRESSURE CLASS (1)	SMACNA DUCT SEAL CLASS(3)
Supply Air -upstream of VAV boxes	Galvanized Steel (2)	3” w.g.	A
Supply Air -downstream of VAV boxes	Galvanized Steel (2)	1” w.g.	A
Return Air	Galvanized Steel	-1” w.g.	A
Exhaust Air	Galvanized Steel	-1” w.g.	A

B. Table Notes:

1. Positive pressure unless noted otherwise in Table.
2. Air device connections may be made with insulated flexible duct as specified herein.
3. Seal Class A Sealing Requirements: Seal all transverse joints, longitudinal seams, and duct wall penetrations. Longitudinal seams are joints oriented in the direction of airflow. Transverse joints are connections of two duct sections oriented perpendicular to airflow. Duct wall penetrations are openings made by any screw fastener, pipe, rod or wire. Spiral lock seams in round and flat oval duct need not be sealed. All other connections are considered transverse joints, including but not limited to taps and other branch connections, access door frames and jambs, duct connections to equipment, etc.

2.3 MATERIALS

A. General Material Requirements.

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. (Minimum duct thickness shall be 24 gauge). Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
2. All duct sizes shown on the Drawings are clear inside dimensions. Allowance shall be made for internal lining, where specified, to provide the required free area.
3. All holes in ducts for damper rods and other necessary devices shall be either drilled or machine punched (not pin punched) and shall not be any larger than necessary. All duct openings shall be provided with sheet metal caps if the openings are to be left unconnected for future connections/phases, otherwise plastic covers are acceptable.

B. Galvanized Steel Sheet Metal:

1. Prime, cold rolled soft galvanized steel sheets.
2. Each sheet shall be stenciled with manufacturer's name and gauge.
3. ASTM A653 and A924.
4. Galvanizing: 1-1/4 ounces per square foot, total both sides.

    a. General: G-90.
    b. Exposed to weather: G-90.
    c. Plenum walls and blank-offs where in contact with cooling coil: G-90.

5. Lock-forming quality.

C. Miscellaneous Products.

1. Screws and rivets:

a. Same material as sheet, except as indicated on the Drawings.
b. On aluminum sheets, provide cadmium plated or stainless steel.
c. Zinc or cadmium plated, permitted on galvanized sheets.
d. Minimum screw size: No. 10.
e. Minimum rivet size: 4 pound.

2. Duct Sealants:

a. Sealing compound: UL-181 listed, water based:

1) Foster Safetee Duct Sealant 32-19.
2) Childers CP-146.
3) Hardcast Products Group Flex-Grip 550.
4) Or equal.

b. Rolled Elastomeric Duct Sealant: Hardcast Products Group Foil Grip 1403-181BFX, or equal, UL 181 listed.
c. Gaskets:

1) Continuous, reinforced, inert self-conforming type.
2) 1/8 inch thick.
3) Width: to match angle connection.
4) 3M Weatherban Ribbon Sealant PF5422 or equal.

d. Two-Part Hard-Setting Joint Tape:

1) Two-part process includes tape and hard setting sealant.
2) Mineral impregnated woven fiber tape.
3) Impregnated with activator/adhesive of polyvinyl acetate type.
4) UL Listed.
5) Flame spread: 10.
6) Smoke contributed: 0.
7) Equal to Hardcast RTA-50 sealant and DT-5400 4 inch tape.

3. Spring Fasteners:

a. Oval head stud and receptacle.
b. Screwdriver slot.
c. Self-ejecting.
d. Dzus or equal.

4. Angles, tie rod and shapes for reinforcing ducts: In accordance with SMACNA HVAC Duct Construction Standards, except as indicated on the Drawings.
5. Duct connection system:

a. Transverse bolted duct joints.
b. Flanges with permanent, non-hardening sealant.
c. Ductmate Industries Ductmate 25 and 35, Fabriduct TDC, or equal.

D. Flexible Connections:

1. Conforming to NFPA 701, UL Standard No. 214 and NFPA 90A.
2. SMACNA HVAC Duct Construction Standards, except as indicated on the Drawings.
3. With metal edges at each end: No. 24 USSG galvanized steel. Double lock joint.
4. Length of fabric connections.

a. Minimum: 4 inch.
b. Maximum: 10 inch.

5. Materials:

a. Coated glass fabric.
b. Flame spread rating: 25.
c. Smoke development rating: 50.
d. 30 ounces per square yard.
e. Sewed and cemented seams.
f. Indoors:

1) Neoprene.
2) Ventfabrics, Inc. Ventglas or equal.

g. Outdoors:

1) Weather-resistant.
2) Fiberglass with Hypalon.
3) UV, sunlight, and ozone resistant.
4) Ventfabrics, Inc. Ventlon or equal.

E. Turning Vanes:

1. Galvanized steel ductwork: galvanized steel or painted black steel, except as indicated on the Drawings.
2. Other ductwork: same material as ductwork.
3. Construction per SMACNA HVAC Duct Construction Standards for:

a. Double wall vanes.
b. Vane length: Provide separate equal size sections for vane length greater than those indicated in referenced Standards.
c. Vane runners: Type 1 or 2 acceptable.

4. Vane radius:

a. 2 inch radius: duct width up to 36 inches.
b. 4-1/2 inch radius: duct with 36 inches or larger.

5. Vane shall be at the correct angle for airflow (leading edge in line with the entering duct section; leaving edge in line with existing duct section). If only 45° angles are available, turning vanes shall only be used in 90° elbows where the entering width equals the exiting width; all other elbows shall be full radius type unless otherwise indicated on the drawings.

F. Conical Taps: Low-pressure round take-off fittings in rectangular duct:

1. Heavy 26-gauge G-90 Galvanized Steel Body
2. (1") 26-gauge G-90 Galvanized Steel Flange
3. Double Sided Adhesive Gasket on Flange
4. Extra Heavy 24-gauge G-90 Galvanized Steel Blade
5. 3/8" Square Axle Secured to Blade with U-bolts (2 U-bolts used for 8" diameter and larger)
6. Nylon bushings on thru and end (all sizes)
7. 2" Stool with Locking Quadrant and Handle (all sizes, wing nuts not acceptable)
8. Sealed on all Seams
9. BO3 (2") Build-out, 3/8" Square Shaft (solid rod), U-bolt, Locking Quadrant, Handle

10. Flexmaster CBD-SOG-BO3 UT 3000G, Crown 3210-DS2 or equal.

2.4 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS (LOW PRESSURE)

A. Duct Classification: Ducts shall be considered low pressure when design velocities are 1500 fpm or less and maximum static pressure is 2-inch W.G., positive or negative.

B. General: Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction with galvanized sheet metal, according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible." Comply with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.

1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure classification.
2. Materials: free from visual imperfections such as pitting, seam marks, roller marks, stains, and discolorations.

C. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inches thick or less, with more than 10 square feet of unbraced panel area, unless ducts are lined.

D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

F. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

G. Bullhead tees are not permitted.

2.5 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS (LOW PRESSURE)

A. Duct Classification: Ducts shall be considered low pressure when design velocities are 1500 fpm or less and maximum static pressure is 2-inch W.G., positive or negative.

B. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

C. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

D. Factory-fabricated spiral lock seam duct:

1. Snap-lock is not acceptable.
2. Factory-fabricated longitudinal seam acceptable for ducts larger than standard factory sizes.
3. Round Duct Flanges: Prefabricated connection system consisting of double-lipped, EPDM rubber gasket. Manufacture ducts according to connection system manufacturer's tolerances. All flanges to be factory mounted.
4. Flat Oval Ducts: Prefabricated connection system consisting of two flanges and one synthetic rubber gasket.

E. Fittings:

1. Same material, gauge thickness and construction as duct in which installed.

2. Full body fittings are acceptable.

3. Elbows:

a. Seams:

1) 4 inch and higher pressure, class and all ducts exposed to occupant view: continuously welded seams.
2) 1 inch to 3 inch pressure: spot welded with bonded (sealed) seams.

b. Gores:

1) 2 gores - less than or equal to 30 degrees.
2) 3 gores - 31 degrees through 45 degrees.
3) 4 gores – 46 degrees through 60 degrees.
4) 5 gores - over 61 degrees

Type	Pressure	Location	Fittings	Traverse Joints	Branches	Couplings
Round	< 2”	Concealed	Factory Fabricated	Conical/ 45° Entry	Loose Saddle Tap Field Installed	Slip ≤ 20” Flanges > 20”
	< 2”	Exposed	Factory Fabricated	Conical/ 45° Entry	Factory Installed	Slip ≤ 20” Flanges > 20”
Oval	< 2”	Concealed	Factory Fabricated	Conical/ 45° Entry	Factory Installed	Slip ≤ 20” Flanges > 20”
	< 2”	Exposed	Factory Fabricated	Conical/ 45° Entry	Factory Installed	Slip ≤ 20” Flanges > 20”

2.6 FLEXIBLE DUCTS

A. General Requirements:

1. Flexible ducts shall be used for supply air ducts only (not acceptable for return, exhaust, relief, outdoor, etc. air ducts).
2. UL 181, Class I Air Duct.
3. Labeled for compliance with IMC.
4. Class 1 Air Duct, NFPA 90A and 90B, BOCA, SBBC, HUD/FHA, MIN Property Std.

5. Maximum flex duct length 5'-0" (five feet), installed with no more than 90 degrees of bend to diffusers and grilles. Where longer duct runs or more bends are necessary, provide rigid round ductwork.

B. Type 1 Acoustical Insulated

1. Minimum working pressure:

   a. 10" w.g. positive
   b. 5" w.g. negative, 16" diameter
   c. 1" w.g. negative, 18" & 20" diameter

2. Rated Velocity

   a. 5,550 fpm

3. Acoustic Performance:

   a. Minimum insertion loss (dB) for 6' of 8" diameter flexible duct for flow velocities less than 2,500 fpm.
   b. Acoustical testing to be performed in accordance with ASTM E477 and ADC Test Code FD 72-RI by ETL

	Sound Power Levels, dB re. 10^{-12} Watts, at Octave Band Center Frequency, Hz					
	125	*250*	*500*	*1000*	*2000*	*4000*
Insertion Loss	*5*	*16*	*17*	*18*	*16*	*11*

4. Duct Fabric:

   a. Polyethylene fabric. Fabric to be mechanically locked to the duct helix without the use of adhesives

5. Duct Helix

   a. Corrosive resistant galvanized steel. Helix is to be mechanically formed to attach the duct fabric without the use of adhesives.

6. Vapor Barrier

   a. Fire retardant, reinforced aluminum.
   b. (.05) perm A.S.T.M. E96, Procedure A

7. Insulation

   a. Factory insulation jacket, factory wrapped. R8 minimum.

8. Flexmaster Type 1M or equal.

C. Type 6 Acoustical Insulated (in locations as indicated on schedules/plans)

1. Minimum working pressure:

a. 6” w.g. positive
b. 5” w.g. negative, 16” diameter
c. 1” w.g. negative, 18” & 20” diameter

2. Rated Velocity

a. 5,550 fpm

3. Acoustic Performance:

a. Minimum insertion loss (dB) for 6’ of 8” diameter flexible duct for flow velocities less than 2,500 fpm.
b. Acoustical testing to be performed in accordance with ASTM E477 and ADC Test Code FD 72-RI by ETL

	Sound Power Levels, dB re. 10^{-12} Watts, at Octave Band Center Frequency, Hz						
	63	*125*	*250*	*500*	*1000*	*2000*	*4000*
Insertion Loss	*5.7*	*14*	*13*	*15*	*16*	*18*	*16*

4. Duct Fabric:

a. Spunbond Nylon fabric. Fabric to be mechanically locked to the duct helix without the use of adhesives

5. Duct Helix

a. Corrosive resistant galvanized steel. Helix is to be mechanically formed to attach the duct fabric without the use of adhesives.

6. Vapor Barrier

a. Fire retardant, reinforced aluminum.
b. (.05) perm A.S.T.M. E96, Procedure A

7. Insulation

a. Factory insulation jacket, factory wrapped. R8 minimum.

8. Flexmaster Type 6M or equal.

2.7 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

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

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

I. Round Duct Supports:

1. Minimum 2" wide 20 gauge galvanized metal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate with work of other trades.

B. Ductwork Installation – General:

1. Install ducts in accordance with manufacturer’s written installation instructions.
2. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
3. Construct with gages, joints, bracing, reinforcing, and other details per latest IMC, ASHRAE, SMACNA and NFPA, unless specified otherwise.

    a. Comply with most stringent.
    b. Provide ducts with IMC gages or thicker when traversing rated corridors.
    c. Combustion air ducts: Minimum 24 gage.

4. Construct of galvanized sheet metal, except where otherwise indicated herein or on Drawings.
5. Provide for duct rigidity by either of these methods:

    a. Beading at 12 inches on center, maximum.
    b. Cross-break outward in ducts having positive internal pressure.
    c. Cross-break inward in ducts having negative internal pressure.

        1) Exception: All ducts exposed to rain shall outward cross-break on top of the duct.

6. Duct dimensions indicated are outside duct dimensions (OD) unless indicated on the Drawings as inside dimension (ID or net, clear dimension).
7. Alter duct sizes on basis of equal friction where required to facilitate installation. Reflect changes in shop drawings for review by Architect.
8. At duct penetrations of walls, floors and ceilings where exposed to occupant view, provide sheet metal angle type escutcheons with no sharp corners or edges.

    a. Clearance from duct to opening shall not exceed 2 inches.
    b. Escutcheons shall overlap wall, floor, or ceiling surface by ½ inch minimum.

9. Frame, trim, caulk and seal all duct penetrations through acoustical walls and partitions.
10. Tapers:

    a. Pitch sides of duct in diverging or converging airflow maximum of 1 to 4 taper.
    b. Abrupt, bushing type fitting not allowed.

11. Duct Openings:

    a. Provide openings where required to accommodate thermometers, smoke detectors, controllers, and the like. Insert through airtight rubber grommets.
    b. Where openings are provided in insulated ductwork for insertion of instruments, install insulation material inside metal ring for use as plug.
    c. At fire dampers allow adequate length of duct to install access door.

12. Avoid penetration of ducts; provide airtight seal at unavoidable penetrations of hanger rods.
13. No exposed sharp metal allowed.

    a. All exposed pins, screws and sharp objects shall be covered with hardening silicon.
    b. All exposed sheet metal edges shall be hemmed with exposed corners rounded smooth.
    c. Remove all sheet metal fish hooks.

14. Install lining in ducts and plenums as specified in Section 230713 – Duct Insulation.
15. Flexible Connections:

    a. Coated glass fabric.
    b. For indoor or outdoor use.
    c. Use diaphragm type at plug fan inlets.
    d. Install at connections to fans and air handling units and as indicated on Drawings.
    e. 2 inch slack in fabric; install to allow minimum movement of 1 inch in both tension and compression.
    f. Protect from direct solar and rain exposure with sheet metal shroud where outdoors.

16. Volume dampers: Install dampers as specified in Section 233300 – Duct Accessories

C. Elbows and Splits:

1. Use radius elbows in rectangular ducts unless otherwise indicated on the Drawings: Centerline radius dimension shall not be less than 1-1/2 duct width.
2. Where space does not permit duct radius specified above, install short radius splitter vanes per SMACNA HVAC Duct Construction Standard.

    a. Number of vanes determined by ratio of inner radius (R) to duct width in plane of radius (W).
    b. One vane: Radius to width ratio above 0.3.

c. Two vanes: Radius to width ratio between 0.1 to 0.3
d. Three vanes: Radius to width ratio 0.1 and smaller.

3. Use square turns with turning vanes in rectangular ductwork, unless otherwise indicated on the Drawings, at following locations.

a. Use only where full radius elbow cannot fit.
b. Use only in ducts with 2000 fpm or less design velocity.
c. In high and medium pressure ductwork spot weld turning vane to duct.

D. Rectangular Duct Joints:

1. Transverse Joints:

a. In medium pressure ductwork shall be Fabriduct TDC or Ductmate or equal.
b. In low pressure ductwork shall be Fabriduct TDC or equal except that ducts under 19 inches longest side may be slip & drive (S&D)

2. Longitudinal seams shall be Pittsburgh. Snap lock not allowed.

E. Plenum walls, blank-offs, and casings:

1. Construct per SMACNA HVAC Duct Construction Standard, Casings and Plenums.
2. Static pressure class:

a. Upstream of fan: -2 inches.
b. Downstream of fan: fan static pressure or greater.

3. Seal all joints, edges, and penetrations as per HVAC ducts as specified herein.

F. Round and oval ductwork:

1. Joints between ducts:

a. Made with beaded sleeve joints as scheduled.
b. Duct sealer applied to male end.
c. Mechanically fastened with sheet metal screws or pop rivets.
d. Over joint and screw or rivet heads, apply coating of duct sealer.

1) Duct where exposed to occupant view: Sealant shall be within joint only and not visible.

2. Joints, duct and fitting:

a. Slip projecting collar of fittings into duct: Per SMACNA HVAC Duct Construction Standard.
b. Apply duct sealer: Seal and tape as specified above.
c. Mechanically fasten: Fastening schedule: Per SMACNA HVAC Duct Construction Standard.

3. Branch take-offs:

a. Medium pressure: 45 degrees (fittings).
b. Low pressure: straight 90 degrees (fittings).

4. Horizontal supports:

    a. One or two-piece clamp band strap.
    b. Minimum: one per section.
    c. Support fittings as required to prevent sagging.

5. Vertical Supports: one of the following:

    a. Clamp bands with extended ends supported by floor.
    b. Clamp bands with knee bracing.
    c. Pedestal at base of vertical.

G. Flexible ductwork:

1. Not allowed for:

    a. Return, exhaust, or outdoor air ducts.
    b. Product conveying systems such as kitchen exhaust and laboratory exhaust.
    c. Dryer exhaust (other than final exposed connection at dryer).
    d. Medium and high pressure, ducts.

2. Continuous, single pieces:
3. Length:

    a. Low pressure:

        1) Maximum 5 feet, except where longer lengths are indicated on drawings. Where longer lengths are shown, the last 3 feet to 5 feet shall be wire flex duct and remaining ductwork shall be aluminum flex duct.
        2) Minimum length: 3 feet.

4. End connections:

    a. Connect to duct collars, terminal unit connections and round air outlets per manufacturer's instructions.
    b. Secure with strap clamps specified above.

5. Installations:

    a. Support adequately to avoid excessive droop.
    b. Minimum inside bending radius not less than one duct diameter.
    c. Install as straight as possible except as shown on drawings for sound attenuation.
    d. Cut ducts to lengths required rather than create bends to take up excess lengths except as shown on drawings for sound attenuation.

H. Grille connections:

1. Provide at entry to diffuser collar either.

    a. Straight duct for 1 duct diameters or greater.
    b. Full radius elbow.
    c. Side inlet plenum.

        1) Height: 4 inches minimum taller than top of grille to provide room for uniform airflow to grille.

2) Width/length: 2 inches wider than duct or round diffuser collar, whichever is larger.
3) Internal surfaces lined with minimum 1/2 inch thick Type AL duct liner as specified under Section 230713 – Duct Insulation.
4) At contractor's option, where plenum is required at round neck diffuser, square neck diffuser with length and width equal to diffuser diameter may be substituted.

d. Thermaflex FlexFlow Elbow or equal.

2. Connections at grilles shall be insulated to the extent the duct is insulated including the final register box.
3. Seal connections at grilles per seal class of upstream ductwork.

I. Sound-rated duct packing:

1. Wherever possible avoid duct penetrations through sound-rated walls, floors and ceilings.
2. Provide packing for unavoidable duct penetrations.

3.2 DUCT SEALING

A. Ducts not exposed to weather: Seal using one of the following:

1. Duct sealer compound.
2. Gasketed TDC or Duct-Mate.
3. Two-Part Hard-Setting Joint Tape.
4. Flexible duct:

a. Secure with straps or clamps as specified herein.
b. Supplement with duct tape, both inner and outer liner.

5. Indoor duct where exposed to occupant view: Sealant shall be within joint only and not visible.
6. Fire and fire/smoke dampers: Sealant shall be listed as approved on manufacturer's UL installation sheet.
7. Continuously welded ducts: Additional sealing not required.

B. Seal punched holes and corner cracks.

C. Seal all factory fabricated ducts, including transverse joints on gored elbows.

D. Seal end caps.

E. After installation and testing reseal joints found to be leaking at no additional cost to the Owner.

3.3 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor, and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.4 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 – Air Duct Accessories.

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.5 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer.

3.6 DUCT AIR LEAKAGE TESTING

A. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test. See the Duct Air Leakage Test Log at the end of this section.
2. Test the following systems:

    a. Supply, Return, Exhaust, and Outdoor Air Ducts: Test 100% of installed duct sections.
    b. Field installed plenums. Test 100% of all field installed plenums.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.

6. Give seven days' advance notice for testing.

B. General:

1. Pretesting shall be conducted prior to conducting test in presence of TAB Agency and Architect. Once all required ductwork has passed the pretest duct pressure test, the TAB Agency and Architect shall be notified to visit the site for witness testing.
2. Use portable high pressure, blower and necessary instruments to indicate amount of leakage.
3. Conduct tests as prescribed in SMACNA HVAC Air Duct Leakage Test Manual and make test before duct sections are concealed.
4. Procedure:

    a. Seal openings in ducts and plenums to be tested.
    b. Connect test apparatus to test section using flexible duct connection or hose.
    c. Close damper on blower suction side, to prevent excessive buildup of pressure.
    d. Start blower and gradually open damper on suction side of blower.
    e. Build up pressure in test section equal to static pressure class.
    f. Noise generated from duct leakage not acceptable. Seal as required.
    g. Determine amount of air leakage by makeup air flow measurements:

        1) Maximum permitted leakage for HVAC ductwork shall be:

$$CFM_{max} = \left(\frac{A}{100}\right) C_L P^{0.65}$$

Where,

CFM_{max} = The maximum permitted leakage, cubic feet per minute (cfm).
A= Surface area of the tested duct sections, square feet.
C_L= Duct leakage class, cfm/100 square feet at 1 inch water column.
= 6 for rectangular sheet metal, rectangular fibrous ducts, and round flexible ducts
= 3 for round/flat oval sheet metal or fibrous glass ducts
P= Test pressure which shall be equal to the design duct pressure class rating, inches water column.

        2) Allowable leakage can also be calculated as 1 percent of the design operating air volume for the entire system. If this method is used, the total system leakage must first be determined and then compared with the 1 percent (of system volume flow) allowable leakage. Acceptance is indicated if the actual measured leakage of the entire system is less than the calculated allowable leakage.
        3) If leakage exceeds permitted limit, repair leaks and retest duct sections at no additional cost to the Owner until permitted leakage limits are obtained.

5. Visually mark tested sections with certification sticker and initials of field test inspector.

C. Documentation:

1. Submit certification of test results of compliance to Architect (must be initialed by TAB Agency representative prior to submitting to Architect).
2. Include Duct Air Leakage Test Log indicating compliance.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and test logs.

3.7 PROTECTION

A. Adhere to SMACNA Duct Cleanliness for New Construction Guidelines for Intermediate Level Duct Cleanliness unless more stringent requirements are indicated herein.

B. Storage: Porous materials, such as lined and flexible duct, shall be stored where they will not be exposed to rain or other moisture sources.

C. Temporary closure: Provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris at the following conditions:

1. Exposed ends of unlined installed ducts at the end of each day.
2. Exposed ends of lined ducts or plenums whether in storage or installed.

D. Duct cleaning:

1. Using the connected fan(s) force air at high velocity through duct to remove accumulated dust.
2. Protect equipment and spaces, which may be harmed by excessive dirt with filters, or bypass during cleaning.
3. In areas, which must be kept dust free, seal all outlets duct tight. When closures are removed avoid spilling dust in room.

3.8 INSPECTION

A. Verify that adequate clearance between ducts and adjacent walls or equipment is available to permit proper sealing, maintenance and repairs.

3.9 PRE-OPERATING CHECKS

A. Before operating the duct systems: Set all manual dampers in full open position.

3.10 TESTING AND ADJUSTING

A. After starting the duct systems: Check for noise and leakage. Repair as required at no additional cost to the Owner.

B. See Section 230593 – Testing, Adjusting, and Balancing: Coordination with Balance Agency:

1. Provide services of a sheet metal installer familiar with the system ductwork to provide assistance to the balancing agency during the initial phases of air balancing in locating all sheet metal dampers.
2. Install missing dampers.

Duct Air Leakage Test Log					
Date	System	Description of Duct Section Tested	Test Press. (in w.g.)	Results Pass/ Fail	Witness (TAB Agency) Initials

END OF SECTION 233113

SECTION 233115 - OUTDOOR DUCT SYSTEMS

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. Work included in this section: materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following:

1. Outdoor Duct Systems
2. Ducts Exposed to Weather

1.3 REFERENCE STANDARDS

A. International Mechanical Code, current edition

B. American Standards: ASTM C 518 2004

C. Standard Test Methods for Water Vapor Transmission of Materials: ASTM E 84–08a

D. Standard Test Method for Surface Burning Characteristics of Building Materials: UL 723

E. Test for Surface Burning Characteristics of Building Materials: NFPA 90A

F. Standard for the Installation of Air Conditioning and Ventilating Systems: NFPA 90B

G. Standard for the Installation of Warm Air Heating and Air–Conditioning Systems: UL/ULC 181

H. SMACNA HVAC Phenolic Duct Construction Standards

1.4 QUALITY ASSURANCE

A. Regulatory Requirements.

1. Entire ductwork system, including materials and installation, installed in accordance with NFPA 90A.

1.5 SUBMITTALS

A. See Section 230010 Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop and coordination drawings according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

C. Product Data: For each type of the following products:

1. Sealants and gaskets.

D. Submit electronic layout and shop fabrications drawings for approval.
1. Isometric view of duct assembly with duct sections indicated on drawing to match part number tagging on delivered duct sections.
2. Fabrication and assembly instructions.
3. Details for connecting to other components (i.e. curbs, rooftop units, mechanical room walls, etc.)
4. Duct layout indicating sizes and pressure classes.
5. Elevations of top and bottom of ducts.
6. Dimensions of main duct runs from building grid lines.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Equipment installation based on equipment being used on Project.
10. Duct accessories, including access doors and panels

Item	Product Data	O&M Manual	Samples	Shop Drawing
Outdoor Ducts and Plenums	R			R
Sealants and gaskets	R			
Duct pressure testing reports		R		

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Outdoor Ducts:

1. AQC Q-Duct.
2. Thermaduct.
3. Polyguard
4. Or approved equal.

2.2 MATERIALS

A. AQC Q-Duct

1. Exterior Ductwork is to be a double layered duct system using the Pal Phenolic Duct panels pre-fabricated and assembled into inter-locking sections. Duct is to be 2.0” thick.

2. The panels used in the fabrication of the ductwork system shall Pal Phenolic Duct rigid Phenolic insulation panels with a thermal conductivity of 0.1977 BTU-in/hr•ft^2 °F and a minimum compressive strength of 29 psi.
3. Pal Phenolic Duct rigid Phenolic insulation panels shall comprise a 3.4–3.75 pcf nominal density CFC/HCFC–free rigid Phenolic insulation core with zero Ozone Depletion Potential (ODP), autohesively bonded on both sides: 60 micron aluminum internal liner and a 200 micron aluminum external liner. Both liners are to be solid aluminum with no perforations.
4. All other components required for the fabrication of the system shall be from the Pal Phenolic Duct System guidelines including the sealant, contact adhesive, aluminum tape, self–adhesive gasket ductwork reinforcements, closures, connectors and flanges or alternate as approved / supplied by AQC Industries.
5. Exterior cladding shall be 5 ply, puncture resistant, tear resistant, flexible, and meet UL1709

B. Thermoduct:

1. Exterior ductwork is to be a pre-insulated, pre-fabricated, duct system. Duct to be 2 layers, 1-3/16" panel.
2. The panels used in the fabrication of the ductwork system shall be closed cell phenolic foam.
3. Duct system shall consist of 1000 micron titanium infused vinyl cladding.
4. Duct system shall use no tapes or adhesives to assemble pieces. Joints to be connected with a gasketed 4 bolt flanging system and covered with manufacturers joint covers.

C. Polyguard

1. Outdoor Duct

a. Galvanized steel G-90, 304 stainless steel, or aluminum.
b. Make ducts subject to rain watertight.
c. Construct as follows to assure water run-off.

1) Arrange standing seams to not act as dams.
2) Longitudinal seams at bottom of duct.
3) Construct all ducts subject to rain watertight and to insure water runoff by one or more of following techniques.

a) Slope entire top of duct down toward side.
b) Vertical struts within duct to bow top panels of duct into convex shape.

d. TDC or Duct-Mate joints: Utilize interior joint gasket material plus a bead of butyl rubber sealant at the joint and continuous metal clip or cleat over the top of all four joints (top bottom and sides).
e. Continuously welded ducts: Additional sealing not required.
f. Other joints: Apply two part hard-setting joint tape to:

1) Longitudinal joints.
2) Horizontal joints.
3) Transverse joints.
4) TDC or Duct-Mate joints.
5) Duct penetrations.
6) Screws through duct.
7) Gores of elbows

2. Insulation

a. Duct Board with Vapor Barrier

1) Insulation: ASTM C612; rigid, noncombustible board.

a) 'K' ('Ksi') value: ASTM C518, 0.23 at 75 degrees Fahrenheit.
b) Maximum service temperature: 350 degrees Fahrenheit.
c) Maximum moisture absorption: 0.20 percent by volume.

b. Vapor Barrier Jacket - factory installed (FSK).

1) Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
2) Moisture vapor transmission: ASTM E96 Procedure E; 0.02 perm.
3) Secure with pressure sensitive tape.

c. Vapor Barrier Tape: Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based, adhesive.
d. Installed conductance: 0.23 BTU-inch/hr./square foot/degree Fahrenheit.
e. 1-inch Thickness, 3.0 pounds per cubic foot.
f. Factory applied jacket.

1) Foil-scrim-kraft laminate.

a) Aluminum foil facing.
b) Glass scrim reinforcing.

3. Self-Adhesive, Field-Applied, Outdoor Jackets

a. Manufacturers:

1) Alumaguard, Alumaguard All-Weather, Alumaguard Lite
2) 3M.
3) MFM Building Products Corp.

b. General Requirements for Self-Adhesive Outdoor Jacket: Laminated vapor barrier and waterproofing membrane with perm rating of 0.00 perm, when tested according to ASTM E 96/E 96M, for installation over either fiberglass or foam board insulation located above ground outdoors; consists of a foil polymer laminated film with a coating of rubberized bituminous compound or acrylic adhesive that allows membrane to self-adhere to the substrate.
c. Alumaguard: Composite membrane consisting of a multi-ply embossed UV resistant aluminum foil/polymer laminate to which is applied a layer of rubberized asphalt.

1) Alumaguard Membrane Thickness: 56-mils
2) Alumaguard Cool Wrap Membrane Thickness: 59-mils.

a) Solar Reflectance, CRRC Initial Rating: 0.86.
b) Solar Reflectance, CRRC 3-Year Rating: 0.77.
c) Thermal Emittance, CRRC Initial Rating: 0.82.
d) Thermal Emittance, CRRC 3-Year Rating: 0.86

d. Alumaguard Lite® is a multi-ply aluminum foil/polymer composite film coated with an aggressive, low-temperature acrylic adhesive.

1) Smooth Silver Thickness: 7-mils.

2) Stucco Embossed Silver Thickness: 9-mils
3) White Matte Cool Wrap Finish Thickness: 9-mils

a) Solar Reflectance, CRRC Initial Rating: 0.86.
b) Solar Reflectance, CRRC 3-Year Rating: 0.77.
c) Thermal Emittance, CRRC Initial Rating: 0.82.
d) Thermal Emittance, CRRC 3-Year Rating: 0.86.

4) Alumaguard Lite White Thickness: 9-mils

e. Alumaguard All-Weather: Hybrid product combining the UV-resistant aluminum foil/polymer laminate and rubberized asphalt used in the Alumaguard product, with a metalized film coated with low temperature acrylic adhesive.

1) Alumaguard All-Weather Membrane Thickness: 35-mil
2) Alumaguard All-Weather with Cool Wrap Coating Thickness: 38-mils

a) Solar Reflectance, CRRC Initial Rating: 0.86.
b) Solar Reflectance, CRRC 3-Year Rating: 0.77.
c) Thermal Emittance, CRRC Initial Rating: 0.82.
d) Thermal Emittance, CRRC 3-Year Rating: 0.86

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate with work of other trades.

B. All duct to be installed in strict accordance with manufacturer's installation instructions and/or guide lines.

3.2 INSTALLATION OF DUCT SYSTEMS

A. Supports

1. It shall be the responsibility of the contractor to ensure that the ductwork system is properly and adequately supported. A number of support systems are approved for use by AQC Industries. It shall be the responsibility of the contractor to ensure that the chosen method of support is compatible with ductwork fabricated from the Pal Phenolic Duct System and AQC Industries. Submit all supports for Duct
2. Supports on straight runs of the QDuct ductwork System shall be positioned at center's not exceeding 10 ft for ductwork sections fabricated in 10 ft lengths, and 13 ft for ductwork sections fabricated in 13 ft lengths.
3. Additionally, ductwork shall be supported at changes of direction, at branch duct connections, tee fittings and etc.
4. All ductwork accessories such as dampers shall be independently supported.

B. Hangers and Supports

1. Hanger Materials: SMACNA Approved duct supports shall be utilized in accordance with SMACNA Standards for Phenolic Duct.
2. Penetration into the QDuct system duct is not permitted.

3. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
4. Exterior Duct Supports:

    a. To meet all SMACNA and ASHRA requirements.
    b. Supports to be installed on the outside finished QDuct System
    c. Supports to be manufactured by PHP System/Design, Miro or Approved Equal.

3.3 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Ductwork exposed to occupant view shall be run straight and true, in line with building elements. No sagging or out-of-true straight runs shall be acceptable. Sidewall taps and duct joints shall be clean and free of visual blemishes and all sealant shall be internal to joint and not visible. Ducts shall have no external markings or tags. All duct beads shall be parallel.

C. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

D. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

E. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

F. Repair or replace damaged sections and finished work that does not comply with these requirements.

G. Hanger and Support Installation

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
2. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

    a. Where practical, install concrete inserts before placing concrete.
    b. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
    c. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
    d. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

3. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
4. Hangers Exposed to View: Threaded rod and angle or channel supports.
5. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at maximum intervals of 16 feet.

6. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.4 DUCT PRESSURE TESTING

A. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:

    a. Supply, Return, Exhaust, and Outdoor Air Ducts: Test 100% of installed duct sections.
    b. Field installed plenums. Test 100% of all field installed plenums.

3. Allow 24 hours for sealant to cure after final assembly before testing the duct system. Additional curing time may be required in high ambient conditions
4. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
5. Test for leaks before applying external insulation.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
7. Give seven days' advanced notice for testing.

B. General:

1. Pretesting shall be conducted prior to conducting test in presence of Architect. Once all required ductwork has passed the pretest duct pressure test, the Architect shall be notified to visit the site for witness testing.
2. Use portable high-pressure blower and necessary instruments to indicate amount of leakage.
3. Conduct tests as prescribed in SMACNA HVAC Air Duct Leakage Test Manual and make test before duct sections are concealed.
4. Procedure:

    a. Seal openings in ducts and plenums to be tested.
    b. Connect test apparatus to test section using flexible duct connection or hose.
    c. Close damper on blower suction side, to prevent excessive buildup of pressure.
    d. Start blower and gradually open damper on suction side of blower.
    e. Build up pressure in test section equal to static pressure class.
    f. Noise generated from duct leakage not acceptable. Seal as required.
    g. Determine amount of air leakage by makeup air flow measurements:

        1) Maximum permitted leakage for HVAC ductwork shall be:

$$CFM_{max} = \left(\frac{A}{100}\right) C_L P^{0.65}$$

Where,

CFM_{max} = The maximum permitted leakage, cubic feet per minute (cfm).
A= Surface area of the tested duct sections, square feet.

C_L= Duct leakage class, cfm/100 square feet at 1 inch water column.
= 6 for rectangular sheet metal, rectangular fibrous ducts, and round flexible ducts
= 3 for round/flat oval sheet metal or fibrous glass ducts
P= Test pressure which shall be equal to the design duct pressure class rating, inches water column.

2) Allowable leakage can also be calculated as 1 percent of the design operating air volume for the entire system. If this method is used, the total system leakage must first be determined and then compared with the 1 percent (of system volume flow) allowable leakage. Acceptance is indicated if the actual measured leakage of the entire system is less than the calculated allowable leakage.
3) If leakage exceeds permitted limit, repair leaks and retest duct sections at no additional cost to the Owner until permitted leakage limits are obtained.

5. Visually mark tested sections with certification sticker and initials of field test inspector.

C. Documentation:

1. Submit certification of test results of compliance to Architect.
2. Include certified test results showing compliance per Section 230010 – Mechanical General Provisions.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 SYSTEM LEAK TESTING

A. Scope of Testing:

1. Supply: All supply air duct systems.
2. Return: All return air duct systems.

B. General:

1. Tests shall be done after air balancing; see 230593 – Testing, Adjusting and Balancing.
2. Determine the maximum allowable leakage per system using the methodology in described above. The duct surface area shall be all ductwork downstream of the fan through the air outlets.
3. Or, use the 1 percent allowable leakage as described above.

C. Test Conditions:

1. Fan balance complete and operating at design airflow conditions.
2. For variable volume fans, set all the variable volume boxes to design maximum airflow rates and operate the fan at optimum static pressure setpoint; (see 230593 Testing, Adjusting and Balancing); fan and boxes to remain in a static state during the testing.

D. Leakage Testing:

1. Collect the following information from air balance reports for each tested fan system. (This work is already required in Section 230593 Testing, Adjusting and Balancing, so no new work is required.)

    a. Pitot traverse in the supply (exhaust) duct downstream, positive pressure side (downstream, negative pressure side) of the fan, and
    b. Totaling the readings of individual air outlets or terminals

2. Subtract the readings in Paragraph above. If the difference in the readings, accounting for the accuracy of the test instruments, is greater than the amount allowed in Paragraphs above, repair air leaks as required and retest.

E. Documentation:

1. Submit certification of test results of compliance to Architect.
2. Include certified test results showing compliance per Section 230010 – Mechanical General Provisions.

3.6 PROTECTION

A. Adhere to SMACNA Duct Cleanliness for New Construction Guidelines for Intermediate Level Duct Cleanliness unless more stringent requirements are indicated herein.

B. Storage: Porous materials, such as lined and flexible duct, shall be stored where they will not be exposed to rain or other moisture sources.

C. Temporary closure: Provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris at the following conditions:

1. Exposed ends of unlined installed ducts at the end of each day.
2. Exposed ends of lined ducts or plenums whether in storage or installed.

D. Duct cleaning:

1. Using the connected fan(s) force air at high velocity through duct to remove accumulated dust.
2. Protect equipment and spaces, which may be harmed by excessive dirt with filters, or bypass during cleaning.
3. In areas, which must be kept dust free, seal all outlets duct tight. When closures are removed avoid spilling dust in room.

3.7 INSPECTION

A. Verify that adequate clearance between ducts and adjacent walls or equipment is available to permit proper sealing, maintenance and repairs.

3.8 PRE-OPERATING CHECKS

A. Before operating the duct systems: Set all manual dampers in full open position.

3.9 TESTING AND ADJUSTING

A. After starting the duct systems: Check for noise and leakage. Repair as required at no additional cost to the Owner.

B. See Section 230593 – Testing, Adjusting, and Balancing: Coordination with Balance Agency:

1. Provide services of a sheet metal installer familiar with the system ductwork to provide assistance to the balancing agency during the initial phases of air balancing in locating all sheet metal dampers.
2. Install missing dampers.

END OF SECTION 233115

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Duct Access Doors.
2. Manual, Automatic and Backdraft Dampers.
3. Fire Dampers.
4. Condensate Pumps.
5. Duct Accessory Hardware.

1.3 QUALITY ASSURANCE

A. Fire dampers shall be UL listed and constructed in accordance with UL Standard 555 Fire Dampers and UL Standard 555S.

B. Demonstrate operation of fire dampers to authorities having jurisdiction and Architect as part of life safety testing.

C. Access doors shall be UL labeled.

D. Damper pressure drop and leakage ratings shall be based on tests and procedures performed in accordance with AMCA 500 - Test Methods for Louvers, Dampers and Shutters.

1.4 SUBMITTALS

A. See Section 230010 Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop and coordination drawings according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Access doors	R2			R
Balancing dampers	R2			R
Automatic dampers	R	R		R

Backdraft dampers	R2			R
Fire dampers	R	R		R
Drain pans	R2			R
Condensate pumps	R	R		

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

2.2 DUCT ACCESS DOORS

A. Manufacturers

1. Ventfabrics, Inc.
2. Duo Dyne, Corporation.
3. Ruskin Mfg. Company.
4. PCI Industries – Pottorff.
5. Ductmate.

B. In accordance with SMACNA Duct Construction Manuals, except as indicated in the Drawings.

C. Construction:

1. Galvanized steel.
2. Rating same as duct pressure class.
3. Where duct is insulated:

    a. Fiberglass insulation, thickness to match duct insulation installed R-value, see 230713 – Duct Insulation.
    b. Double wall.

4. Removable type with safety chain linking door permanently to frame.
5. Positive seal polyethylene gasket.
6. Paired progressive cam-locks, quantity as required for tight, low leakage fit.
7. No tools required for opening and closing.

D. Size:

1. 20 inches x 14 inches unless otherwise indicated in the Drawings.
2. Ducts less than 16 inches: one dimension 20 inches; other dimension 2 inch less than duct width.
3. Larger sizes where required for access.

E. Provide in the following locations:

1. Coils in ducts (including at VAV boxes).

a. Entering and leaving side for cooling coils.
b. Entering side for heating coils.

2. Automatic dampers: linkage side.
3. Fire dampers.
4. At the top of each lined duct riser accessible from the fan room floor (for inspection of duct liner).
5. Fan bearings enclosed in ducts.
6. Sprinkler heads in ducts.
7. Motors, actuators or other accessories that require access or service inside ducts.
8. Outdoor air plenums as required to clean plenum from dirt and debris.
9. Where otherwise indicated on the Drawings.

2.3 MANUAL, AUTOMATIC AND BACKDRAFT DAMPERS

A. Manufacturers:

1. Ruskin Manufacturing Company.
2. Greenheck Fan Corp.
3. PCI Industries - Pottorff
4. Johnson Controls

B. Manual Dampers:

1. Conform to requirements of SMACNA HVAC Duct Construction Standards.
2. General:

a. Blades of same material as duct where damper is located.
b. Damper Hardware:

1) Ventlok 400 and 4000 series or equal; for low pressure systems 2 inch SMACNA pressure class and less.
2) Ventlok HiVel hardware or equal; for greater than 2 inch SMACNA pressure class.

c. Actuating quadrants typical for single and multi-blade dampers; provide closed bearing on opposite end from quadrant to prevent air leakage: Ventlok No. 609 or equal.
d. Bearing at one end of damper rod: Ventlok No. 609 or equal.
e. Sealed bushings installed at both ends to avoid duct leakage.
f. Accessible quadrant at other end of damper rod.

1) With lever and lock screw: Ventlok No. 635 or equal.
2) Insulated ducts.

a) Quadrants mounted on collar to clear insulation.
b) Ventlok Nos. 637, 638, or 639 or equal.
c) Selection based on insulation thickness.

g. For dampers above non-removable ceilings and without ceiling access panels provide Ventlok No. 677 or equal concealed damper regulator.

1) With paintable cover plate.
2) Required interconnecting hardware.

3. Round, Inline

    a. Heavy 26-gauge G-90 Galvanized Steel Body (all sizes)
    b. Extra Heavy 24-gauge G-90 Galvanized Steel Blade
    c. 3/8" Square Axle Secured to Blade with U-bolts
    d. Nylon bushings on thru and end (all sizes)
    e. 2" Stool with Locking Quadrant and Handle (all sizes, wing nuts not acceptable)
    f. Sealed on all Seams
    g. BO3 (2") Build-out, 3/8" Square Shaft (solid rod), U-bolt, Locking Quadrant, Handle
    h. Flexmaster Co. Connecting Sleeve (SL-BO3), Crown 175-XS2 or equal.

4. Rectangular

    a. Single blade dampers:

        1) Galvanized steel ductwork: galvanized steel, except as indicated in the Drawings.
        2) Blade: Two gages heavier than duct gage, or 18 gage, whichever is lighter.

    b. Multi-blade dampers.

        1) Low Pressure/Low Velocity Systems (2-inch water column or less static pressure class and 1500 fpm or less face velocity).

            a) Opposed blade damper.
            b) Ruskin Model CD35 or equal.

5. High Pressure/High Velocity Systems (greater than 2-inch water column static pressure class or greater than 1500 fpm face velocity):

        1) Rectangular.

            a) Opposed blade damper.
            b) Ruskin Model CD60 or equal.

        2) Round and Oval.

            a) Oval: Ruskin Model CDR25 and DO25 or equal.
            b) Round: Up to 20-inch diameter: Ruskin Model MDRS25 or equal.
            c) Round: Larger than 20-inch diameter: Ruskin Model CDRS25 or equal.

C. Automatic Dampers:

1. Actuators: See Section 230913 – EMCS Basic Materials and Control System.
2. Construction:

    a. Return air dampers (AHUs):

        1) Class 2 smoke-rated Ruskin Model SD-36 or equal.
        2) End switches: Provide end switch to indicate fully-closed position.

    b. Blade Action:

        1) Throttling duty: opposed.

2) Mixing duty: parallel.
3) Two-position: parallel or opposed.

c. Bearings: Molded synthetic sleeve, turning in extruded hole in frame.
d. Seals:

1) Blade: Inflatable PVC coated fiberglass material or neoprene mechanically attached to blade edge.
2) Jamb: Flexible metal compression type.

e. Linkage: concealed in frame. External linkage and jack-shafts will not be accepted.
f. Axles: Minimum 1/2-inch diameter plated steel, hex-shaped, mechanically attached to blade. Side access for direct-coupled actuator.

3. Finish: Mill galvanized.
4. Damper area: See Drawings for sizes.
5. Low Pressure/Low Velocity Systems (2-inch water column or less static pressure class and 1500 fpm or less face velocity).

a. Integral, heavy-duty factory-installed motorized damper acceptable for exhaust fans unless otherwise scheduled.
b. Ruskin Model CD36 or equal.

6. High Pressure/High Velocity Systems (greater than 2-inch water column static pressure class or greater than 1500 fpm face velocity):

a. Ruskin Model CD60 or equal.

2.4 FIRE DAMPERS

A. Manufacturers:

1. Ruskin Manufacturing Company.
2. Greenheck Fan Corp.
3. Air Balance Inc.
4. PCI Industries – Pottorff.

B. Ratings (test conditions and label) per UL Standard 555.

1. 250 degrees Fahrenheit minimum.
2. 1-1/2 hour fire rating, unless otherwise indicated in the Drawings.
3. Dynamic (closes against air flow).

C. Factory sleeve.

D. Damper.

1. Multi-bladed, equipped with fusible link, spring loaded type.
2. Style:

a. As indicated on the Drawings.
b. Ducted, rectangular duct: Style B (out of airstream).
c. Ducted, round duct: Style A (in airstream) with damper sleeve 2” in each dimension larger than duct; plus, cap and collar.

d. Un-ducted: Style A (in airstream).

E. Fusible Link.

1. UL listed.
2. Fusible links on fire dampers shall be constructed to UL Standard 33 – Fusible Links for Fire Protection Service.
3. Temperature rating: Per code.

F. Type:

1. Rectangular type up to 1000 feet per minute: Ruskin DIBD2 or DIBD10 Style A or equal.
2. Rectangular type 1000 feet per minute and higher: Ruskin DIBD2 or DIBD10 Style B or equal.
3. Circular and oval type: Ruskin DIBD2 Style CR and CO, or DIBD10 Style R and LO or equal.

G. Status end switches:

1. Where indicated on the Drawings.
2. Ruskin SP100 or equal Switch Package.

2.5 CONDENSATE PUMP

A. Manufacturer: Little Giant, Diversitech, or equal.

B. Provide where scheduled.

C. Contractor shall verify pumping head requirements.

D. Features:

1. Discharge check valve.
2. 115-volt with grounded plug connection.
3. High level alarm contact.

2.6 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Compliance with ASHRAE/IESNA 90.1-2010 includes Section 6.4.3.3.3 - "Shutoff Damper Controls," restricts the use of backdraft dampers, and requires control dampers for certain applications. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Volume dampers.

1. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

    a. Volume dampers shall be installed as far away from air outlets as functionally reasonable to avoid noise in the occupied space.
    b. Provide also in wyes and branch take-offs to outlets whether indicated on the Drawings or not, except.

        1) To sidewall outlets in exposed ducts (opposed blade dampers in outlets shall be provided).

2. For ductwork exposed to occupant view, volume damper handles shall be on top of duct or otherwise concealed from occupant view.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Fire dampers.

1. Provide in ducts and openings as indicated in the Drawings.
2. Provide access door in duct adjacent to each in location where damper may be inspected and internal fusible link or fire-stat may be replaced.

H. Control dampers.

1. Field mounted control dampers installed with concealed linkage shaft accessible on side of damper with space for direct-coupled actuator.
2. Actuator installation: See Section 230913 – EMCS Basic Materials and Devices

I. Install belt guards at all exposed belts.

J. Drain pans.

1. See Section 221316 – Sanitary Waste and Vent Piping.
2. Auxiliary drain pans.

    a. See Section 221316 – Sanitary Waste and Vent Piping.
    b. Separate drain from main drain pan.
    c. Discharge where water flow is readily observed but not over any material or equipment that may be damaged by water.

K. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire dampers, to reset or reinstall fusible links. Access doors for access to fire dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-foot spacing.
8. Upstream from turning vanes.
9. Upstream or downstream from duct silencers.
10. Control devices requiring inspection.
11. Elsewhere as indicated.

L. Install access doors with swing against duct static pressure.

M. Label access doors according to Section 230553 Mechanical Identification to indicate the purpose of access door.

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

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

3.3 TESTING AND ADJUSTING

A. After starting duct accessories.

1. Check for noise and leakage; repair as required at no additional cost to the Owner.
2. Operation test: Test each piece of equipment to show that it will operate in accordance with requirements.

B. See Section 230593 – Testing, Adjusting, and Balancing

END OF SECTION 233300

SECTION 233423 - HVAC POWER VENTILATORS

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. Ceiling Exhaust Fans.
2. Centrifugal Square Inline Fans

1.3 REFERENCE STANDARDS

A. ANSI/AFBMA Standard 9 – Load Rating and Fatigue Life for Ball Bearings.

B. AMCA 99 – Standards Handbook.

C. AMCA 211 – Product Rating Manual for Fan Air Performance.

D. AMCA 300 – Reverberant Room Method for Sound Testing of Fans.

E. AMCA 311 – Fan Sound Performance.

F. ANSI/AFBMA 11 – Load Ratings and Fatigue Life for Roller Bearings.

G. UL 705 – Standard Power Ventilators.

1.4 QUALITY ASSURANCE

A. AMCA certified ratings per applicable AMCA standard based on the testing conducted in an independent laboratory.

B. Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal.

C. Sound Ratings: AMCA 301; tested to AMCA 300 and bear the AMCA Certified Sound Rating Seal.

D. Fabrication: Conform to AMCA 99.

E. Conform to AMCA Bulletins regarding construction and testing.

1. Fans shall bear AMCA certified rating seal.

F. Scheduled equipment performance is minimum capacity required.

G. Scheduled electrical capacity shall be considered as maximum available.

1.5 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. "R" means required.
2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Fans	R	R		R
Performance curves	R			
Sound Power ratings	R			
Motor ratings and electrical characteristics	R			
Dampers, housings, linkages, and operators	R			
Fan speed controllers and other accessories	R	R		

C. Include:

1. Complete graph of fan curves, not just curve for design conditions.
2. Sound power levels:

a. Fans 1 horsepower and larger: dB by octave bands.
b. Fans less than 1 horsepower: sones.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

1. Loren Cook.
2. Greenheck.
3. PennBarry.
4. Or equal.

2.2 GENERAL

A. AMCA certification in accordance with ARI Standard 210 and 211, and AMCA Standard 2408 for centrifugal fans.

B. Fans used shall not increase motor size, increase noise level, or increase tip speed by more than 10 percent, or increase inlet air velocity by more than 20 percent, from specified criteria.

C. Performance.

1. See fan schedule on the Drawings.
2. Capacities: minimum as scheduled on the Drawings.
3. Brake horsepower rating: Maximum 10 percent above that scheduled on the Drawings.
4. Fans and drives shall be capable of accommodating static pressure variations of plus or minus 10 percent.
5. Motor horsepower: No larger than that scheduled on the Drawings or compensate Division 26 contractor for any associated cost to increasing motor size.
6. Sized for a critical speed of at least 125% of maximum RPM.

D. Painting.

1. Electrostatically applied, baked polyester powder coating, minimum 2 mil thick.
2. Paint must exceed 1,000 hour salt spray under ASTM B117 test method.

E. Discharge: As indicated on Drawings.

F. Unit shall bear an engraved aluminum nameplate. Nameplate shall indicate design CFM, static pressure, and maximum fan RPM. Unit shall be shipped in ISTA Certified Transit Tested Packaging

2.3 CEILING EXHAUST FANS

A. Description

1. Fan shall be ceiling mounted centrifugal exhaust fan.

B. Housing: Fan housing shall be galvanized steel and acoustically insulated. Galvanized steel shall be minimum as required by manufacturer model number on plans.

C. Fan Wheel: Wheel shall be centrifugal forward curved type

D. Motor (see Construction Drawings for specified type):

1. Motor shall be totally enclosed type with permanently lubricated bearings and built-in thermal overload protection. Motor shall be furnished at the specified voltage and phase.
2. Motor shall be totally enclosed, not ventilated (TENV) electronically commutated (EC) with permanently lubricated bearings, built-in thermal overload protection and disconnect plug. Motor shall have an adjustable speed range from 500 to 1725 rpm. Motor shall be furnished at the specified voltage.

E. Grille: Painted aluminum, louvered grille with flange on intake and thumbscrew attachment to fan housing.

F. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

G. Sound Data: Maximum sound data allowed per schedules.

H. Accessories:

1. Isolation: Rubber-in-shear vibration isolators.
2. Fan Speed Controller: pre-wired.
3. EC Controls:

    a. Internally mounted potentiometer speed controller with leads for connection to 0-10 VDC signal.

4. Motion Sensor: Motion detector with adjustable shutoff timer from 20 seconds to 30 minutes. Wall or ceiling as required by schedule or coordinated with professional.

2.4 CENTRIFUGAL SQUARE INLINE FANS

A. Description

1. Fan shall be duct mounted centrifugal square inline fan.

B. Housing

1. Galvanized steel with integral duct collars.
2. Bolted access doors on three sides, sealed with closed cell neoprene gasketing.
3. Pre-drilled to accommodate universal mounting feet for vertical or horizontal installation.

C. Motor (see Construction Drawings for specified type)

1. Direct-Drive

    a. Motor shall be NEMA design B with a minimum of class B insulation rated for continuous duty and furnished at the specified voltage, phase and enclosure.
    b. Provide with pre-wired fan speed controller.
    c. Motor shall be an electronically commutated motor rated for continuous duty and furnished either with internally mounted potentiometer speed controller or with leads for connection to 0-10 VDC external controller
    d. Two speed motor

D. Fan Wheels: Aluminum, centrifugal backward inclined.

E. Disconnect Switch

1. Provide with prewired, factory mounted disconnect switch
2. NEMA rated as required below:

    a. NEMA 1: Indoor application, no water

3. Positive electrical shut-off
4. Wired from fan motor to junction box installed within motor compartment

F. Accessories:

1. Fan Speed Controller: pre-wired
2. EC Controls:

    a. Internally mounted potentiometer speed controller with leads for connection to 0-10 VDC signal.
    b. Remote Speed Control: 0-10V rotary speed control with stainless steel faceplate mounted on 2x4 electrical junction box. Provided with control transformer.
    c. 1" Pressure Control: Allow modulation of motor RPM via 0-10V signal to maintain a differential pressure across the pressure ports. LCD readout of pressure and setpoint on home screen. NEMA 1 enclosure. Provided with control transformer.

3. Backdraft Dampers: gravity.
4. Vibration Isolators: Rubber in Shear.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate with work of other trades.

B. Install fans in accordance with manufacturer's written installation instructions.

C. See Section 233113 – Metal Ducts for duct connections.

D. See Section 230900 – Energy Management & Control System.

E. Flexible duct connection at inlet and outlet: See Section 233113 – Metal Ducts.

F. Backdraft Dampers.

1. Comply with ASHRAE 90.1 and IMC.
2. Provide backdraft or shutoff dampers for suction or discharge of every exhaust fan as scheduled on the Drawings.
3. See schedules on the Drawings and Section 233300 – Air Duct Accessories for where fan manufacturer may provide dampers and when specialty damper manufacturer must provide them.

3.2 MOUNTING AND ALIGNMENT

A. Mount and align fans and motors per manufacturer's written instructions.

3.3 INSPECTION

A. Verify that adequate clearance between fans and adjacent walls or equipment is available to permit maintenance and repairs.

3.4 PRE-OPERATING CHECKS

A. Do not operate fans for any purpose, temporary or permanent, until:

1. Ductwork is clean.
2. Filters in place.
3. Bearings lubricated.

3.5 TESTING AND ADJUSTING

A. Before starting fans install belts and motor guards.

B. Start and test fans in accordance with manufacturers written installation instructions.

C. Start up and adjust fans to insure proper operation.

D. The submitted sound power level shall be verified through actual measurements and calculations in accordance with AMCA standards 300 and 301.

E. After starting fans: Check for objectionable noise or vibration. Correct as needed at no additional cost to the Owner.

F. Balancing: See Section 230593 – Testing, Adjusting and Balancing.

3.6 TRAINING

A. See Section 230010 – Mechanical General Provisions.

END OF SECTION 233423

SECTION 233600 - AIR TERMINAL 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:

1. Shutoff, single-duct air terminal units.

1.3 QUALITY ASSURANCE

A. Terminal units rated and certified in accordance with ARI Standard 880-98 Certification Program.

B. Heating coils rated in accordance with ARI Standard 410.

C. All electrical components shall be UL listed and installed in accordance with the UL Standard 1995.

1.4 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
VAV boxes	R	R		R
Hot water coils	R			R
Air terminal unit accessories	R	R		

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. VAV Boxes.

1. Titus.
2. Price.
3. Trane.
4. Or equal.

2.2 VAV BOXES

A. General.

1. Ship as a complete assembly requiring no field assembly (including accessories).
2. Casings:

a. Minimum 22-gage, galvanized steel outer wall.
b. Leakage rating: 7 cubic feet per minute maximum leakage at 1 inch water column.
c. Acoustic lining.

1) Material: Fiberglass with high density facing.
2) Minimum thickness:

a) Terminals located in conditioned space or return air plenum: 1/2 inch.
b) Terminals located in unconditioned spaces: 1 inch.

3) Minimum 1.5 pound per cubic foot density.
4) Maximum thermal conductivity: 0.28 Btu-in per hour per foot squared per degree Fahrenheit (BTU-inch/h·ft^{2}·°F) measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 75 degrees Fahrenheit.
5) Meet erosion test method described in UL publication No. 181.
6) Meet smoke developed and flame spread rating requirements of NFPA-90A.
7) Meet ASTM C1136 and ASTM C665 for biological growth in insulation.

d. Gasketed access door.

1) For actuators inspection, repair and replacement if mounted internally.
2) Upstream of reheat coil for inspection and cleaning.
3) Door to be in bottom of VAV box.

e. Discharge duct connection.

3. Controls unit mounted by manufacturer.

a. Multi-point, cross-flow or flow-ring, center averaging sensor.

1) The average amplification factor for sizes 6 to 16 inch shall be greater than 2.0 and minimum amplification factor shall be 1.8. Provide documentation with submittal that substantiates this requirement.
2) Be rated for inlet or discharge duty, as indicated on the Drawings.
3) Provide accurate flow sensing regardless of inlet duct configuration.
4) Brass balancing taps and unit mounted airflow versus flow sensor pressure signal charts for field airflow measurements.

b. Control panel.

1) Control panel with cover to fully enclose VAV box controller.

c. For Direct Digital Controls, see Section 230900 – Energy Management & Control Systems

4. Radiated and discharge sound power.

a. Equal or less in each octave band than terminal selections scheduled on the Drawings at noted capacities assuming 1.0 inch inlet static pressure, with a tolerance of + 2 dB in any band.
b. Minimum performance sound power less than 68 dB in the 125 Hz octave band.
c. Due to added space and pressure drop, providing additional plenums or attenuators to meet sound power ratings is not acceptable.

5. Total pressure drop.

a. Equal or less than terminal selections scheduled on the Drawings at noted capacities, with a tolerance of 0.02 inches of water.
b. This limitation is in total, not static, pressure. Where total pressure is not listed on certified performance documents, provide a table of manual adjustments of static pressure with velocity pressure calculated from inlet and outlet velocities.

6. Dampers.

a. Heavy gage steel.
b. Single blade damper; opposed blade dampers are not acceptable.
c. Shaft rotating in self-lubricating Delrin or equal bearings; nylon bearings are not acceptable. Shaft shall be clearly marked on the end to indicate damper position.
d. Damper shall have durable synthetic seal. Foam seals are not acceptable.
e. Close-off leakage rating: 5 cubic feet per minute maximum leakage at 1.50 inches water column.

7. Hot water heating coils.

a. Removable type.
b. Tubes.

1) 2-row, unless otherwise scheduled on the Drawings.
2) Copper, 0.015 inches minimum tube wall thickness.
3) Connections: external, same end, solder type connection, minimum 1/2 inch outside diameter.

c. Fins.

1) Aluminum, with full fin collars.

2) As scheduled on the Drawings or as required to provide heating capacity listed.
3) Maximum: 12 fins per inch.

d. Factory leak-tested at 300 pounds per square inch.
e. Access or removable panel for coil inspection and cleaning. Access door to be in bottom of VAV Box.

B. Variable Air Volume Terminal Units.

1. Single duct: Equal to Trane VCWF.
2. Options and features: As scheduled on the drawings.
3. Electrical Services (factory mounted).

a. One-point wiring connection for all electrical devices.
b. Control panel.
c. Controls transformer.
d. Components mounted in sheet metal control enclosure.
e. ETL or UL listed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate with work of other trades.

B. Install terminal units in accordance with manufacturer's written installation instructions.

C. Duct connections: See Section 233113 – Metal Ducts.

1. Provide sheet metal duct connections at inlet; flexible not acceptable.
2. No flexible connection required on duct outlet.

D. Sound attenuation discharge duct.

1. Downstream of units where indicated on the Drawings.
2. Sound linings: Type AL. See Section 230713 – Duct Insulation.
3. Minimum lining 5 feet of duct downstream of box.
4. Provide a minimum of 3 feet of ductwork prior to first fitting or outlet branch duct takeoff.

E. Piping connections: See Section 232112 – Hydronic Piping.

F. Coordinate access with respective trades.

G. See Section 230900 – Energy Management & Control Systems.

3.2 MOUNTING AND ALIGNMENT

A. Support VAV boxes at four corners with minimum, 1" x 18 gage sheet metal straps or 3/8 inch all-thread rod. Secure lower end of strap to the side of unit casing with minimum two #10 sheet metal screws, or bolt through casing with washers to prevent leakage. Bend end of strap and secure to bottom of casing with one #10 sheet metal screw.

B. See Section 230548 – Mechanical Sound and Vibration Control.

3.3 INSPECTION

A. Verify that adequate clearance between air terminal units and adjacent walls or equipment is available to permit maintenance and repairs.

3.4 TESTING AND ADJUSTING

A. Before operating air terminal units.

1. Complete the provided Pre-Functional Test Data Sheet for each air terminal unit.

B. After starting air terminal units: Check for objectionable noise or vibration. Correct as needed at no additional cost to the Owner.

C. See Section 230593 – Testing, Adjusting, and Balancing.

3.5 TRAINING

A. See Section 230010 – Mechanical General Provisions.

END OF SECTION 233600

SECTION 233700 - AIR OUTLETS AND INLETS

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. Work included in this section: materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following: All air outlets, inlets, grilles, registers and diffusers except where integral with manufactured piece of equipment

1.3 REFERENCE STANDARDS

A. ARI Standard 650 – Air Outlets and Inlets.

B. ASHRAE Standard 70 – Methods of Testing for Rating the Airflow Performance of Outlets and Inlets.

C. AMCA Standard 500 – Laboratory Methods of Testing dampers for Rating.

D. NFPA Standard 90A – Installation of Air Conditioning and Ventilating Systems.

E. NFPA 90B – Standard for the Installation of Warm Air Heating and Air Conditioning Systems.

1.4 QUALITY ASSURANCE

A. Comply with ARI Standard 650, ASHRAE Standard 70, AMCA Standard 500, NFPA Standard 90A, and NFPA Standard 90B.

B. Provide outlets and inlets that have, as minimum, throw and noise criteria ratings for each size device as listed in manufacturer's current data, rated as required by the above standards.

1.5 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Grilles, registers, and diffusers	R			R
Accessories	R			

PART 2 - PRODUCTS

2.1 MANUFACTUERERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

1. Titus.
2. Price.
3. Metal Aire.
4. Nailor.
5. Or equal.

2.2 AIR DISTRIBUTION DEVICES

A. Manufacturer shall examine and approve of application of each outlet.

B. Noise level at design capacities: no larger than diffuser selection indicated on the drawings.

C. Material:

1. All grilles are to be of steel construction unless otherwise indicated on schedules.

D. Volume dampers:

1. Do not provide dampers built into grille or directly attached to the grille unless specifically called out on drawings.
2. Opposed blade volume damper key-operated adjustable from face of diffuser on register except as noted.

E. Diffuser frame:

1. Frame type shall be coordinated with ceiling type. Refer to architectural reflected ceiling drawings.

a. At plaster or drywall ceilings:

1) Lay-in diffuser with drywall frame (Titus TRM to match diffuser material). Drywall frame to match diffuser color.

2. No visible screw allowed on diffusers or frames, unless otherwise indicated on the Drawings.
3. Linear and bar diffusers shown as one collinear piece on plans shall be constructed as one piece within manufacturing limitations and to appear as one section if manufacturing

limitations require multiple pieces. Provide with Border Type shown on plans. Coordinate exact border type with design professional before ordering.

F. Color:

1. Face and frame: Factory-baked #26 white enamel unless otherwise indicated on the Drawings.
2. Internal parts of grille visible from occupied space, including all parts behind perforated face diffusers and visible parts of plenums: flat black.

G. Provide square to round adapters where required.

H. Provide one-, two-, three- or four-way discharge patterns as indicated on plans.

I. See mechanical schedules for type and sizes.

2.3 SCREENED OPENINGS

A. Mesh:

1. 3/4 in. square pattern.
2. No. 16 galvanized wire.
3. Interwoven.
4. Welded or secured to frame.

B. Frames:

1. 1 inch by 1 inch by 1/8 inch galvanized steel angles.
2. Continuous around perimeter of screen (welded at corners).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate with work of other trades.

B. Install air outlets and inlets in accordance with manufacturer's written installation instructions and Section 233113 – Metal Ducts.

C. Return and exhaust registers: Install with blades oriented to prevent sight through outlets.

D. Grille backs or plenums visible through grilles painted flat black.

E. Transfer grilles.

1. See indications on the Drawings.
2. Wall installations, unless otherwise indicated, provide two grilles.

a. One on each side of wall, except where open to return air plenum.
b. Connecting sheet metal collar with 18 inch elevation offset for sound and light attenuation.

F. Provide duct screens at termination ducts as indicated on the Drawings.

3.2 MOUNTING AND ALIGNMENT

A. All air outlets and inlets shall be secured to building.

1. Ceiling grilles shall be secured to prevent falling from ceiling during construction or service with minimum of two 16-gauge ceiling wires, two 22-gauge by 1 inch galvanized sheet metal strap or two #10 sheet metal screws.
2. Comply with IBC.

B. Mount directional grilles as indicated on the Drawings.

C. Adjust grille throw patterns.

1. As indicated on the Drawings.
2. For double-deflection grilles, adjust rear blades horizontal and front blades in 45 degree pattern at each end gradually rotating to be almost straight at blades in center of grille.
3. Adjust grille throw patterns prior to test and balance. See Section 230593 – Testing, Adjusting, and Balancing.

3.3 INSPECTION

A. Verify mounting, direction and adjustments are installed as indicated on the Drawings.

3.4 TESTING AND ADJUSTING

A. See Section 230593 – Testing, Adjusting, and Balancing.

END OF SECTION 233700

SECTION 234000 - AIR CLEANING DEVICES

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. Work included in this section: materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following:

1. Filter media.

1.3 REFERENCE STANDARDS

A. ASHRAE Standard 52.2-1999 – Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.

B. ANSI/UL 900 – Test Performance of Air Filter Units.

1.4 QUALITY ASSURANCE

A. Filters shall have MERV ratings in accordance with ASHRAE Standard 52.2 with preconditioning as specified in Appendix J of that Standard.

1.5 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Filters	R			

PART 2 - PRODUCTS

2.1 MANUFACTUERERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

B. Filter Media:

1. Camfil/Farr Filtration Group.
2. Flanders/Precisionaire.
3. American Air Filter.
4. Or equal.

2.2 FILTERS

A. General.

1. UL 900 listed.
2. Disposable type.
3. Each filter shall consist of media, media support grid, and enclosing frame.
4. Each filter shall have flow direction and MERV rating permanently affixed to frame.

B. Type 1: Pleated Filter:

1. 2 inch or 4 inch pleated.
2. Media: Cotton & synthetic media (no polyester).
3. Minimum performance:

    a. MERV 13 for use after construction period.
    b. MERV 11 for use at startup and during construction period.

4. Maximum initial pressure drop at 500 feet per minute face velocity shall not to exceed 0.3 inches water column. Final pressure drop shall be no less than 1.0 inch water column.
5. Camfil/Farr 30/30 or equal.

C. Type 2: Bulk Media:

1. 1 inch fiberglass.
2. Filter media shall consist of a continuous filament fiberglass of graduated density. Media shall include a skin on the leaving air side. Furthermore, the media shall be treated with a non-toxic, non-flammable, odor free adhesive.
3. UL listed, Class 2.

2.3 FRAMES

A. For air handlers and fan-coils, see individual specifications Sections.

PART 3 - EXECUTION

3.1 FILTER MEDIA

A. Media as selected in equipment schedules on the Drawings.

B. Construction filters:

1. Type 1 for all equipment: roll media not acceptable.
2. Type 2 filter media is intended to be utilized over return/exhaust air grilles, registers and/or open ductwork during the construction period when the systems are being operated. This filter media is not to be utilized inside the housing of any HVAC systems.

C. Spare Filters:

1. Provide three (3) sets of spare filters for each piece of HVAC equipment and filter grille except the following (provide only one (1) spare set):

a. VRF system (indoor units).

3.2 INSTALLATION

A. Factory installed in air handling equipment.

B. Coordinate with work of other trades.

C. Install Air Cleaning Devices in accordance with manufacturer's written installation instructions.

D. See Section 230593 – Testing, Adjusting, and Balancing.

3.3 START-UP PROCEDURES

A. Do not operate air handling unit fan systems for any reason until spaces served have been cleaned of dust and debris, to avoid contamination of supply air or return air paths and equipment.

B. Supply fans shall not be operated unless filters are installed, including temporary filters for use during test and balance.

C. If the final pressure drop of the temporary filters is reached during test and balance, replace them with a spare set.

D. Before turning system over to the Owner, remove temporary construction filters and install clean final filters:

1. Remove prefilters in front of cartridge, bag, and HEPA filters after construction and do not replace. Prefilters shall not be used during normal operation.
2. See also Section 230593 – Testing, Adjusting, and Balancing, Section 230010 – Mechanical General Provisions and Section 230500 – Basic Materials and Methods for media installation during temporary equipment operation and test and balance periods.

3.4 INSPECTION

A. Verify that adequate clearance between Air Cleaning Devices and adjacent walls or equipment is available to permit maintenance and replacement of filters.

B. Verify that filters are firmly seated in frame to minimize bypass.

3.5 TRAINING

A. See Section 230010 – Mechanical General Provisions.

END OF SECTION 234000

SECTION 237313 - MODULAR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Work included in this section: materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following:

1. Air handling units.
2. Field installed coils.

1.3 REFERENCE STANDARDS

A. AMCA 99 – Standards Handbook.

B. AMCA Standard 203.

C. ANSI/AMCA 210 – Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.

D. ANSI/AMCA 230 – Laboratory Methods of Testing Air Circulator Fans for Rating.

E. AMCA 300 – Reverberant Room Method of Sound Testing of Fans.

F. AMCA Standard 301 – Method for Calculating Fan Sound Ratings from Laboratory Test Data.

G. AMCA Standard 500-D – Laboratory Methods of Testing Dampers for Rating.

H. AMCA 500-L – Laboratory Methods of Testing Louvers for Rating.

I. ARI 410 – Standard for Forced – Circulation Air-Cooling and Air Heating Coils.

J. ARI 430 – Central Station Air-Handling Units.

K. ANSI/AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings.

L. ANSI/AFBMA 11 – Load Ratings and Fatigue Life for Roller Bearings.

M. ASHRAE/ANSI Standard 111.

N. ASHRAE Standard 52.

O. ASHRAE 90.1.

P. ASTM A525 – Specification for General Requirements for Steel Sheet, Zinc Coated (Galvanized) by the Hot-Dip Process.

Q. NFPA 90A – Installation of Air Conditioning and Ventilation Systems.

R. SMACNA – Low Pressure Duct Construction Standards.

S. UL Standard 1995.

1.4 QUALITY ASSURANCE

A. AMCA certified ratings per applicable AMCA standard based on the testing conducted in an independent laboratory.

B. Conform to AMCA Bulletins regarding construction and testing. Fans shall bear AMCA certified rating seal for both sound and performance.

C. Units shall be designed and manufactured in strict accordance with UL 1995, Standard for Heating and Cooling Equipment. Air handler shall be ETL or UL listed in accordance with UL 1995, or the current equivalent by UL, and shall carry the ETL or UL label. If manufacturer cannot provide ETL/UL sticker on air handler, it will be the sole responsibility of the contractor to arrange for local, on-site, ETL or UL approval and labeling at no additional cost to the Owner.

D. Schedule equipment performance is minimum capacity required.

E. The Contract Documents are based on the equipment scheduled. Contractor is advised that the use of equipment other than that scheduled may directly affect and require coordination with (but not limited to) the following items:

1. Mechanical room sizes and building structural conditions, with required clearances.
2. Variable frequency drive/electrical starter/disconnect switch, wire and conduit sizes; electrical clearances as per NEC.
3. Ductwork and piping layouts and return air opening sizes and locations.
4. Plumbing floor drain location.

F. Units shall fit into the space available with adequate clearances meeting manufacturer's requirements for service and as determined by the Architect. Submitted units, which do not meet these criteria, shall be rejected. The Contractor shall not assume that all of the manufacturers listed as acceptable manufacturers will provide a unit that will fit in the space allocated for the unit(s).

1.5 SUBMITTALS

A. See Section 230010 Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop and coordination drawings (where shop and coordination drawings are required) according to the following table.

1. "R" means required.
2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Air handling units	R	R		R
Coils, performance data	R	R		R
Fans, performance data	R			
Acoustical performance data	R			
Motors	R	R		
Variable frequency drives	R	R		R
Dampers and actuators	R	R		
Filters	R			
Factory installed controls	R	R		R
Accessories	R	R		R
Coordination drawings				R

C. Additional submittal requirements.

1. List of exceptions to the specifications including section number and a detailed description of alternative materials and methods. If there are no exceptions, so state in precise language.
2. List of proposed manufacturers for fans, filters, coils, motors, drives, dampers and other components.
3. Complete graph of fan curves (not just curve for design conditions) indicating efficiency, BHP, and RPM.
4. Sound power levels per ARI 260 by octave bands; radiated and at inlet and discharge.
5. Coil performance and flow rates.
6. Filter and filter frame product data.
7. Wiring diagram.
8. Control panel location, including elevation indicating height above the ground.
9. Internal static pressure drop with filters clean and dirty.
10. Casing materials of construction and methods of assembly.
11. Construction details including panel sealing, thermal break, door seal and hardware, shipping split and field treatment of panel penetration (sleeve) details.
12. The number of shipping sections requiring field reassembly.
13. Complete dimensional data including exterior dimensions and dimensions of internal components.
14. Coordination Drawings: Submit with Shop Drawings. Show mechanical-room layout and relationships between components and adjacent structural and mechanical elements. Show service clearance requirements, and support locations, type of support, and weight on each support. Indicate and certify field measurements.

1.6 DELIVERY, STORAGE AND HANDLING

A. Accept products on Site in factory-fabricated protective containers or covered to protect from weather and construction debris, with factory-installed shipping skids and lifting lugs. Inspect for damage and make any necessary repairs at no expense to the Owner.

B. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish. Replace damaged equipment.

C. Protect openings in casing and seal them with plastic wrap to keep out dirt and debris. Protect coils from entry of dirt and debris with pipe caps or plugs.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models are acceptable.

1. Daikin Vision.
2. Trane CSAA.
3. York/Johnson Controls Solution.
4. Or equal.

2.2 GENERAL

A. Types and performance as scheduled on Drawings.

B. Performance certified under ARI Standard 430.

C. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

D. All internal components specified shall be factory furnished and installed. Units shall be post and panel bolted modular and sectionalized construction for ease of disassembly and reassembly for maintenance, cleaning, and inspection in accordance with the most recent edition of ASHRAE Standard 62.1. At a minimum, sectionalized modules shall consist of fan, coils, access and filter sections. All internal components specified shall be factory furnished and installed as applicable.

E. Provide all necessary and required tags and decals to aid in the service or indicate caution areas.

F. Ship unit in one piece whenever possible. If shipping splits are required for installation, the unit must be assembled, with all required gasketing. If assembled on-site, unit shall comply with casing leakage requirements herein.

G. Provide complete unit with segments as indicated on Drawings and in this Specification or as required for unit operation in accordance with performance requirements specified herein. Refer to filter Specification Section for filter requirements.

H. All outdoor openings shall have a 1/2 inch mesh bird-screen provided on louvers.

2.3 FANS, MOTORS, AND DRIVES

A. Comply with Section 233400 – HVAC Power Ventilators and Section 230513 – Motors and Controllers.

B. Mounted on common shaft.

C. Type.

1. Provide fan sections with single-width single-inlet (SWSI) plenum (PF) fans, minimum class II, as scheduled on Construction Drawings, or:

D. Fan and unit performance shall be rated and certified in accordance with AHRI 430, AMCA300 and AHRI 260 as specified elsewhere herein.

E. Fan wheels shall be constructed aluminum or steel, keyed to the fan shaft, and shall be statically and dynamically balanced at the factory as a complete fan assembly regardless of duty. Dynamic fan balancing shall be conducted from 16Hz to 105Hz to identify and eliminate critical speeds to ensure stable operation through the entire operating range of the fan and drive assembly.

F. Forward factory balancing test report upon request of Architect.

G. Mount motor drive and fan on integral framework, internally isolated from the casing with factory installed 1-inch deflection spring vibration isolators on units with 8 square feet of coil area or less, and 2-inch deflection on units with coils greater than 8 square feet in area. The fan, and base assembly shall be factory point load tested and balanced on corner isolators selected accordingly for increased stability and to minimize fan assembly noise and vibration.

H. Provide internal flexible connection on the fan inlet cone to isolate the fan vibration from casing. Additionally, provide spring loaded fan-shroud-to-casing thrust restraints for plug fans, and on all units with coil face areas greater than 30 square feet.

I. Each plenum fan shall be provided with a backdraft damper to isolate the inlet side of the fan/motor that has failed, on standby, or is being removed from the fan array. The function shall prevent air bypass through a fan cube when not in operation. The backdraft damper shall be constructed of extruded aluminum frame and blades with low friction bearings for long life, continuous operation.

J. Discharge arrangement: As indicated on the Drawings.

K. Motors and Drives.

1. Fan motor shall be premium efficiency and compatible for inverter duty and meet the endurance and bearing performance requirements for the standard nominal horsepower rating per Section 230513 – Motors and Controllers.
2. Fan motors shall have permanently sealed non-greasable bearings.
3. Units with scheduled plenum fans and variable frequency drives shall be direct drive.
4. Variable Frequency Drives (VFD).

    a. Refer to Section 230513 – Motors and Controllers.
    b. Where indicated on the Construction Drawings, furnish as a part of the unit assembly by the AHU manufacturer, with drive matched to motor without noise or vibration over the entire operating range.

2.4 UNIT CONSTRUCTION

A. Base Rail.

1. Minimum 6-inch height.
2. Minimum 12 gauge, continuous full-length galvanized structural steel unit perimeter base frame rail to form a unitized assembly.
3. Base rail height shall be sufficient to allow proper condensate trapping. Lowest coil condensate drain connection shall not be less than a minimum of 6 inches from the bottom of the rail.

B. Double wall, 2-inch thick with solid galvanized steel exterior and interior panels.

1. The construction of the air handling unit shall consist of a complete structural frame with removable panels. Casing shall be supported in such a manner so that maximum allowable air leakage shall not exceed 1% and panel deflection shall not exceed a L/240 ratio when subjected to ±8-in. w.g. static pressure. This maximum leakage shall include the access doors. All panels shall be completely gasketed prior to shipment and shall be completely removable for unit access and removal of components. Removal of any or all panels shall not affect the structural integrity of the unit.
2. Outer liner: Minimum 22-gauge galvanized sheet metal.
3. Inner liner shall be 22-gauge solid galvanized steel except as follows:

    a. Provide solid 304 stainless steel liner at humidifier, 1 foot upstream, 3 feet downstream.
    b. Provide 22 gauge perforated steel liner in any section of the unit (except at cooling coil) where required to meet acoustical criteria, and at a minimum in all sections exposed to the fan.

4. Floor panels: Double wall construction, designed to provide at most L/240 deflection based on 300 lb. concentrated load at mid-span. The interior liner of the floor panels shall be a solid lining of minimum 22-gauge galvanized steel.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Insulation.

1. Minimum 2-inches thick. R-13 minimum
2. Minimum 1.5 pound density.
3. Casing panels (roof, walls, floor) and external structural frame members shall be completely insulated filling the entire panel cavity in all directions so that no voids exist. Panel insulation shall comply with NFPA 90A.

E. Provide coil removal panel on access side of AHU to facilitate ease of coil removal

F. Standard factory finish.

1. Indoor units galvanized.

2.5 ACCCESS DOORS

A. Hinged access doors with quick opening handles.

B. Gasketed air tight when closed.

C. Provide minimum 18 inch access doors on fan, access and filter sections of the unit and additional locations where specified on the Drawings. Comply with door sizes shown on AHU detail. If size is not shown on detail, size is to be confirmed with the Professional during submittal process. Maximum door size to be provided.

D. Sections with dual thermal pane windows, minimum window dimensions 8 inches by 8 inches. Provide with LED lights in each section with a window.

1. Economizer section (when return/relief fan is present)
2. Fan sections.
3. All access sections.

E. Sections without window.

1. Both upstream and downstream of cooling coils.
2. Upstream of filter section.

F. All doors shall be a 60-inch high when sufficient unit height is available, or the maximum height allowed by the unit height.

G. Multiple door handles shall be provided for each latching point of the door necessary to maintain the specified air leakage integrity of the unit.

H. All access doors shall open against air pressure, unless approved by the Architect in writing.

I. Provide factory re-sealable test ports in each access door.

2.6 DRAIN PANS

A. Provide drain pans extending under complete cooling coil section and extending 24 inches minimum downstream of cooling coil. Provide intermediate drain pans that extend minimum of 6 inches from the coil face with downspouts to bottom drain pan for cooling coil banks more than one coil high. Intermediate drain pans shall be stainless steel to match the main drain pan.

B. 304 Stainless steel: minimum 16-gauge; in accordance with ASHRAE 62.1.

C. Corners soldered, welded or brazed.

D. Pitched to drain flange to fully drain; double broken, double sloped to ensure no standing water.

E. Drain flange.

1. Minimum per code.
2. Stainless steel or brass.
3. Welded or soldered into bottom of pan.

F. Accessible for cleaning.

G. Insulation: The drain pan insulation shall be closed cell foam injected water impervious rigid type, minimum R-value of 14, and shall occupy all voids and areas between the drain pan and outer wall to prevent the occurrence of trapped water, condensation, and microbial growth. Fiberglass drain pan insulation is not acceptable. Intermediate drain pans need not be insulated.

H. Separate field constructed drip pan shall be installed under the entire equipment base.

2.7 FILTER SECTION

A. Holding Frames: Holding frames shall be factory fabricated of 16-gauge galvanized steel and shall be equipped with gaskets and 2 heavy duty positive sealing fasteners. Each fastener shall be capable of withstanding 25 pounds pressure without deflection and be attached or removed without the use of tools.

B. Filter type, MERV rating, and arrangement shall be provided as defined in Section 234000 – Air Cleaning Devices.

C. Filters shall be lifted out where access is available upstream of the filter, or side slide out when front access is not available.

D. Filter gauges: See Section 234000 – Air Cleaning Devices. Magnahelic differential pressure gauges shall be installed and mounted on drive side of unit to measure the pressure drop across the filter sections as indicated on the Construction Drawings.

E. Performance: Select fan for mean pressure drop (midway from clean to maximum).

F. Manufacturer shall provide one set of startup filters. Spare filters provided by Contractor

2.8 ECONOMIZER (OR MIXING BOX)

A. Low leakage parallel blade dampers, Ruskin CD-60 or equal. Damper leakage rate shall meet ASHARE 90.1 (latest edition).

B. Blades shall have vinyl or rubber blade edge seals and compressible jamb seals. Blades shall rotate on stainless steel sleeve bearings.

C. Outdoor air and return airflow directed into each other.

D. Actuators: See Section 230913 – EMCS Basic Materials and Devices.

E. Dampers designed to operate with direct-coupled electric actuators with linkage concealed in frame (exposed linkage and jackshafts not acceptable), independent actuator for each damper section.

F. Do not link outdoor air and return air dampers. Each shall operate independently.

2.9 VIBRATION ISOLATION

A. Internally isolated.

B. Spring, 2 inch static deflection.

C. Comply with Section 230548 – Mechanical Sound and Vibration Control.

2.10 REFRIGERANT COILS

A. Extended surface type coils.

1. Copper tubes.

a. Brazed or welded joints.
b. Minimum thickness: 0.025 inches.
c. Outside diameter: 1/2 inch.

2. Plate fins of aluminum, unless otherwise indicated on Drawings.

a. Minimum thickness: 0.0075 inches.

B. Rows and fin spacing.

1. To meet performance scheduled at similar pressure drop.
2. Maximum fins: 10 per inch.
3. Select to avoid moisture carryover.

C. Circuiting: full row, intertwined.

D. Headers: Copper tubing.

E. Certified by ARI per current Standard 410.

F. For field installed coils, coil frame designed for bolting to other sections or ductwork.

G. Coil Casing.

1. Minimum 16-gauge.
2. 304 stainless steel casing and tube sheet.
3. Intermediate supports of same materials as casing.

H. Design for 200 pounds per square inch, 250 degrees Fahrenheit unless otherwise indicated on Drawings.

I. Factory tested to.

1. 450 psi for refrigerant evaporator coils.

J. Factory cleaned, degreased and flushed. Piping connections shall be capped with removable caps.

2.11 TESTING AND BALANCING PORTS

A. Provide a permanent factory-installed sealable port on each section of unit to allow for testing and balancing of system, except where port would be blocked by filters or coils.

2.12 AUXILIARY CONTAINMENT PAN (UNDERNEATH AHU)

A. Provide fully welded galvanized leak containment pan underneath AHU. Containment pan shall be sized to such that it extends 6 inches beyond the AHU on all sides with 6 inch high sides (completely around perimeter). Containment pan shall be sealed with waterproof protective coating.

2.13 ELECTRICAL PROVISIONS

A. Each motor shall be wired to a factory installed external junction box for electrical service connection.

B. Provide water-proof, LED light fixtures in each section of the air handling unit. Each light fixture shall output a minimum of 3,000 lumens at a 4,000 K color temperature. Light fixtures in each air handling unit section shall be switched. Wire lights to external 120V, 20A power connections (one for each service) for connection by Division 26.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate with work of other trades.

B. Units shall ship with all openings securely covered and watertight. Protection shall be retained until completion of construction or until opening is field connected to ductwork.

C. Verify that adequate clearance between air handling units and adjacent walls or equipment is available to permit maintenance and repairs.

D. Provide auxiliary drain pans where required, see Section 233300 – “Air Duct Accessories.”

E. Provide accurate alignment between unit and connected ducts.

F. Install air handling units in accordance with manufacturer’s written installation instructions.

G. Outdoor units shall be fully waterproof.

H. Mount units sufficiently high to allow for proper condensate trapping and drainage.

I. Piping.

1. See Section 232300 – “Refrigerant Piping.”
2. See piping diagrams.
3. Do not block access doors with piping. Access doors shall be capable of opening 90 degrees.
4. Pipe condensate to nearest appropriate drain.

J. See Section 230900 – “Energy Management and Control System.”

K. The Contractor shall be responsible to coordinate all installation requirements with other trades to ensure that a complete installation for each unit is being provided. Coordination efforts shall include such items as unloading and hoisting requirements, field wiring requirements, field piping requirements, field ductwork requirements, requirements for assembly of field-bolted or welded joints, and all other installation and assembly requirements.

L. The AHU manufacturer shall provide all screws and gaskets for joining of sections in the field.

M. The Contractor shall verify that the following items have been completed prior to scheduling the AHU manufacturer's final inspection and start up:

1. All spring-isolated components have had their shipping restraints removed and the components have been leveled.
2. On all field-joined units, that all interconnections have been completed, i.e., electrical and control wiring, piping, casing joints, bolting, welding, etc.
3. All water piping connections have been completed and hydrostatically tested and all water flow rates have been set in accordance with the capacities scheduled on the Drawings.
4. All ductwork connections have been completed and all ductwork has been pressure tested for its intended service.
5. All power wiring, including motor starters and disconnects, serving the unit has been completed.
6. All automatic temperature and safety controls have been completed.

7. All dampers are fully operational.
8. All shipping materials have been removed.
9. All (clean) filter media has been installed in the units.

3.2 INSPECTION

A. Verify that adequate clearance between air handling units and adjacent walls or equipment is available to permit maintenance and repairs.

3.3 PRE-OPERATING CHECKS

A. Before operating air handling units:

1. Complete provided Pre-Functional Test Data Sheet for each unit.

3.4 CLEANING

A. Clean modular air-handling units externally and internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.

B. After completing system installation and testing, adjusting, and balancing modular air-handling and air-distribution systems, clean filter housings and install new filters.

3.5 TESTING AND ADJUSTING

A. Do not operate fans for any purpose, temporary or permanent until:

1. See Section 230500 – Basic Mechanical Materials and Methods.
2. Ductwork is clean.
3. Filters are in place.
4. Bearings are in place.
5. Bearings are lubricated.
6. Fan(s) has been run under observation.

B. Start and test fans in accordance with manufacturer's written installation instructions.

C. Test cooling coil drain pans. See Section 233300 – Duct Accessories.

D. Start-up and adjust completed air handling units to insure proper operation.

E. See Section 230593 – Testing, Adjusting, and Balancing.

F. After starting fans: Check for objectionable noise and/or vibration. Correct as needed at no additional cost to the Owner.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

B. See Section 230010 – Mechanical General Provisions.

END OF SECTION 237313

SECTION 237433 - DEDICATED OUTDOOR-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 dedicated outdoor air units capable of supplying up to 100 percent outdoor air and providing cooling and heating.

1.3 SUBMITTALS

A. See Section 23 00 10 Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop and coordination drawings (where shop and coordination drawings are required) according to the following table.

1. "R" means required.
2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Makeup air units	R	R		R
Coils, performance data	R	R		R
Fans, performance data	R			
Acoustical performance data	R			
Motors	R	R		
Variable frequency drives	R	R		R
Dampers and actuators	R	R		
Filters	R			
Factory installed controls (controllers, control devices, etc.)	R	R		R
Accessories	R	R		R
Coordination drawings				R

C. Additional submittal requirements.

1. List of exceptions to the specifications including section number and a detailed description of alternative materials and methods. If there are no exceptions, so state in precise language.
2. List of proposed manufacturers for fans, filters, coils, motors, drives, dampers and other components.

3. Complete graph of fan curves (not just curve for design conditions) indicating efficiency, BHP, and RPM.
4. Sound power levels per ARI 260 by octave bands; radiated and at inlet and discharge.
5. Coil performance and flow rates.
6. Filter and filter frame product data.
7. Wiring diagram.
8. Control panel location, including elevation indicating height above the ground.
9. Internal static pressure drop with filters clean and dirty.
10. Casing materials of construction and methods of assembly.
11. Construction details including panel sealing, thermal break, door seal and hardware, shipping split and field treatment of panel penetration (sleeve) details.
12. The number of shipping sections requiring field reassembly.
13. Coordination Drawings: Submit with Shop Drawings. Show mechanical-room layout and relationships between components and adjacent structural and mechanical elements. Show service clearance requirements, and support locations, type of support, and weight on each support. Indicate and certify field measurements.

1.4 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: Two sets for each air-handling unit.
2. Gaskets: Two sets for each access door.
3. Fan Belts: One set for each air-handling unit fan.

1.5 QUALLITY ASSURANCE

A. Regulatory Requirements: Comply with provisions of the following codes:

B. UL Standard: Provide units complying with UL 1812, "Ducted Heat Recovery Ventilators"; or UL 1815, "Nonducted Heat Recovery Ventilators."

C. UL and NEMA Compliance: Provide ancillary electrical components required as part of energy recovery units that are listed and labeled by UL and that comply with applicable NEMA standards.

D. Comply with NFPA 70 for components and installation.

E. DX and water coils shall be AHRI Certified per standard 410-2001.

1.6 SEQUENCING AND SCHEDULING

A. Coordinate size and location of equipment supports, housekeeping pad, and wall penetrations.

B. Coordinate construction sequencing of associated plumbing and electrical systems.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to replace components of units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Heat Exchangers: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

1. Greenheck.
2. Valent.
3. Aaon.
4. Or equal.

2.2 DEDICATED OUTDOOR AIR UNITS

A. Surfaces in contact with the airstream shall comply with requirements of ASHRAE Standard 62.1-2010.

B. Unit Casing and Frames.

1. Double wall construction.
2. Unit shall be of internal frame type construction of G90 galvanized steel per ASTM A653.
3. Exterior panels shall be a minimum of 18 gauge galvanized steel. Where top panels are joined there shall be a standing seam.
4. All exterior metal-to-metal-seams shall be sealed with closed cell neoprene gasketing, requiring no caulking at job site.
5. Unit shall be furnished with a G90 galvanized base rail of sufficient height to install a condensate p-trap per manufacturer's recommendation. Minimum base rail height shall be 6". Units not provided with a factory fabricated base rail, a field constructed base rail shall be provided with same construction as factory fabricated base rail.
6. Contractor shall be responsible for providing a housekeeping pad.

C. Casing Insulation.

1. Rigid urethane foam.
2. Thickness: 2inch (minimum).
3. Meets UL94HF-1 flame requirements.
4. Location and application: Full coverage of entire cabinet exterior to include walls, roof of unit. Insulation shall be installed between inner and outer shells of all cabinet exterior

D. Access Doors.

1. Hinged access doors.
2. All components shall be easily accessible through large hinged access doors for both exhaust and supply compartments.
3. Energy recovery wheel shall be mounted in a slide-out track.
4. Access doors to be provided in each individual section where blowers, filters and motorized damper are required.
5. Fabricated of 18 gauge G90 galvanized steel.

E. Fan Sections.

1. Direct-drive plenum fans.
2. All blower wheels shall be statically and dynamically balanced.
3. Motors shall be permanently lubricated, heavy duty type, matched to the fan load and furnished at the specified voltage, phase and enclosure.
4. Ground and polished steel fan shafts shall be mounted in permanently lubricated, sealed ball bearing pillow blocks.
5. Bearings shall be selected for minimum (L10) life in excess of 100,000 hours at maximum cataloged operating speeds.
6. Fan and motor assembly shall be mounted on heavy gauge galvanized rails and internally isolated on 1.125 inch thick neoprene vibration isolators.
7. Blower performance shall be factory tested for flow rate, pressure, power, air density, rotation speed and efficiency. Ratings are to be established in accordance with AMCA 210, “Laboratory Methods of Testing Fans for Rating”.

F. Motor and Drives.

1. Premium efficiency, see 230513 Motors and Controllers. Inverter duty, suitable for use with variable frequency drive.
2. Motors shall be permanently lubricated, heavy duty type, matched to the fan load and furnished at the specified voltage, phase, and enclosure.
3. Drives shall be sized for a minimum of 150% of driven horsepower.
4. Pulleys shall be fully machine cast.
5. Energy recovery wheel motors shall have integral overload protection.
6. Supply and exhaust fan motor controllers: Variable frequency drives, see Section 230513 Motors and Controllers.

G. Dampers.

1. Motorized outdoor air intake and exhaust air dampers.
2. Low leakage type, factory installed. End/jamb seals and insulated blades.
3. Meet ASHRAE Standard 90.1-2010 damper leakage requirements.

H. Drain Pan.

1. Materials of Construction: Welded stainless steel.
2. Sloped in two directions.
3. Welded stainless steel drain connection.
4. Complies with ASHRAE Standard 62.1-2010.
5. P-trap per manufacturer’s recommendation.

I. Filters.

1. 2” MERV 8 disposable filters.

J. Electrical.

1. All internal electrical components shall be prewired for single point power connection.
2. All electrical components shall be UL listed, approved or classified where applicable and wired in compliance with the National Electrical Code.
3. Single-point high voltage connection.

K. Direct Expansion (DX) Cooling/Heating Coil.

1. Factory tested and rated in accordance with AHRI 410.
2. Copper tubes with permanently expanded aluminum fins, 12 fpi or less.
3. Galvanized frame.
4. Interlaced configuration.

L. Hot Gas Reheat Coil.

1. Factory tested and rated in accordance with AHRI 410.
2. Copper tubes with permanently expanded aluminum fins, 12 fpi or less.
3. Galvanized frame.

M. Natural Gas Furnace.

1. Indirect gas-fired furnace.
2. Factory assembled, piped and wired complying with NFPA 54 and ANSI Z21.47.

    a. Furnace shall bear AGA label.

3. Burners: Stainless steel.

    a. Ignition: electronically controlled electric spark with flame sensor.

4. Stainless steel heat exchanger drain pan.
5. Power vent: integral, motorized centrifugal fan interlocked with gas valve.
6. Concentric vent kit.
7. 4:1 electronically modulating gas control valve.
8. Gas train: single-body, regulated, redundant, 24 VAC gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.
9. Fabricate section to allow removal and replacement of furnace and to allow in-place access for service.

N. Condensing Section

1. Outdoor coils shall be cast aluminum, micro-channel coils. Plate fins shall be protected and brazed between adjoining flat tubes such that they shall not extend outside the tubes. A sub-cooling coil shall be an integral part of the main outdoor air coil. Each outdoor air coil shall be factory leak tested with high-pressure air under water.
2. Fan motors shall be an ECM type motor for proportional control. The unit controller shall proportionally control the speed of the condenser fan motors to maintain the head pressure of the refrigerant circuit from ambient condition of 0~120°F. Mechanical cooling shall be provided to 25º F. The motor shall include thermal overload protection and protect the motor in the case of excessive motor temperatures. The motor shall have phase failure protection and prevent the motor from operation in the event of a loss of phase.
3. The condenser fan shall be low noise blade design. Fan blade design shall be a dynamic profile for low tip speed. Fan blade shall be of a composite material.
4. The unit shall have scroll compressors. One of the compressors shall be an inverter/digital compressor providing proportional control. The unit controller shall control the speed of the compressor to maintain the discharge air temperature.
5. Pressure transducers shall be provided for the suction pressure and head pressure. Temperature sensor shall be provided for the suction temperature and the refrigerant discharge temperature of the compressors.
6. Refrigerant circuit shall have a bypass valve between the suction and discharge refrigerant lines for low head pressure compressor starting and increased compressor reliability. When there is a call for mechanical cooling the bypass valve shall open to

equalizing the suction and discharge pressures. When pressures are equalized the bypass valve shall close and the compressor shall be allowed to start.

7. Each circuit shall be dehydrated and factory charged with R-410A Refrigerant and oil.

O. Roof Curb.

1. Factory assembled, 14 gauge galvanized steel.
2. Provide perimeter support of the entire unit.
3. Coordinate height with field conditions to ensure curb has sufficient height for duct connections,

P. Unit Controls.

1. The unit shall be constructed so that it can function as a stand-alone heating and cooling system controlled by factory-supplied controllers, thermostats and sensors or it can be operated as a heating and cooling system controlled by an Energy Management and Control System (EMCS).
2. DDC controller with integral LCD screen and built-in keypad.
3. DDC controller communication protocol: BACnet MSTP.
4. Variable frequency drives (supply fans).
5. Unit shall be furnished with the following sensors, also See Drawings for additional controls.

    a. Dirty filter sensors (supply and exhaust).
    b. Temperature sensors.

        1) Outdoor air.
        2) Leaving cooling coil.
        3) Leaving HGRH coil.
        4) Supply air.
        5) Space.

    c. Humidity sensors.

        1) Supply air.
        2) Space humidity.

    d. Current sensors.

        1) Supply fan.

    e. Phase monitor.
    f. Defrost control.

6. Additional controls, sensors, and accessories shall be provided as required for a fully operational system to meet the intended sequence of operation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

C. Examine roof curbs and equipment supports for suitable conditions where units will be installed.

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

3.2 INSTALLATION

A. Comply with manufacturer's rigging and installation instructions for unloading units and moving to final locations.

B. Curb Support: Install roof curb on concrete equipment pad.

1. Install and secure units on curbs.

C. Equipment Mounting:

1. Install air units on cast-in-place concrete equipment bases.
2. Install 3000-psi, compressive-strength (28-day) concrete base, 6 inches thick minimum. Concrete and reinforcement are specified with concrete.

D. Install wall- and duct-mounted sensors furnished by manufacturer for field installation. Install control wiring and make final connections to control devices and unit control panel.

E. Install separate devices furnished by manufacturer and not factory installed.

F. Comply with requirements for gas-fired furnace installation in NFPA 54, "National Fuel Gas Code."

G. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

H. Install drain pipes from unit drain pans to sanitary or storm drain.

1. Drain Piping: Solid wall schedule 40 PVC with DWV fittings and solvent cemented joints.
2. Pipe Size: Same size as condensate drain pan connection.

3.3 CONNECTIONS

A. Where installing piping adjacent to units, allow space for service and maintenance.

B. Duct Connections:

1. Comply with requirements in Sections 233113 – Metal Ducts and 233115 – Outdoor Duct Systems.
2. Drawings indicate the general arrangement of ducts.
3. Connect ducts to units with flexible duct connectors. Comply with requirements for flexible duct connectors in Section 233300 "Air Duct Accessories."

C. Gas Piping Connections:

1. Comply with requirements in Section 231123 "Facility Natural-Gas Piping."

2. Connect gas piping to furnace, full size of gas train inlet, and connect with union, pressure regulator, and shutoff valve with sufficient clearance for burner removal and service.
3. Install drip/dirt leg per International Fuel Gas Code.

D. Electrical Connections: Comply with requirements for power wiring, switches, and motor controls in electrical Sections.

1. Install electrical devices furnished by unit manufacturer but not factory mounted.

3.4 CLEANING

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

3.5 STARTUP SERVICE

A. Startup to be by a manufacturer/factory employee (factory authorized startup is not acceptable). Design professional is to be present during startup with manufacturer employee present. Provide 48 hours' notice before startup at a minimum to allow design professional to be present.

B. Provide startup checklist in submittal and provide during startup. Items below are a minimum for startup.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Inspect units for visible damage to furnace combustion chamber.
3. 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 flue-gas temperature at furnace discharge.
    d. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
    e. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

4. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:

    a. High-limit heat exchanger.
    b. Alarms.

5. Start refrigeration system when outdoor-air temperature is within normal operating limits and measure and record the following:

    a. Cooling coil leaving-air, dry- and wet-bulb temperatures.
    b. Cooling coil entering-air, dry- and wet-bulb temperatures.
    c. Condenser coil entering-air dry-bulb temperature.
    d. Condenser coil leaving-air dry-bulb temperature.

6. Simulate maximum cooling demand and inspect the following:

a. Compressor refrigerant suction and hot-gas pressures.
b. Short-circuiting of air through outside coil or from outside coil to outdoor-air intake.

7. Inspect casing insulation for integrity, moisture content, and adhesion.
8. Verify that clearances have been provided for servicing.
9. Verify that controls are connected and operable.
10. Verify that filters are installed.
11. Clean coils and inspect for construction debris.
12. Clean furnace flue and inspect for construction debris.
13. Inspect operation of power vents.
14. Purge gas line.
15. Inspect and adjust vibration isolators.
16. Verify bearing lubrication.
17. Clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding.
18. Adjust fan belts to proper alignment and tension.
19. Start unit.
20. Inspect and record performance of interlocks and protective devices including response to smoke detectors by fan controls and fire alarm.
21. Operate unit for run-in period.
22. Calibrate controls.
23. Adjust and inspect high-temperature limits.
24. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
25. Verify operational sequence of controls.
26. Measure and record the following airflows. Plot fan volumes on fan curve.

a. Supply-air volume.
b. Outdoor-air flow.

C. After startup, change filters, verify bearing lubrication, and adjust belt tension.

D. Remove and replace components that do not properly operate and repeat startup procedures as specified above.

E. Prepare written report of the results of startup services.

3.6 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. After starting units: Check for objectionable noise or vibration. Correct as needed at no additional cost to the Owner.

D. Balancing: See Section 230593 “Testing, Adjusting and Balancing for HVAC.”

E. Prepare test and inspection reports.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 237433

SECTION 238123 – COMPUTER ROOM 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. Work included in this section: materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following:

1. Computer room air conditioners.
2. Outdoor condensers.
3. Controls and accessories.

B. Related Sections.

1. Section 230010 – Mechanical General Provisions.
2. Section 230500 – Basic Mechanical Materials and Methods.

1.3 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. Underwriters Laboratories (UL) standard UL1995, Heating and Refrigeration equipment.

C. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15 – 2019.
2. Applicable requirements in ASHRAE/IESNA 90.1 – 2019.

D. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

E. ANSI/AMCA 230 – Laboratory Methods of Testing Air Circulator Fans for Rating.

F. AMCA 300 – Reverberant Room Method of Sound Testing of Fans.

G. ARI 410 – Standard for Forced – Circulation Air-Cooling and Air Heating Coils.

H. NFPA 90A – Installation of Air Conditioning and Ventilation Systems.

I. Schedule equipment performance is minimum capacity required.

1.4 SUBMITTALS

A. See Section 230010 Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop and coordination drawings (where shop and coordination drawings are required) according to the following table.

1. "R" means required.
2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Computer-Room Air Conditioner (color sample)	R	R	R	R
Outdoor condenser	R	R		R
Controls (factory and field mounted)	R	R		
Accessories	R	R		
Mounting details				R

C. Additional submittal requirements.

1. List of exceptions to the specifications including section number and a detailed description of alternative materials and methods. If there are no exceptions, so state in precise language.
2. Complete graph of fan curves (not just curve for design conditions) indicating efficiency, BHP, and RPM.
3. Sound power levels per ARI 260 by octave bands; radiated and at inlet and discharge.
4. Coil performance and flow rates.
5. Wiring diagram.
6. Control panel location, including elevation indicating height above the ground.

1.5 COORDINATION

A. Coordinate layout and installation of computer-room air conditioners and suspension system with other construction that penetrates ceilings, floors, or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, floor framing and partition assemblies.

B. Coordinate installation of computer-room air conditioners with computer-room access flooring Installer.

C. Coordinate sizes and locations of equipment supports with actual equipment provided.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.

2. Warranty Period for Humidifiers: Manufacturer's standard, but not less than five years from date of Substantial Completion.
3. Warranty Period for Control Boards: Manufacturer's standard, but not less than five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models are acceptable.

1. Data Aire.
2. Liebert.
3. Stulz.
4. Trane.
5. Or equal.

2.2 GENERAL

A. Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, coils, humidifier, fan, filters, and controls; for vertical floor mounting in upflow configuration.

2.3 CABINET AND FRAME

A. Frame shall be constructed of welded 14 gauge tubular steel, braced for rigidity, supporting mechanical equipment. Frame shall be coated with a corrosion inhibiting finish.

B. Unit shall be provided with complete front, rear and side access via heavy duty hinged steel doors. Doors shall be fabricated of 18 gauge steel. Quarter turn door latches shall be manually actuated via a hand tool. Door gaskets shall be polyurethane to prevent air leakage.

C. Unit shall have powder coated exterior finish. Finish shall prevent corrosion. Unit color shall be by the Architect.

D. Unit Insulation: Thermally and acoustically insulate cabinet interior with 1-inch thick, 1-1/2-pound density fiber insulation.

E. Condensate Drain Pan: Constructed of stainless steel and constructed per ASHRAE Standard 62.1 – 2010.

2.4 FANS, MOTORS, AND DRIVES

A. The supply air fans shall be single width, single inlet plenum fan with backward inclined blades. Fan wheel shall be directly connected to its motor. Fan/motor assembly shall be statically and dynamically balanced for quiet, vibration-free operation.

B. The fan motor shall be an electronically commutated (EC) synchronous DC motor; having soft start capability and shall be controlled via the unit mounted controller and automatically regulated through all modes of operation.

C. Each fan shall have fault monitoring circuitry and integral speed controller for a level of redundancy.

D. The fan shall be mounted within the unit and fully enclosed in a sheet metal enclosure to prevent access to moving parts.

E. The system shall be designed for draw through air arrangement to ensure even air distribution to the entire face of the coil.

F. In the event of a fan failure, the remaining fans will automatically increase in speed to temporarily deliver as much air flow as possible to the controlled space until the failed fan can be repaired or replaced.

2.5 FILTRATION

A. The filter chamber shall be an integral part of the system, designed within the unit for easy front accessibility.

B. An initial set of filters shall be factory installed in the unit.

C. Filters shall be 4-inch deep, disposable, pleated design, extended-surface, nonwoven, reinforced cotton fabric; supported and bonded to welded-wire grid; enclosed in cardboard frame design.

D. Rated not less than MERV 8 per ASHRAE Standard 52.2.

E. A filter differential switch for alarm activation shall be included.

2.6 REFRIGERANT (R-410A)

A. The system shall be designed for use with R-410A refrigerant, which meets the U.S. Clean Air Act for phase-out of HCFC refrigerants. Refrigerant shall be field-supplied and field-charged by the installing contractor.

2.7 REFRIGERATION SYSTEM (INDOOR UNIT)

A. The indoor unit refrigeration system shall consist of one (1) refrigeration circuit, scroll compressor with vibration isolating grommets, evaporator coils, thermostatic expansion valve, liquid solenoid valve, high and low pressure safety switches, liquid line filter drier, and refrigerant sight glass with moisture indicator. Compressor shall be located outside the airstream and shall be removable and serviceable from the front of the unit. The high and low-pressure safety switches shall be installed with Schrader type fittings with valve core.

B. Constant Speed Compressor:

1. The unit shall be configured with a suction gas cooled motor fixed speed hermetic scroll compressor based on temperature set-point plus dead band control through the micro-processor controller.
2. The compressor shall have a complete overload protection on all three power lines, internal thermostats, rotolock service valve, crankcase heater, sight-glass, and low pressure override timer for positive starting at low temperatures.

C. Direct Expansion (DX) Evaporator Cooling Coil:

1. Arrangement: The direct expansion cooling coil shall be in an “A” frame arrangement to allow maximum coil surface in a small cabinet.
2. Coils: Shall be constructed of seamless, rifled copper tubes expanded into enhanced style aluminum fins for maximum heat transfer.
3. Face Velocity: Shall be less than 500 feet per minute.
4. Drain Pan: Coil shall sit in a stainless steel drain pan sloped for drainage.
5. The suction or discharge (hot gas) and liquid refrigerant piping ports shall be sealed and pressurized with dry nitrogen for shipment to indicate a leak-free system at installation.
6. Refrigerant pipe connections shall be terminated three (3) inches inside the bottom of the cabinet for field connection to piping coming from below.

D. Electronic Expansion Valve:

1. The electronic expansion valves shall be an electronic expansion type control by a dedicated driver. This driver shall communicate with the unit controller via Modbus and shall have the ability to display superheat setpoint, suction temperature, suction pressure, and EEV opening position.
2. The controller shall have the ability to display the following alarms:

    a. Low suction pressure.
    b. High suction pressure.
    c. Low suction temperature.
    d. High suction temperature.
    e. Low superheat.
    f. High superheat.
    g. EEV Failure.
    h. EEV Motor Failure.
    i. Suction temperature sensor failure.
    j. Suction pressure sensor failure.
    k. Electronic Valve Driver disconnected.

3. The EEV uses a stepper motor for high precision control, allowing a low superheat setpoint with improved system efficiency.
4. The control logic of the EEV shall be based on Proportional-Integral-Derivative (PID) operation via the unit controller. The P, I and D values shall be factory tested for accurate and stable control.

2.8 REMOTE OUTDOOR AIR-COOLED CONDENSER

A. The remote outdoor air-cooled condenser shall be a low profile with direct drive axial fans with EC motors. The EC motors shall have soft start capability.

B. The condenser housing shall be constructed of aluminum and contain a seamless rifled copper tube expanded into aluminum fin coil for maximum heat transfer.

C. The air discharge shall be vertical to minimize the effects of wind blowing through the coil at low ambient temperatures.

D. The condenser shall have the ability to control the fan speed via a pressure transducer feedback signal to modulate the speed of the fans and provide positive start-up and operation at ambient temperatures down to -20ºF.

E. All controls including the fan speed control shall be factory mounted in the air cooled condenser in an integral factory wired and tested control panel.

F. The air cooled condenser shall be manufactured by the manufacturer of the indoor evaporator unit.

G. The evaporator and condenser shall be factory assembled and tested.

H. Piping and wiring between the indoor evaporator and the remote outdoor air-cooled condenser shall be field provided by the installing contractor.

2.9 ELECTRICAL

A. All electrical components, including contactors, relays and control transformers shall be pre-wired and contained in a unit-mounted electrical enclosure with hinged door that shall swing out for easy access and servicing.

B. The control circuit voltage shall be 24 VAC.

C. The input electrical power shall be as detailed on the Construction Documents.

2.10 ELECTRIC REHEAT

A. The reheat shall be of the finned enclosed, sheath type, fabricated of stainless steel core sheath with plated fins to withstand moist conditions.

B. The reheat shall be installed on the air discharge side of the cooling coil.

C. The reheat shall be capable of maintaining room dry bulb conditions when the system is in dehumidification mode.

D. The reheat section shall include safety switches to protect the system from overheating.

2.11 HUMIDIFIER

A. The unit shall be provided with a self-contained, microprocessor-controlled steam generator type humidifier. The steam generating humidifier shall use disposable cylinder type with electronic controls.

B. The humidifier shall discharge pure steam with no material dust carry-over and have a self-regulating automatic flush cycle. Cylinders shall be disposable not requiring cleaning or maintenance. The humidifier fill level, water conductivity and flush rate shall automatically adapt, both in frequency and duration, to variations in the incoming water.

C. Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.

D. Drain duration and drain interval shall be field-adjustable.

2.12 WATER DETECTION SENSOR

A. Each unit shall be provided with one (1) water under floor detection sensor.

B. The solid-state water sensor shall be mounted under the unit by the installing contractor to sense the presence of water.

C. The water detector shall become an integral part of the microprocessor panel and shall display "WATER DETECTED IN UNDER FLOOR AREA" message and activate an audible alarm when the sensor is activated.

D. Additionally, three (3) adjustable action settings shall be available when an alarm is detected: Alarm only, shutdown unit or lockout compressor.

2.13 HIGH TEMPERATURE SENSOR

A. The high temperature sensor (Firestat) shall be factory-installed in the unit and shall be factory-set to 125 ºF. It shall immediately shut down the environmental control system when activated. The sensor shall be mounted with the sensing element in the return air.

2.14 MICROPROCESSOR CONTROL SYSTEM

A. The environmental control system shall be furnished with a microprocessor based panel. The panel shall include unit control functions and display normal functions and service diagnostics on a backlit liquid crystal display (LCD). The panel shall allow recall and display of the high and low temperature for the last 24 hours, high and low humidity for the last 24 hours, current percent of capacity and average percent of capacity for the last hour of operation for chilled water valve (if applicable), compressor (if applicable), reheat, humidification, dehumidification, component runtimes (if applicable) for fan motor(s), reheat, humidification, dehumidification and chilled water valve. Programming shall have multilevel password access to prevent unauthorized access. Programming shall be accomplished entirely from the front of the unit without the need to access, set or program switches inside the unit (front door of the unit does not need to be opened). Programmable functions shall be entered on flash memory to ensure program retention should power fail. The historical database shall be maintained by battery backup. Multiple messages shall be displayed by automatically scrolling from each message to the next. Alarm conditions shall be displayed by automatically scrolling from each message to the next. Alarm conditions, in addition to being displayed, shall enunciate an audible alarm. Four programmable summary contacts shall be available for remote alarm monitoring. Additional test or service terminal shall not be required for any functions. The control shall include temperature anticipation, moisture level humidity control and automatic flush cycles.

B. An alarm condition shall continue to be displayed until the malfunction is corrected. Multiple alarms shall be displayed sequentially in order of occurrence and only those alarms which have not been acknowledged shall continue to sound an audible alarm. The panel shall perform an automatic self-test on system start-up. A user accessible diagnostic program shall aid in system component trouble shooting by displaying on the unit LCD screen the name of the controlled item, output relay number, terminal plug and pin number for each controlled function.

C. The control system shall support communication with a BACnet MS/TP Energy Management and Control System (EMCS). See Section 230900 Energy Management & Control System.

2.15 ADDITIONAL REQUIREMENTS

A. Thru-Door Locking Disconnect Switch: The environmental control unit shall include a non-automatic disconnect switch mounted in the high voltage section of the electrical panel. The operating mechanism shall prevent access to the high voltage electrical components until switched to the "OFF" position. The operating mechanism shall protrude through the exterior door and be lockable in the OFF position.

B. Condensate Pump: Units shall be provided with dual float condensate pump. If condensate pump fails control panel shall enunciate an alarm and display. Pumps shall be factory mounted/wired and shall include sump, motor, and automatic control. A factory installed high condensate water level alarm switch shall disable the unit prior to condensate pan overflow should the drain become plugged with debris. The audio alarm shall be activated and a “High Condensate Water Level” message shall be displayed on the display module. The pumps shall be rated for 130 GPH at 20 foot of water maximum head (or 40 GPH at 20 foot of water maximum head with check valve).

C. Discharge Air Temperature Sensor: The environmental control unit shall be provided with a discharge air temperature sensor for field installation on the supply air side air temperature display via the unit controller.

D. Hot Gas Bypass - The environmental control unit shall be provided with hot gas bypass. The hot gas bypass valve shall be installed between the compressor discharge line and the leaving side of the expansion valve through a side outlet distributor.

E. Smoke Detector: The environmental control unit shall be provided with a smoke detector. The smoke detector shall be mounted with the sensing element in the return air stream. When the smoke detector is activated, it shall immediately shut down the unit.

F. No Water Flow Alarm: Unit shall be furnished with a NEMA 1 flow switch for field mounting into the chilled water piping to the unit. Upon a loss of water flow the unit control panel shall indicate “No Water Flow” and alarm shall sound.

G. Phase Loss Relay: Phase loss relay shall be used to shut down the environmental control unit on the loss of any phase of power. Three phase (3-Ph) equipment only. Automatic reset.

H. Floor Stand: Upflow unit(s) shall be provided with floor stand and vibration isolation pads. The floor stand shall be a completely welded structural angle base frame engineered to support the operating unit. The floor stand height shall be verified and shall have adjustable legs.

I. Floor Stand Turning Vane: A factory-supplied, field-mounted turning vane shall be provided.

J. Vibration Isolation Pads: Vibrations isolation pads consisting of high density cork sandwiched between two layers of neoprene shall be supplied for field mounting.

K. Discharge Plenum: Up flow units shall be equipped with an 18” (457mm) (or taller) discharge plenum with factory installed double deflection front discharge grille. Plenum shall be constructed of minimum 18 gauge steel, lined with 1 inch (25.4mm) thick, 1-1/2-pound (0.68 kg) density fiber insulation and powder coated to match the cabinet of the computer room air Conditioning unit.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate with work of other trades.

B. Units shall ship with all openings securely covered and watertight. Protection shall be retained until completion of construction or until opening is field connected to ductwork.

C. Provide access space around equipment for service. Provide no less than minimum as recommended by manufacturer.

D. Install in conjunction with server cabinets for integrated line up of equipment.

E. Examine roughing-in for piping systems to verify actual locations of piping connections before equipment installation.

F. Piping.

1. See Section 232300 – “Refrigerant Piping.”
2. See piping diagrams.
3. Do not block access doors with piping. Access doors shall be capable of opening 90 degrees.
4. Pipe condensate to nearest appropriate drain.

G. Examine walls, floors, and roofs for suitable conditions where equipment will be installed.

H. See Section 230900 – “Energy Management and Control System.”

I. The Contractor shall be responsible to coordinate all installation requirements with other trades to ensure that a complete installation for each unit is being provided. Coordination efforts shall include such items as unloading and hoisting requirements, field wiring requirements, field piping requirements, field ductwork requirements, requirements for assembly of field-bolted or welded joints, and all other installation and assembly requirements.

3.2 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties. Provide all piping, fittings, and additional specialties required by manufacturer.

B. Piping Connections: Connect equipment furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer’s piping connection diagram submittal to piping contractor. Install piping to allow proper service and maintenance.

C. Electrical Wiring: Install and connect electrical devices furnished by manufacturer but not specified to be factory mounted. Furnish copy of manufacturer’s electrical connection diagram submittal to electrical contractor.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, start-up and adjust components, assemblies, and equipment installations, including connections.

B. Perform manufacturer’s required 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.

3.4 CLEANING

A. Clean units externally and internally, on completion of installation, according to manufacturer’s written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.

B. After completing system installation and testing, adjusting, and balancing, clean filter housings and install new filters.

3.5 TESTING AND ADJUSTING

A. Do not operate fans for any purpose, temporary or permanent until:

1. See Section 230500 – Basic Mechanical Materials and Methods.
2. Ductwork is clean.
3. Filters are in place.
4. Bearings are in place.
5. Bearings are lubricated.
6. Fan(s) has been run under observation.

B. Start and test fans in accordance with manufacturer’s written installation instructions.

C. Test cooling coil drain pans. See Section 233300 – Duct Accessories.

D. Start-up and adjust completed air handling units to insure proper operation.

E. See Section 230593 – Testing, Adjusting, and Balancing.

F. After starting fans: Check for objectionable noise and/or vibration. Correct as needed at no additional cost to the Owner.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

B. See Section 230010 – Mechanical General Provisions.

END OF SECTION 238123

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. Work included in this section: materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following:

1. Split-system heat pumps.

1.3 SUBMITTALS

A. See Section 230010 Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop and coordination drawings (where shop and coordination drawings are required) according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Split-system indoor unit and direct expansion coil	R	R		R
Outdoor heat pump	R	R		R
Controls	R	R		
Accessories	R	R		
Installation details				R

1.4 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. Gaskets: One set for each access door.
2. Fan Belts: One set for each air-handling unit fan.

1.5 REFERENCE STANDARDS

A. ARI Standard 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.

B. AMCA Standard 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating (ANSI).

C. UL 1995 – Heating and Cooling Equipment.

1.6 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/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.8 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 and Coils: Five years parts and labor non-prorated from date of Substantial Completion.
b. For Other Parts: One year from date of Substantial Completion.
c. For Labor: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models are acceptable.

1. Lennox.
2. Trane.
3. York.
4. Or equal.

2.2 AIR SOURCE HEAT PUMP AIR HANDLING UNITS

A. Air Handler Casing: Casing shall be heavy gauge steel, phosphatized and finished with baked-on enamel. Evaporator and heat exchanger sections shall be insulated with one-inch (1") thick foil-faced glass fiber. Modular in design, multi-position up/down flow, horizontal left/right. Access panels with captive screws.

B. External Filter Rack:

1. Factory assembled, side or top service housings, constructed of 18 gage galvanized steel with integral track to receive 2-inch MERV 8 filters.
2. Access Door: Continuous gasket on perimeter and locking device which does not require use of any tools to open or close.
3. Sealing: Size of housing shall match the size of the inlet of the furnace being served. Incorporate positive-sealing gasket material between furnace and filter housing and return air plenum to prevent bypass of unfiltered air.

C. Condensate Drain Pans:

1. Fabricated with two 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.

a. Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
b. Depth: A minimum of 2 inches deep.

2. Single-wall, polymer or stainless-steel sheet.
3. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.

D. Evaporator coil shall be constructed of aluminum fins, mechanically bonded to copper tubes. Coil shall be tested at 400 psig. Coil shall be dual circuited on units larger than 6 tons, or as indicated on Construction Drawings. Electronic expansion valve with low ambient and low superheat protection.

E. 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.

F. Supply fans.

1. Centrifugal, factory balanced, adjustable belt drive, permanently lubricated bearings.
2. Centrifugal, factory balanced, resilient mounted, direct drive.
3. Dual fans on air handling units 12.5 tons and greater.
4. See fan type indicated on Construction Drawings.

G. Fan motors.

1. Motor sheave on standard belt drive units shall be adjustable. Motor sheave on Single Zone VAV units shall be fixed. Motors shall have inherent overload protection.
2. Constant torque Electrically Commutated Motor (ECM).
3. Variable frequency drive (VFD) where indicated on Construction Drawings.
4. See motor type indicated on Construction Drawings.
5. See Section 230513 – Motor and Controllers.

H. Electrical.

1. Provide units with single point power connection and control box with circuit breakers for overload and short circuit protection. Factory wired and mounted on electric heat unit. Circuit breakers shall qualify as disconnect means at unit. Provide unit with circuit breaker cover kit to protect circuit breaker.

I. Controls.

1. Provide unit with low voltage electric controls.
2. BACnet communicating thermostat/controller.

    a. See Section 230913 – EMCS Basic Materials and Devices (TS-4).

2.3 AIR SOURCE HEAT PUMP OUTDOOR UNITS

A. Air-Cooled, Compressor-Condenser Components:

1. Units shall be single or dual circuit type, as scheduled, and shall consist of scroll compressor(s) and, condenser coil(s), condenser fans, refrigerant receiver, charging valves, controls and holding charge.
2. 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. Casing shall have factory provided and installed condenser coil hail guards.
3. 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. Refrigerant Charge: R-410A.
    c. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.

4. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
5. Fan: Aluminum-propeller type, directly connected to motor.
6. Motor: Permanently lubricated, with integral thermal-overload protection.

7. Controls shall include contactors, high-pressure outlet with thermostatic reset, low-pressure cutout and reset relay to prevent unit cycling on overloads once the automatic resetting safety control trips. Where indicated or scheduled, provide units with low ambient controls with stable operation down to 0 ˚F including variable feed refrigerant head pressure controlled condenser fan operation. All wiring and devices shall be internal to cabinet. Exposed wiring is not acceptable.

B. Controls.

1. Provide single point unit power connection.
2. Provide unit with low voltage electric controls.
3. Unit control box shall be located within the unit and shall contain controls for compressor, reversing valve and fan motor operation and shall have a 50 VA 24-volt control circuit transformer and a terminal block for low voltage field wiring connections.
4. Safety Controls - High pressure, low temperature, and low pressure safety switches shall be wired through a latching lockout circuit to hold the conditioner off until it is reset electrically by interrupting the power supply to the conditioner. All safety switches shall be normally closed, opening upon fault detection.

2.4 ACCESSORIES

A. Automatic-reset timer to prevent rapid cycling of compressor.

B. Hard start kit.

C. Drain Hose: For condensate, where required.

2.5 AUXILLIARY DRAIN PAN

A. Provide auxiliary drain pan underneath indoor air handling units installed above ceilings.

B. Auxiliary drain pan shall extend six inches beyond the perimeter of the air handling unit in all directions.

C. Pipe drain pan discharge to sanitary sewer, See Section 221316 -Sanitary Waste and Vent Piping.

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. Equipment Mounting:

1. Install ground-mounted, compressor-condenser components on cast-in-place concrete housekeeping pad.

D. Install and connect refrigerant piping 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.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

C. Piping: Comply with requirements in Section 232300 – Refrigerant Piping.

D. Duct Connections: Duct installation requirements are specified in Section 233113 – Metal Ducts. Drawings indicate the general arrangement of ducts. Connect supply and return 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. 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.

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust initial temperature set points.

3.5 CLEANING

A. After completing installation, clean units externally and internally according to manufacturer's written instructions.

B. Install new filters in each indoor unit prior to performing Testing, Adjusting, and Balancing work.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 238126

SECTION 238129 – VARIABLE REFRIGERANT FLOW SYSTEMS

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. Variable Refrigerant Flow (VRF) Heat Recovery Systems

1.3 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. "R" means required.
2. "R2" means required only for products and equipment differing for the specified manufacturer and model and for "or equals" where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Outdoor units	R	R		R
Indoor units	R	R		R
Heat recovery units (branch controllers)	R	R		R
System controls and accessories	R	R		R
Manufacturer's Refrigerant Piping Diagrams				R
Flares	R	R	R	
Commissioning Forms with all Serial Numbers		R		
Installation, Pre-Start and Commissioning Checklist	R	R		
Nitrogen Leak Check	R	R		
Triple Evacuation	R	R		
Installer's qualifications (factory training certificate)	R			

1.4 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 type of indoor unit.

1.5 QUALITY ASSURANCE

A. The VRF system installer shall be factory-trained and certified prior to submission of bid. A factory-trained and certified employee of the installer shall be on-site when HVAC system is being installed and placed in operation. All certificates must be within the calendar year of the project and must be labeled as installation on the certificate.

B. See 2.1.B for requirements of piping design. All systems (including Basis of Design) must meet this section before approval.

C. Provide a letter from the manufacturer verifying the training certification of the installation contractor. Certificate must be within the calendar year of the project from all installers in the field.

D. Product Options: Drawings indicate size, profiles, and dimensional requirements of equipment and are based on the basis of design system indicated.

E. The units shall be listed by Electrical Laboratories (ETL) and bear the ETL label.

F. All wiring shall be in accordance with the National Electrical Code (N.E.C.).

G. The units shall be manufactured in a facility registered to ISO 9001 and ISO 14001 which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).

H. A full charge of R-410A for the condensing unit only shall be provided in the condensing unit.

I. 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.

J. 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."

K. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.6 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. All outdoor units to be bolted to concrete pad.

B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

C. Contractor is responsible for all additional condensate, electrical, structural, etc. for the actual equipment provided.

1.7 WARRANTY

A. Warranty Period:

1. Parts Only:

a. Parts and Components: Ten-year manufacturer parts only warranty from date of Substantial Completion. This includes indoor units, outdoor units (compressors) and branch selectors.
b. Controls: Three-year parts only warranty. This include all thermostats, touch-screen controllers, gateways, etc.

2. For Labor

a. Parts and Components: Three years from date of Substantial Completion including all branch selectors, indoor units, outdoor units including compressors, excluding filter maintenance.
b. Refrigerant: Three years from date of Substantial Completion. This includes replacement refrigerant due to warranty labor calls for compressor failure, leak in evaporator, indoor unit replacements, etc.. This does not include refrigerant loss due to leaking flares, full port Schrader valves leaking, pipes breaking due to end user accidents/fault.
c. Controls: Three years from date of Substantial Completion. This include all thermostats, touch-screen controllers, gateways, etc. All devices shall be reprogrammed during the warranty period with no additional cost to the owner.

B. The system shall be installed by a factory trained and manufacturer certified contractor with extensive training on this type equipment. Training to be performed and certification to be provided by the manufacturer. A completed system commissioning report shall be submitted to the Manufacturer's service department to ensure full warranty coverage for the "Owner".

C. The installation date is the date that the unit is originally commissioned but all warranty periods are to be the date of substantial completion, No Exceptions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Daikin.
2. Trane-Mitsubishi HVAC
3. Hitachi

B. The piping systems, controls, electrical systems, drains, equipment space (including service space), and equipment capacities are as required by the basis of design system. A bid based using any other equipment must also include the cost for the system design and installation which includes the additional or revised equipment, piping, electrical, supports, controls, and drains required for proper operation. Design of all systems (including Basis of Design) shall be prepared, and documents sealed, by a Professional Engineer registered in the State of Mississippi. The system design must be approved by the Architect (including all references above) before executing the sub-contract. The Contractor shall assume all additional cost for

design review, design revisions, controls, electrical, piping, and drains beyond those quantities required for the basis of design system.

2.2 HVAC SYSTEM DESIGN

A. The variable capacity heat recovery air conditioning system shall consist of multiple evaporators, branch selector boxes, joints and headers, a three-pipe refrigeration distribution system using PID control and condensing unit.

B. The condenser shall be a direct expansion (DX), air-cooled heat recovery, multi-zone air-conditioning system with variable speed inverter driven compressors using R-410A refrigerant.

C. A dedicated hot gas pipe shall be required to ensure optimum heating operation performance.

D. Operation of the system shall permit either individual cooling or heating of each indoor unit simultaneously or all the indoor units associated with each branch of the cool/heat selector box. Each indoor unit or group of indoor units shall be able to provide set temperature independently via a local remote controller, touch screen controller or a BMS interface.

E. Branch selector boxes:

1. The branch selector boxes shall consist of electronic expansion valves, refrigerant control piping and electronics to facilitate communications between the box and main processor and between the box and indoor units.
2. The branch selector box shall control the operational mode of the subordinate indoor units. The use of EEV's ensures continuous heating during defrost (multiple condenser systems), no heating impact during changeover and reduced sound levels.

F. All zones are each capable of operating separately with individual temperature control.

G. The condensing unit shall be interconnected to indoor unit models as specified on the plans and shall range in capacity from 7,500 Btu/h to 96,000 Btu/h in accordance with the engineering data book detailing each available indoor unit.

H. The indoor units shall be connected to the condensing unit utilizing manufacturers piping joints and headers to ensure correct refrigerant flow and balancing.

2.3 OUTDOOR UNITS

A. General: The outdoor units shall be designed specifically for use with a variable refrigerant flow system and components. Units shall be equipped with multiple circuit boards that interface to the control system and perform all functions necessary for operation. The units shall have a powder coated finish and shall be completely factory assembled, piped and wired. Each unit shall be run tested at the factory.

B. Unit Cabinets.

1. The condensing unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from rust-proofed galvanized steel panels coated with a baked enamel finish

C. Fan.

1. The condensing unit shall consist of one or more propeller type, direct-drive fan motors that have multiple speed operation via a DC (digitally commutating) inverter.
2. The motor shall have inherent protection, permanently lubricated bearings, and be completely variable speed.
3. The fan shall be provided with a raised guard to prevent contact with moving parts.
4. The outdoor unit shall have a vertical discharge airflow except for single phase equipment as specified.

D. Coil.

1. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond or aluminum micro-channel tubes.
2. The heat exchanger on the condensing units shall be manufactured from seamless copper tube with internal grooves mechanically bonded on to aluminum fins.
3. The fins shall be coated with an anti-corrosion hydrophilic blue coating as standard from factory with a salt spray test rating of 1000hr per ASTM test standards.
4. The outdoor coil shall have a heat exchanger design eliminating the need for a drain pan heater. The lower part of the coil shall be used for inverter cooling and be on or off during heating operation enhancing the defrost operation.

E. Compressor.

1. The inverter scroll compressors shall be variable speed (PVM inverter) controlled which is capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit
2. The capacity control range shall be as low as 3% to 100%.
3. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.
4. In the event of compressor failure, the remaining compressors shall continue to operate and provide heating or cooling as required at a proportionally reduced capacity. The microprocessor and associated controls shall be manually activated to specifically address this condition for single module and manifold systems.
5. The outdoor unit shall be capable of operating at 0 deg. F ambient temperature.

F. Electrical.

1. The outdoor unit electrical power shall be as indicated on plans.
2. The unit shall be capable of satisfactory operation within voltage limits as required.
3. The outdoor unit shall be controlled by integral microprocessors.

G. Wiring

1. The control voltage between the indoor units and the outdoor unit shall be completed using a 2-conductor shielded or non-shielded cable per manufacturer's recommendations.
2. The control wiring shall be a two-wire multiplex transmission system, making it possible to connect multiple indoor units to one condensing unit with one 2-cable wire, thus simplifying the wiring installation.
3. The control wiring maximum lengths shall be as per manufacturer's recommendations.

2.4 INDOOR UNITS

A. All indoor units to be type and minimum capacities (including airflow) as per plans/schedules.

B. All indoor units to be completely factory assembled and tested.

C. Provide all indoor units with toggle type disconnect switch.

D. Factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate pan, condensate drain pump (when a condensate drain pump is not factory mounted provide external condensate pump), condensate safety shutoff and alarm, self-diagnostics, auto-restart function, 3-minute fused time delay and test run switch shall be included on all indoor units.

E. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

F. The indoor unit shall be separately powered with 208~230V/1-phase/60Hz.

G. The return air on ductless indoor units shall be filtered by means of a washable long-life filter with mildew proof resin and antibacterial treatment. Provide each unit with an additional washable filter and turn over to owner after commissioning.

H. The return air on ducted indoor units shall be filtered by MERV 13 Filter Kit. Filter Kit shall be configured for right or left access as required for proper changing of filters. Right/Left access shall be field verified before installation to allow for proper maintenance. Any changes in the field will be responsibility of the contractor to replace and reinstall proper filter kit for proper maintenance. Filters shall be able to be changed without any tools.

2.5 CONTROLS

A. Overview.

1. The unit shall have controls provided by the manufacturer to perform input functions necessary to operate the system.
2. Exact location of all remote controllers and central controllers are to be submitted on the piping diagrams. All locations are to be coordinated with owner/end user before installation. Location of remote controllers on plans are approximate locations only.

B. VRF control system network.

1. The VRF control system shall consist of remote controllers, centralized controllers, and integrated web-based interface communicating over a high-speed communication bus. The control system shall support operation monitoring, scheduling, error email distribution, personal browsers, tenant billing, online maintenance support, and integration to the EMCS via a BACnet/IP Gateway.

C. Programmable, Wired, Remote Controllers.

1. The local remote control shall be made from plastic materials with a neutral color. Each controller shall have an LCD (Liquid Crystal Display) that shows set point, room temperature, mode of operation (on/off/cool/heat), and fan speed.
2. Remote controllers shall be compatible with all VRV indoor units.
3. The remote controller wiring shall consist of a non-polar two-wire connection to the indoor unit.
4. The remote controllers shall be wall-mounted and shall be adjustable to maintain the optimal operation of the connected indoor unit(s).
5. Temperature setpoint shall be adjustable in increments of 1°F.

6. In the cases where a system or unit error may occur, the VRV controllers shall display a two-digit error code and the unit address.
7. The remote controller shall be mounted into a standard 2" x 4" junction box. If programmable thermostat is larger than a standard 2" x 4" junction box, remote controller shall be securely mounted to wall with no movement. All remote controllers to be mounted level.
8. Wiring from the remote controller to indoor unit(s) shall per manufacturer's recommendations and installed by HVAC contractor.

D. Central controller.

1. Centralized controller shall be touch-screen with a backlit LCD display.
2. Centralized controller shall have BACnet Interface built into touch screen controller.
3. The BACnet interface shall be compliant with BACnet/IP (ANSI/ASHRAE 135, 135a) and UDP/IP of Ethernet (ANSI/ASHRAE 135-1005, 135b). The BACnet® interface shall support BACnet Broadcast Management (BBMD).
4. Operation and monitoring points include, but are not limited to, on/off, temperatures, operation mode, fan speed, prohibit remote controller, filter sign reset, alarm state, error code, scheduling, and error address.
5. Centralized controller shall have web access functions and shall be available so that facility staff can securely log into each centralized controller via the PC's web browser to support monitoring, scheduling, error recognition, and general user functions. Error emails shall also be sent to designated email addresses.
6. The central controller shall be powered as per manufacturer's recommendations.
7. The centralized controller communication wiring shall be terminated in a daisy chain design at the outdoor unit, which shall then daisy chain to branch selector (Heat Recovery system), then daisy chain to each indoor unit in the system and terminating at the farthest indoor unit. The termination of the wiring shall be non-polar. The remote-control wiring shall run from the indoor unit control terminal block to the remote controller connected with that indoor unit.

PART 3 - EXECUTION

3.1 PRE-INSTALLATION

A. All pipe lengths and quantity of long radius 90s used in each pipe run are to be marked on as-built plans.

B. Outdoor unit service valves shall not be opened until commissioning.

C. Indoor units, outdoor units or branch selectors (heat recovery) shall not be energized during piping.

D. Install full port ball valves with Schrader on both lines to all indoor units.

3.2 INSTALLATION

A. All pre-commissioning and final checklists shall be submitted to engineer and end-user for review.

B. Install unit level and plumb.

C. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

D. All burrs shall be removed before flaring and tubing.

E. A dedicated R-410A flaring tool is required. A sample of a flare shall be submitted to the design professional with cut sheet from manufacturer showing proper flare dimension.

F. Use only synthetic oil – PVE (polyvinlyether) specifically formulated for refrigerant systems.

G. All brazing to be with a medical grade nitrogen purge 91-3 psig) with a 15% silver braze.

H. Provide nitrogen leak check for the entire refrigerant piping system and submit results in O&M clearly defined as below.

1. Step 1 – Pressurize system to 150 psi. Hold pressure for 5 minutes.
2. Step 2 – Pressurize system to 300 psi. Hold pressure for 15 minutes.
3. Step 3 – Pressurize system to 550 psi. Hold pressure for 24 hours.
4. Test pressure gage readings shall be witnessed and signed off on by general contractor. Final test results shall be submitted to owner in closeout documents.
5. Refrigerant service valves at outdoor units shall remain closed. These valves shall be opened only by the manufacturers commissioning agent.

I. Provide triple evacuation for the entire refrigerant piping system and submit results in O&M clearly defined as below. Micron readings are invalid when pump is pulling on micron gauge.

1. Step 1 - evacuate the system to lowest micron level possible.
2. Step 2 - break vacuum with 50 psi nitrogen purge for appropriate amount of time to sweep piping system free of moisture contamination.
3. Step 3 - purge nitrogen down to 1-3 psi.
4. Step 4 - evacuate to lowest micron level of <500.
5. Step 5 - break vacuum with 50 psi nitrogen purge for appropriate amount of time.
6. Step 6 - purge nitrogen down to 1-3 psi.
7. Step 7 - evacuate to static micron level of <500.
8. Step 8 - micron level shall remain .500 for 24 hrs.
9. Test pressure gage readings shall be witnessed and signed off on by general contractor. Final test results shall be submitted to owner in closeout documents.
10. Refrigerant service valves at outdoor units shall remain closed. These valves shall be opened only by the manufacturers commissioning agent

J. 20" piping rule - A minimum of 20" of straight pipe run shall be maintained into, out of and in between y-branches, branch selectors, elbow fittings, connections to indoor units, etc.

K. All flares are to be tightened with a torque wrench and a backup wrench, tightened as per manufacturer’s recommendations.

L. Submit VRF System design tree (piping schematic, includes pre-charge and additional refrigerant added). Each revised/updated system design tree shall be laminated and installed in in each outdoor unit. Frame and mount each tree adjacent to VRF system controller.

M. Equipment Mounting:

1. Install ground-mounted, compressor-condenser components on cast-in-place concrete housekeeping pad. Anchor outdoor unit to concrete pad.

3.3 CONNECTIONS

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

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 and return ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Section 233300 – Air Duct Accessories.

D. Connect condensate drain piping and extend condensate collection piping system. Condensate drain piping from condensate pump not to be higher than manufacturer's recommendations. If any piping is higher than manufacturer's recommendations, piping to be removed, lowered and routed to drain at contractors' expense.

E. Electrical: Comply with applicable requirements in Division 26 Sections for power wiring, switches, and motor controls.

3.4 FIELD QUALITY CONTROL

A. 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. Condensate Test: Test all condensate drains with log per detail on plans.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.5 Installation Support Services

A. VRF manufacturer shall provide installation support services, as outlined in herein, via a regional technical specialist.

B. Site visits shall be conducted at installation milestones noted below.

1. Project kick off meeting
2. Site visit at 25% project completion
3. Site visit at 50% project completion
4. Pre-startup site visit
5. Site visit for startup of the first system

C. The kickoff meeting shall be completed at the project site, prior to the start of piping, equipment, and wiring installation. Topics to be addressed during this meeting will include the following:

1. Establish clear path of communication channels for the project

2. Installation requirements specific to the VRF systems being installed
3. Review of the VRF equipment and controls submittal
4. Review the manufacturer's software tool and what required for as-built warranty documentation
5. Review what will be observed during 25% and 50% site visits
6. Review pre-startup checklist provided by the manufacturer
7. Review required startup actions and confirm the party responsible for each activity

D. Activities to be completed by the manufacturer's VRF specialist during each site visit are as follows:

1. Review installed VRF systems and controls for compliance with manufacturer's requirements
2. Verify that equipment has been addressed and communications/controls wiring has been installed per manufacturer's requirements
3. Check updates that installing contractor has input into the file in the manufacturer's software tool for as-built requirements
4. Provide a field report identifying any installation issues requiring attention

E. Activities to be completed by the manufacturer's VRF specialist during the pre-startup site visit are as follows:

1. Perform visual observation of the system equipment and controls installation
2. Verify that equipment has been addressed and communications/controls wiring has been installed per manufacturer's requirements
3. Check the completed as-built file in the manufacturer's software tool (including port assignments, piping lengths, and piping sizes)
4. Confirm that pressure testing with nitrogen to manufacturer's requirements is complete
5. Confirm that evacuation to manufacturer's requirements is complete
6. Confirm that the calculated refrigerant charge from manufacturer's software tool is complete, has been weighed in, and all service valves are open
7. Confirm that electrical connections to the outdoor unit are complete and per manufacturer's requirements for startup
8. Review logs completed by installing contractor for each outdoor unit, branch controller, and indoor unit

F. Services to be provided by the manufacturer's VRF specialist during the Day 1 startup site visit are as follows:

1. Assist the mechanical contractor's certified trained technician in system startup
2. Confirm that all the documentation has been completed and recorded to comply with the manufacturer's warranty requirements.

3.6 ADJUSTING

A. Adjust initial temperature and humidity set points.

3.7 CLEANING

A. After completing installation, clean furnaces internally according to manufacturer's written instructions.

B. Install new filters in each indoor unit prior to performing Testing, Adjusting, and Balancing work.

3.8 STARTUP SERVICE

A. Startup of the VRF equipment and controls will be accomplished by the contractor, per the requirements addressed in prior meetings and site visits. The VRF tech specialist will be on site for assistance during the startup of the first system.

B. Final Checks before Startup: Perform the following:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to piping, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Perform cleaning and adjusting specified in this Section.

C. Provide all technical assistance required to Division 23C Energy Management and Controls contractor in mapping across points to the EMCS.

3.9 CLEANING

A. Clean indoor and outdoor units on completion of installation, according to manufacturer's written instructions.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain Variable Refrigerant Flow Systems. Refer to Division 23 Section 230010 – Mechanical General Provisions.

END OF SECTION 238129

SECTION 238143 – DUCTLESS SPLIT-SYSTEM HEAT PUMPS

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. Wall Mounted.
2. Ceiling Cassette.

1.3 REFERENCE STANDARDS

A. AHRI Standard 210/240 – Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment.

B. U.S. Environmental Protection Agency – Energy Star Products.

1.4 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
DSS outdoor units	R	R		R
DSS indoor units	R	R		R
DSS controls and accessories	R	R		

1.5 QUALITY ASSURANCE

A. Ductless split-system heat pumps rated and certified in accordance with AHRI Standard 210/240.

B. Ductless split-system heat pumps Energy Star rated.

C. Product Options: Drawings indicate size, profiles, and dimensional requirements of split-system units and are based on the specific system indicated. Other manufacturers' systems with equal performance characteristics may be considered. Refer to Division 01 Section "Substitutions."

D. 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.

1.6 WARRANTY

A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

B. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace components of split-system heat pump units that fail in materials or workmanship within specified warranty period.

C. Warranty Period: Five year parts from date of substantial completion with first year labor.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models of listed manufacturers are acceptable.

1. Daikin.
2. Trane-Mitsubishi.
3. Hitachi.

2.2 WALL-MOUNTED HEAT PUMP INDOOR UNITS

A. General: The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant piping shall be charged with dehydrated air before shipment from the factory.

B. Unit Cabinet:

1. The unit shall have multi-directional drain and refrigerant piping arrangements providing options for four (4) directions for refrigerant piping and two (2) directions for draining.
2. Unit shall have a separate back plate which secures the unit firmly to the wall.

C. Fan:

1. The evaporator fan shall be an assembly with one or two line-flow fan(s) direct driven by a single motor, be statically and dynamically balanced and run on a motor with permanently lubricated bearings.
2. A manual adjustable guide vane shall be provided with the ability to change the airflow from side to side (left to right).
3. A motorized air sweep louver shall provide an automatic change in airflow by directing the air up and down to provide uniform air distribution.
4. The indoor fan shall be capable of four (4) speeds, High, Mid 1, Mid 2, and Low, two of which may be selected by the room controller.

D. Filter:

1. Return air shall be filtered by means of an easily removable washable filter.

E. Coil:

1. The evaporator coil shall be of nonferrous construction with smooth plate fins on copper tubing with inner grooves for high efficiency heat exchange.
2. All tube joints shall be brazed with phoscopper or silver alloy and shall be pressure tested at the factory.
3. A condensate pan and drain shall be provided under the coil.
4. The condensate pump shall be able to raise drain water 33 inches above the condensate pan.

F. Electrical:

1. The unit electrical power shall be 208 volts, 1 phase, 60 hertz. (Contractor shall be responsible for coordinating unit electrical characteristics with actual site electrical service.)

G. Control:

1. The unit shall have controls provided by the manufacturer to perform input functions necessary to operate the system.

2.3 CEILING CASSETTE INDOOR UNIT

A. General: The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant piping shall be charged with dehydrated air before shipment from the factory.

B. Unit Cabinet:

1. The case to be designed to mount against the ceiling surface in a horizontal supply air configuration.
2. The return air is to be from the bottom and supply air is from a single slot on the front of the unit.
3. The unit shall be manufactured using a coated metal frame covered with an off-white ABS architectural polymeric resin exterior case.
4. Cold surfaces are to be covered with a coated polystyrene insulating material.

C. Fan:

1. Unit to have a single, direct driven, fan made of high strength ABS HR-2407 polymeric resin.
2. The fan motor to have permanently lubricated and sealed ball bearings.
3. The fan/motor assembly to be mounted on vibration attenuating rubber grommets.

D. Filter:

1. Return air to be filtered with a removable, washable filter. Access to the filter media to be through a hinged, spring clip (screwless) return air grille located on the bottom of the unit.

E. Coil:

1. The evaporator coil shall be of nonferrous construction with smooth plate fins on copper tubing with inner grooves for high efficiency heat exchange.
2. All tube joints shall be brazed with phoscopper or silver alloy and shall be pressure tested at the factory.
3. A condensate pan and drain shall be provided under the coil.
4. The condensate pump shall be able to raise drain water 33 inches above the condensate pan.

F. Electrical:

1. The unit electrical power shall be 208 volts, 1 phase, 60 hertz. (Contractor shall be responsible for coordinating unit electrical characteristics with actual site electrical service.)

G. Control:

1. The unit shall have controls provided by the manufacturer to perform input functions necessary to operate the system.

2.4 AIR-COOLED, COMPRESSOR-CONDENSER COMPONENTS

A. Casing: Steel, finished with baked enamel, 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.

B. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

1. Compressor Type: DC inverter driven twin rotary with manual-reset high-pressure switch and automatic-reset low-pressure switch.

C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid sub-cooler.

D. Heat Pump Components: Reversing value and low-temperature air cut-off thermostat.

E. Fan: Aluminum-propeller type, directly connected to motor.

F. Motor: Permanently lubricated, with integral thermal-overload protection.

G. Low Ambient Kit: Permits operation down to 0 °F.

H. Mounting Base: Polyethylene.

2.5 ACCESSORIES

A. Thermostat: Remote, hard-wired control compressor and evaporator fan, with the following features:

1. Status monitoring.
2. Seven day programming of system stop and start.
3. Liquid-crystal display indicating mode, temperature, set-point temperature, indoor temperature, time setting, operating mode, fan speed, air-flow direction, filter sign and error alarm and code.
4. Fan-speed selection, including auto setting.

B. Automatic-reset timer to prevent rapid cycling of compressor.

C. Diamondback refrigerant line sets (or equal) with flared fittings, each end pre-insulated.

D. Refrigerant Valves and Piping:

1. Valves in the variable refrigerant flow system shall be Diamondback BV series ball valves (or equal) with HKG-20HF insulation kits (or equal). Valve shall be a 700 psig Schrader valve for service connections. This valve kit shall be used with all systems.
2. Refrigerant piping between outdoor units and indoor units shall be pre-charged, pre-insulated, copper line sets provided by the equipment manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate with work of other trades.

B. Install all system components in accordance with manufacturer’s written installation instructions.

C. Provide access space around indoor and outdoor units for service. Provide no less than minimum as recommended by manufacturer.

D. Install units level and plumb.

E. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

3.2 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 unit to allow service and maintenance.

C. Ground equipment.

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Installation Inspection: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections, and to prepare a written report of inspection.

B. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new components, and retest.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 COMMISSIONING

A. Engage a factory-authorized service representative to perform startup service.

B. Verify that units are installed and connected according to the Contract Documents.

C. Lubricate bearings, adjust belt tension, and change filters.

D. Perform startup checks according to manufacturer's written instructions and do the following:

1. Fill out manufacturer's checklists.
2. Check for unobstructed airflow over coils.
3. Check operation of condenser capacity-control device.
4. Verify that vibration isolation devices and flexible connectors dampen vibration transmission to structure.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain units.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining units. See Section 230010 “Mechanical General Provisions.”
2. Review data in maintenance manuals. Refer to Section 230010 “Mechanical General Provisions.”

END OF SECTION 238143

SECTION 238416 – DEHUMIDIFIERS

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. Work included in this section: materials, equipment, fabrication, installation and tests in conformity with applicable codes and authorities having jurisdiction for the following:

1. In-line Dehumidifiers.

1.3 REFERENCE STANDARDS

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this Section with three (3) years documented experience.

1.5 SUBMITTALS

A. See Section 230010 Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop and coordination drawings (where shop and coordination drawings are required) according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Dehumidifier	R	R		R
Accessories	R	R		R

1.6 WARRANTY

A. Provide a two (2) year warranty including all accessories (parts and labor).

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Named manufacturer model numbers used as example of item and establish minimum level of quality and minimum standard options. Equivalent models are acceptable.

1. Quest Dry
2. Honeywell.
3. Santa Fe.

2.2 GENERAL

A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.3 In-Line Dehumidifiers

A. Furnish and install in-line dehumidifiers of the sizes and capacities shown on the Drawings.

1. Dehumidifier shall remove the minimum pints per day of water per mechanical schedules.
2. Dehumidifier shall be capable of a fresh air connection.
3. A minimum of a MERV-11 filtration required.
4. Auto-restart after power outages
5. R410A refrigerant

2.4 ACCESSORIES

A. Supply and install the following accessories in accordance with the manufacturer's recommendation.

1. Controller

a. Digital control of relative humidity.
b. Fan filter operation
c. Programmable ventilation timer
d. High temperature cut-out
e. Dryout cycle timer
f. Auto Reboot
g. LCD Display

2. Condensate Pump

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate with work of other trades.

B. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

C. All installations shall be in accordance with manufacturer’s published recommendations.

D. Install in accordance with ARI 630.

E. Connect outlet of unit to drain piping. Provide ball valve.

F. Install the unit with space to access the back and side panels for maintenance and service and also to allow easy access to the filter cover panel. DO NOT INSTALL UNIT WITH THE FRONT PANEL OR FILTER COVER PANEL INACCESSIBLE

G. A drain pan SHALL be placed under the unit if installed above an area where water leakage could cause damage

H. Place the dehumidifier on supports that raise the base of the unit 2.5” above the top of the flanges on the drain pan beneath it. Do not place the dehumidifier directly on structural building members without vibration absorbers.

I. The dehumidifier may be suspended with steel hanger straps or a suitable alternative from structural members, unit must be supported from underneath. Don’t hang from sides or ends.

J. Condensate drains by gravity via the drain port. Use 3/4” male NPT PVC pipe. Route drainpipe to drain. Install a trap if possible. Take care when installing drainpipe to drain port. Use an adjustable wrench to secure the drain port. An optional condensate pump kit may be installed if a lift is required to dispose of the condensate. Provide an auxiliary galvanized or PVC drip pan with safety water sensing/equipment shutoff controls for each unit.

3.2 STARTUP AND TESTING

A. Start-up by a factory authorized technician.

3.3 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain dehumidifiers.

B. See Section 230010 – Mechanical General Provisions.

END OF SECTION 238416

DIVISION 26

ELECTRICAL

DIVISION 26
ELECTRICAL SYSTEMS

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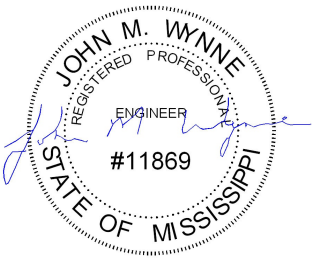
END OF DIVISION 26 TABLE OF CONTENTS



10/04/2022

SECTION 260500
GENERAL REQUIREMENTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications, apply to all Division 26 Specification Sections.

1.2 INTENT OF DOCUMENTS

A. The intent of the drawings and specifications is to obtain complete systems furnished, installed, tested, adjusted and ready for operation per industry standards, applicable codes and manufacturer's recommendations.

B. Incidental materials and details not typically shown or specified, but required for proper installation and operation shall be deemed part of this Specifications and shall be provided.

1.3 REFERENCED CODES & STANDARDS

A. Agencies or publications referenced in this Specification refer to the following:

1. ADA Americans with Disabilities Act
2. AEIC Association of Edison Illuminating Companies
3. AHJ Authority Having Jurisdiction
4. ANSI American National Standards Institute
5. ASME American Society of Mechanical Engineers
6. ASTM American Society for Testing and Materials
7. BICSI Building Industry Consulting Services International
8. EIA Electronic Industries Association
9. FCC Federal Communications Commission
10. IBC International Building Code
11. ICEA Insulated Cable Engineers Association
12. IEEE Institute of Electrical and Electronics Engineers
13. IESNA Illuminating Engineering Society of North America
14. IFC International Fire Code
15. NEC National Electrical Code
16. NECA National Electrical Contractors Association
17. NESC National Electrical Safety Code
18. NETA National Electrical Testing Association
19. NFPA National Fire Protection Association
20. NIST National Institute of Standards and Technology
21. OSHA Occupational Safety and Health Administration
22. TIA Telecommunications Industries Association
23. UL Underwriters Laboratories, Inc.

B. Work shall be performed in accordance with the latest edition of Codes and Standards unless indicated otherwise.

C. Electrical equipment and material and their installation and connection shall strictly comply with the latest editions and applicable sections of the following Codes and Standards as well as additional applicable Codes and Standards referenced in the technical Sections of this Specification for the products and systems to be provided.

NFPA 70 - National Electrical Code (NEC)
NFPA 101 - Life Safety Code
International Building Code (IBC)
International Fire Code (IFC)
National Electrical Safety Code (ANSI-C2)
Americans with Disabilities Act

D. Rules, regulations and ordinances of Federal, State and Local Authorities and Utility Companies in force at the time of execution of this Contract shall become part of this Specification.

E. All equipment and material shall be manufactured in compliance with applicable NEMA, ANSI and NEC standards and requirements.

F. All electrical equipment and materials provided shall be listed by Underwriter's Laboratory (UL) when such listings are issued for the type of equipment or materials. All equipment/material shall be installed and connected in full compliance with their UL listing.

1.4 CONTRACTOR QUALIFICATIONS

A. The Electrical Contractor shall be licensed in the State in which the project is located as an Electrical Contractor with Electrical Contracting as their primary business function. The Electrical Contractor's on-site project Superintendent shall be a licensed Jouneyman Wireman (JW) or similar recognized licensing and shall be familiar with the systems, equipment and materials; their installation, connection and operation; and associated governing codes and standards typical for the type of facility(ies) being constructed as part of this project. The Electrical Contractor's Superintendent shall be on-site whenever any electrical construction work for this project is being performed.

B. The successful Electrical Contractor shall submit to the Professional within 2 weeks of award of the project Contract and prior to any electrical construction work being performed a resume on his proposed project Electrical Superintendent for approval. The Superintendent's resume shall include a minimum of 5 previously performed projects of similar scope and complexity within 10 years of this project's contract date in which he was the project superintendent. For each project listed include an electrical construction cost, general description of the electrical work performed, Owner/Using Agency's name and a contact person with phone number.

C. It is not the intent of this Specification to reiterate or list all the requirements of the published Codes and Standards applicable to this project. It shall be the Contractor's

responsibility to be familiar with, understand and adhere to the minimum requirements of the applicable Codes and Standards. Where this Specification requires more stringent requirements than the applicable Codes and Standards, this Specification shall govern.

D. By submitting a price or bid for the work associated with this project, the Electrical Contractor testifies that he has adequate experience in the type of work to be performed and the systems to be provided to satisfactorily complete the project, and that he is familiar with the applicable Codes and Standards.

1.5 SUBMITTAL REQUIREMENTS

A. Refer to and comply with Division 01 - Submittal Procedures.

B. Submit to the Professional appropriate shop drawings and product data for equipment and material for the electrical systems indicated in the technical Sections of the Specifications. Submittals shall be provided for approval for indicated equipment or material whether or not substituted equipment or materials.

C. Shop Drawing Log: The Contractor shall provide, as a separate submittal prior to submitting any Product Data/Shop Drawings or included with his first submittal for the project, a Log of Shop Drawings/Product Data to be provided as part of the project. The Log shall include the following information as a minimum:

1. Title/Heading Lines including:
    a. Project Name
    b. General Contractors Name
    c. Electrical Contractors Name and Contact Information
    d. Date - This date shall be changed to reflect future updates and changes to the log.

2. Submittal Information for each Submittal in Table Format including:
    a. Submittal Number, if assigned as part of the project submittal tracking.
    b. Associated Specification Section Number.
    c. Specification Section Name.
    d. Specific Equipment Description.
    e. Date Submitted or Date to be Submitted.
    f. Column(s) for Indicating Review Status: Approved, Approved as Noted, Rejected, etc.
    g. Date of Approval.

D. Shop Drawings and Product Data shall be submitted in electronic format using pdf files as follows:

1. Shop Drawings and Product Data shall be separated into separate pdf files with one file for each Technical Section of the Specifications in which information is being provided.
2. PDF files shall be originally generated files and shall not be scanned or faxed reproductions.

3. All information listed on the shop drawings shall be typed. Handwritten notations or information are not acceptable.
4. Any notations made by the Contractor shall be in a legible color other than “red”.
5. Each pdf file shall have a Title Page indicating the following as a minimum:

   (a) Project Name and Address
   (b) Electrical Contractor Company’s name, address and contact information.
   (c) Electrical Distributor Company’s name, address and contact information.
   (d) The Specification Section Number and Name.

6. Each pdf file shall have an Index Page indicating the following as a minimum:

   (a) The Specification Section Number and Name.
   (b) An index style general listing of the type of equipment/material included.
   (c) Space for the Electrical Professional’s review stamp and comments. This space shall be clearly labeled as to its use and shall have a minimum size of 7" wide X 5" high.

7. Samples: Submit the number stated in each technical section of this Specification.

E. All submitted equipment/material and associated options, accessories, special features, etc. shall be clearly marked and indicated on the shop drawings by highlighting or underlining in distinguishable color. Provide appropriate shop drawings on all required accessory equipment.

F. For all substituted equipment or material, the Contractor shall clearly indicate on the shop drawings or product data sheets a deviation statement indicating all variations in dimensions, function, operation, installation, connection, etc. of the proposed substitution equipment or material. Failure to provide this information shall be interpreted to mean that the proposed substituted equipment is identical to the specified equipment in all respects.

   Substituted equipment or material provided and found to not be equal to the specified equipment and whose submittal documents did not indicate the deviation(s) from the specified equipment shall be replaced at the Contractor’s expense with equal equipment or material whether or not installed, connected and/or energized.

G. All shop drawings for all systems, equipment and materials including any required one-line drawings, diagrams, etc. from all sections of the Specification shall be submitted together. Partial submittals will not be reviewed without prior consent.

H. Do not submit shop drawings for equipment/material that is not requested in this Specification.

I. The Professional's review and approval of the shop drawings is only for general conformance with the design concept of the Project and the information given in the Contract Documents. The Contractor is responsible for dimensions to be confirmed and correlated at the job site; information that pertains solely to the fabrication process

or to the means and methods of construction; coordination of work of all trades; and performing all work in a safe and satisfactory manner. Review and/or approval of the shop drawings does not modify the Contractor's duty to comply with the Contract Documents. Any equipment or work found in the judgement of the Professional to be defective or otherwise unsuitable due to substituted equipment or material shall be repaired or replaced by the Contractor at no additional cost to the Owner.

1.6 SUBMITTALS

A. Electrical Contractor qualifications and certifications.

B. Project Electrical Superintendent resume, qualifications, licenses and certifications.

1.7 COORDINATION

A. This Contractor shall familiarize himself with the general construction and building systems of all divisions specified in the Contract Documents. Fully coordinate the installation of all electrical equipment and materials with the general construction work and work of other divisions of the specifications prior to the start of the installation. Notify the Professional, prior to installation, of conflicts between electrical and structural, architectural, mechanical, etc. work.

B. Layout and installation of Division 26 work shall be the responsibility of this Contractor and all conflicts with other trades shall be resolved by the Contractor and approved by the Professional prior to installation.

C. Sequence, coordinate and integrate installing electrical equipment and materials for efficient flow of the work. Coordinate the installation and positioning of large equipment before closing in the building. Providing appropriate pathways, lifting devices, etc. for the installation of electrical equipment and/or materials in new or existing facilities is the responsibility of this Contractor.

D. Fully coordinate prior to installation all Utility Company services including metering facilities for the facility with the appropriate serving Utility Company. Comply with the requirements of the serving Utility Companies.

E. Electrical drawings are not to scale. Follow architectural, equipment supplier shop drawings, and manufacturer's shop and installation drawings for accuracy. Coordinate the installation of electrical devices, equipment and/or materials with the architectural drawings, features and finishes for the space where installed.

1.8 TEST & OBSERVATIONS

A. The complete project shall be, during and/or after construction, subject to the tests and observations as herein specified and as indicated on the Drawings. Deficiencies found as a result of these tests and observations shall be corrected by the Contractor within a reasonable period and at no expense to the Owner.

B. The complete project shall be subject to observations and tests conducted by the Professional or for him in his presence. Upon notice, the Contractor shall furnish not to exceed two men, one to include the project Superintendent, and required tools to assist and be directed by the Professional for a reasonable amount of time to make such tests and observations as are requested by the Professional.

C. The complete project shall be subject to observations and tests conducted by any Federal, State and/or local authority having jurisdiction. The Contractor shall make all corrections of any deficiencies required by the authority having jurisdiction to allow building occupancy.

D. The complete project shall be subject to observations and tests conducted by the Owner's Insurance carrier. After inspection by this agency, Contractor shall make corrections of any deficiencies found adversely affecting the insurance to be carried by the Owner. Acceptance of this report or subsequent reports lie with the Professional or Owner.

1.9 RECORD DOCUMENTS

A. Refer to and comply with Division 01 - Contract Closeout.

B. In addition to the requirements of Division 01, the Contractor shall provide to the Professional with the Close-Out Documents the following:

1. Scanned drawings in pdf format of same scale as original drawings indicating "as built" conditions of the work legibly marked in red showing all variations in the installed work from the requirements of the original Contract Documents. The "as-built" drawings shall include all addenda, approved and installed change orders, field condition changes and other departures from the original Drawings and Specifications.

2. Electronic files in pdf format of the approved shop drawings reflecting the manufacturer's shop fabrication of the equipment and materials actually installed and the approved product data information required by this Specification.

3. Operation and maintenance manuals and manufacturer's instructions for all equipment and systems installed.

4. Copy of all reports of system, equipment or material test as required by this Specification.

1.10 WARRANTY

A. Refer to and comply with Division 01 for general warranty requirements.

B. The Contractor shall guarantee to the Owner all work performed under this contract to be free from defects in workmanship and materials for a period of one year from the date of final acceptance by the Professional and the Owner except as hereinafter noted.

C. Refer to technical sections for specific additional warranty requirements and/or time frames.

D. The Contractor shall correct, repair and/or replace upon notice from the Owner or his authorized representative within a reasonable period of time any defects in the work performed under this Contract arising during the warranty period.

E. Warranty repair work shall include labor, material and travel and shall be provided at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 MATERIAL & EQUIPMENT

A. Use only new equipment and materials of current manufacturer. Equipment/material shall be of current production from manufacturers' of long experience in the manufacture of such types of equipment/material and who are regularly engaged in the production of this type of equipment/material.

B. Notwithstanding any reference in the specifications to any equipment, material or type of construction by name, make or catalog number, such reference shall be interpreted as establishing a standard of quality and shall not be construed as limiting competition. Where the phrase "or approved equal" is used in the Division 26 Specification, substitute equipment, equivalent in all respects to that specified, of any qualified manufacturer is permitted with the written approval of the Professional. Approval will not be considered until after award of contract and only if submitted by the successful Contractor. Where a list of manufacturers and/or catalog numbers is provided and the phrase "or approved equal" is omitted, substitute equipment, equivalent in all respects to that specified, from one of the listed manufacturers is permitted with the written approval of the Professional.

C. Equipment is specified by manufacturer's name and catalog number and is intended to establish the minimum standards of quality acceptable. The manufacturer's name and/or catalog number first mentioned in this Specification shall be considered the specified equipment. The "or equal" manufacturers mentioned or other manufacturers proposed by the Contractor shall be considered as substituted equipment.

D. Substituted equipment shall meet the dimensional and functional requirements of the building as represented by the Drawings and Specifications. All revisions to the contract precipitated by the use of substituted equipment shall be incorporated by the Contractor, after approval in writing by the Professional, and at no additional cost to the Owner.

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE & HANDLING

A. Deliver products to the construction site under provisions of Division 01.

B. Store and protect products under provisions of Division 01 and the associated manufacturer's recommendations.

C. Store all electrical equipment and material in a clean, dry space.

D. Maintain factory wrapping or provide suitable protective covering to protect equipment from dirt, water, construction debris, traffic, etc.

E. Handle in accordance with manufacturer's written instructions. Handle carefully to avoid damage to components, enclosures and finish. Lift only with lugs provide for the purpose.

F. Provide supplemental heat if required to prevent moisture contamination.

3.2 GENERAL EQUIPMENT INSTALLATION

A. Equipment and materials shall be installed and connected in strict compliance with manufacturer's recommendations unless these requirements are exceeded as indicated on the Drawings or specified herein.

B. Perform all work in a "neat and workmanlike" manner as defined in ANSI/NECA 1, Standard for Good Workmanship in Electrical Contracting.

C. Install equipment and materials level, plumb, and parallel and perpendicular to other building systems' elements and components unless otherwise indicated.

D. Install equipment to facilitate service, maintenance, and repair or replacement of components.

E. Install electrical equipment with required "working space" clearances and "dedicated equipment spaces" per NFPA 70 (NEC).

F. Install electrical equipment and associated raceways and accessories to permit access to equipment for maintenance, removal, repair or changes. Do not install electrical equipment in a manner to block required access to non-electrical equipment or components.

G. Electrical equipment and devices shall be mounted at the height specified in the technical sections of this Specification or as indicated on the drawings. Mounting heights may be adjusted slightly to permit cutting of masonry block to the top or bottom of the block course nearest the required height. All heights shall be consistently cut above or below the block coursing so that they are the same height above the reference.

H. The mounting heights of electrical equipment and material shall reference the height above the finished floor or grade above which they are mounted. Mounting heights specified shall reference the center of the box, device, switch or circuit breaker operating handle unless indicated otherwise.

I. Locate electrical outlets and equipment to fit details, panels, decorating or finishes at space. The Professional may direct the Contractor to move the location of any outlet or equipment connection and associated raceways up to 10 feet in any direction within the same space from the location indicated on the drawings if so directed prior to the installation of the work.

3.3 EQUIPMENT SUPPORTS

A. Provide supporting steel not indicated on the drawings as required for the installation of electrical equipment and materials including angles, channels, beams, hangers, etc. Support steel located out of doors or in wet or corrosive environments shall be hot-dipped galvanized.

3.4 IDENTIFICATION

A. Refer to Section 260553 “Electrical Systems Identification” and associated technical sections of this Specification.

3.5 FIRE STOPPING

A. Openings around electrical penetrations through smoke and/or fire rated wall, partition, floor or ceiling assemblies shall be smoke and/or fire stopped using an approved UL listed system designed for the materials encountered to maintain the smoke and/or fire rating of the assembly.

B. All fire proofing in rated walls, partitions, floors or ceiling assemblies shall be performed by a certified Fire Proofing Contractor. The Division 26 Contractor shall be responsible for procuring and coordinating with the Fire Proofing Contractor to provide the required fire proofing of all electrical penetrations in or through rated assemblies.

3.6 CUTTING & PATCHING

A. Refer to the General Conditions of the Contract and Division 01 - Cutting and Patching.

B. Cut, channel, chase and/or drill floors, walls, partitions, ceilings and other surfaces required to permit electrical installations. Obtain permission in writing from the Professional and the General Contractor prior to cutting or penetrating any structural member.

C. Repair and refinish disturbed finish materials and other surfaces indoors and out-of-doors to match adjacent undisturbed surfaces and/or to existing condition prior to work performed.

D. Use experienced and skilled mechanics of the trades involved or employ appropriate sub-contractor to perform all repair and refinishing.

E. All roof penetrations shall be weatherproofed by the Division 07 Contractor. Division 26 Contractor shall be responsible for procuring and coordinating with the Division 07 Contractor to weatherproof all roof penetrations created by the Division 26 work. Roof work shall be performed by the proper personnel and in a manner to maintain any Roof Warranty.

3.7 CLEANING & PROTECTING

A. Properly protect equipment and installations during the construction period to ensure that components, coatings, finishes, cabinets and enclosures are without damage or deterioration at the time of acceptance by the Owner.

B. On completion of construction within an area, inspect exposed finish of outlets, devices, fixtures, equipment, etc. Remove burrs, dirt, paint spots and construction debris.

C. Remove construction debris from all electrical enclosures prior to energizing.

D. Provide touch-up paint on equipment finishes marred during the construction or installation process. Paint shall be as recommended by the equipment manufacturer and shall match the installed equipment finish.

E. Where louvers and vent panels are provided in electrical equipment for cooling purposes, vacuum free of dust, dirt and debris. Provide new filter medium after construction site clean up.

END OF SECTION

SECTION 260505
SELECTIVE ELECTRICAL DEMOLITION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 EXISTING CONDITIONS

A. This project requires renovations and/or additions to existing facilities, additions and modifications to existing systems and associated demolition. The Contractor is responsible for visiting the site and verifying all existing conditions prior to bid and making necessary adjustments to the electrical installations to accommodate the existing conditions.

1.3 FIELD CONDITIONS

A. Owner Occupancy:

1. The Owner will occupy portions of or adjacent facilities during the demolition and construction periods.

B. Project Phasing:

1. The required demolition and construction shall be phased to allow Owner's occupancy and use of the facility or portions of the facility.
2. Refer to the Professional's phasing plan and directions.

C. Testing of Existing Systems:

1. Prior to the beginning of any new work or demolition, the Contractor shall review and test the existing system(s) to be modified and note in writing to the Professional any deficiencies or visible code violations. It is advised that the condition and operation of existing systems in close proximity to the new work be noted as well. These notations will be used to determine the responsibility of the final operating condition of systems at the completion of the project.

1.4 DEFINITIONS

A. Disconnect and Remove: Disconnect equipment from electrical power source. Remove serving electrical branch and/or feeder circuits including raceways and conductors. Remove safety disconnect switches, control panels, operator stations, etc. Place serving overcurrent protection device in the "Off" position and label as spare unless reused in new work.

B. Disconnect: Disconnect equipment from serving branch and/or feeder circuits. Remove serving electrical branch and/or feeder circuits including raceways and conductors back to safety disconnect switch. Place serving overcurrent protection device in the “Off” position and re-label.

C. Disconnect and Reinstall: Disconnect equipment from electrical power source. Remove serving electrical branch and/or feeder circuits including raceways and conductors. Remove safety disconnect switches, control panels, operator stations, etc. Place serving overcurrent protection device in the “Off” position and label as spare unless reused in new work. Maintain and protect equipment for reinstallation and/or relocation under new work.

D. Existing to Remain: Existing items that are not to be disconnected, disconnected and removed or dismantled. Maintain and protect throughout construction period.

1.5 DEMOLISHED MATERIALS OWNERSHIP

A. The Owner shall have first rights of salvage of all demolished equipment and/or material. Demolished equipment and/or material not retained by the Owner shall become the property of the Contractor and shall be removed from the site.

B. Properly dispose of all demolished equipment, material and debris per applicable governmental laws and regulations.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Electrical Equipment & Material: Verify that all electrical services to equipment have been placed in the “Off” position at the source of power and properly locked and tagged.

B. Area or Space Demolition: Verify that all electrical branch circuits and feeder circuits serving the area or space in which demolition is being performed have been de-energized and disconnected and removed or properly locked-out and tagged-out if to remain.

C. Building Demolition: Verify that all electrical service entrances to the facility have been physically disconnected from their source of power.

3.2 REQUIREMENTS

A. Area or Space Demolition: In the areas shown on the Drawings to be renovated, other areas specifically noted, or as required for the installation of the new work, disconnect and remove all existing electrical equipment, lighting luminaires, wiring devices, etc. and associated branch circuits unless indicated on the Drawings or herein specified otherwise. Removal of branch circuits shall include exposed conduits, surface boxes and conductors back to next in-line active device, junction or over-current protection device.

B. Equipment Services:

1. Equipment To Be Removed: Disconnect and remove existing electrical service(s) including but not limited to final connections, disconnect switches, branch circuits, control panels, etc. Unless specifically indicated to be removed or space is required in existing electrical distribution equipment for new electrical services, serving circuit breaker shall become spare and shall be labeled as such and left in the Off position.
2. Equipment To Be Replaced: Where indicated on the Drawings for new equipment to be connected to the existing branch circuit(s) that served the removed equipment, provide the following:

    a. Existing Disconnect Switch & Branch Circuit(s) To Remain: Provide and connect new final connection branch circuit(s) from existing disconnect switch(es) to new equipment connection point(s). Branch circuit(s) conduit & conductors shall match existing construction unless indicated otherwise.
    b. Existing Branch Circuit To Remain: Provide and connect new disconnect switch(es) as indicated. Extend and connect existing branch circuit(s) to associated new disconnect switch(es). Provide and connect new final connection branch circuit(s) from disconnect switch(es) to new equipment connection point(s). Branch circuit(s) conduit & conductors shall match existing construction unless indicated otherwise.

3. If existing electrical services or a portion thereof are not specifically indicated to be reused for the connection of new or replacement equipment, the electrical service(s) shall be new.

C. Lighting Luminaires, Wiring Devices, Feed-Thru Devices: Disconnect and remove indicated luminaires and devices and associated outlet box(es) and serving branch circuit(s). Remove branch circuit back to next in-line active outlet box(es) or junction box(es). Reroute, relocate, refeed, etc. feed-thru branch circuits interrupted by demolition and serving remaining active outlets.

D. Electrical Service & Distribution System: Disconnect and remove the existing electrical service entrance equipment, electrical distribution equipment and associated feeder circuits unless indicated on the Drawings or herein specified otherwise. Removal of feeder circuits shall include exposed conduits, surface boxes and conductors back to over-current protection device.

3.3 RACEWAY DEMOLITION

A. Surface and Exposed Raceways serving Demolished Equipment: Disconnect and remove including boxes, conduits and conductors.

B. Concealed or Abandoned Raceways serving Demolished Equipment: Cut back flush with finish or surface and cap. Provide blank plate or cover on all abandoned flush mounted junction boxes in existing walls to remain without new finishes.

3.4 CIRCUITS TO REMAIN

A. Maintain and restore, if interrupted, all existing feed-thru feeder and/or branch circuits serving areas not under renovation, other areas outside the scope of this project or existing equipment to remain.

B. Reroute and connect as indicated, as directed or required all existing branch and feeder circuits routed through areas of demolition that will conflict with the new construction. Raceways and conductors required to accomplish this work shall be sized per the existing rerouted circuit and connected to the existing circuit by specified splicing methods in a properly sized junction box unless indicated on the Drawings or herein specified otherwise.

C. Comply with NFPA 70 (NEC).

3.5 CLEANING

A. Clean adjacent equipment, finishes and improvements of dust, dirt and debris caused by electrical demotion operations.

END OF SECTION

SECTION 260519
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. Copper Conductors, rated 600V or less.
2. Connectors, Splices and Terminations rated 600V or less.

B. Related Sections:

1. Division 7 Section “Penetration Firestopping”.

1.2 REFERENCES

A. ANSI/IEEE C2 - National Electrical Safety Code.

B. ANSI/NFPA 70 - National Electrical Code.

C. ANSI/UL 467 - Grounding and Bonding Equipment.

D. ASTM B 1 - Standard Specification for Hard-Drawn Copper Wire.

E. ASTM B 8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

F. NEMA WC 3 - Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-19-81).

G. NEMA WC 5 - Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-61-402).

H. UL 44 - Thermoset-Insulated Wires and Cables.

I. UL 83 - Thermoplastic-Insulated Wires and Cables.

J. UL 486A-486B - Wire Connectors.

K. UL 486C - Splicing Wire Connectors.

L. UL 486D - Standard for Insulated Wire Connector Systems for Underground Use or in Damp or Wet Locations.

M. UL 2196 - Standard for tests for Fire Resistive Cables.

1.3 DEFINITIONS

A. Branch Circuit: An electrical power circuit consisting of the overcurrent protection device, the power and equipment grounding conductors, the raceway system, the safety disconnect device (when required by Code) and the final connection to the outlet, device or equipment.

B. Branch Circuit Homerun: The power and equipment grounding conductors and associated raceways connecting the branch circuit overcurrent device(s) to an outlet box for electrical connection to a device or equipment or to a homerun junction box for separation of the individual branch circuit conductors for routing to their respective loads when conductors for multiple branch circuits are combined in the same raceway.

C. Homerun Junction Box: A junction or outlet box in a branch circuit raceway system where all of the associated branch circuit conductors are combined into a single raceway for routing to the serving electrical distribution equipment. A Homerun Junction Box shall be located in an accessible location as close to the connected outlets, devices and equipment served by the associated branch circuits as reasonably possible.

1.4 SUBMITTALS

A. Refer to Section 260500 “General Requirements for Electrical Systems” for additional requirements.

B. Product Data:
   1. Listed Manufacturer: None Required.
   2. Proposed Equal Manufacturer: For each type of proposed product.

1.5 SUBMITTALS FOR CLOSE-OUT

A. Field Acceptance Test Reports on installed low-voltage power conductors.

1.6 DELIVERY, STORAGE & HANDLING

A. Visually inspect conductors prior to installation and during installation for damage and signs of mis-handling.

B. Store in a clean, dry space. Protect from dirt, fumes, water, corrosive substances and construction debris.

PART 2 - PRODUCTS

2.1. MANUFACTURERS

A. Southwire Company
B. General Cable Corporation
C. American Insulated Wire Corporation; a Leviton Company

D. Approved Equal

2.2 COPPER CONDUCTORS

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600V or less.

B. Standards:

1. Listed and labeled as defined in NFPA 70 (NEC) by a qualified testing agency and marked for intended location and use.
2. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

D. Insulation:

1. Type THHN and Type THWN-2: Comply with UL 83.
2. Type XHHW-2: Comply with UL 44.

2.3 CONNECTORS & SPLICES

A. Description: Factory-fabricated connectors, splices and lugs of size, ampacity rating, material, type and class for application and service indicated; compatible with indicated conductors; listed and labeled as defined in NFPA 70 (NEC) by a qualified testing agency and marked for intended location and use.

B. Lugs: One piece, seamless, compatible with indicated conductor.

1. Material: Copper or Aluminum.
2. Type: One or two hole with standard barrel as required for termination.
3. Termination: Compression.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. All power conductors shall be copper.

B. Conductors #10 AWG and smaller shall be solid. Conductors #8 AWG and larger shall be stranded. All final connections to motors and vibrating equipment shall be made with stranded conductors.

C. Minimum Conductor Sizes shall be as follows:

1. Power Conductors: #12 AWG minimum.

2. Control/Signal Systems: #14 AWG minimum unless indicated otherwise.

D. Branch Circuit Wiring Length Limitations:

1. 208Y/120V Branch Circuits over 100 feet in Length: Increase conductor size one size for each 100 feet of length. Increase raceway size as required in compliance with NFPA 70 (NEC).
2. 480Y/277V Branch Circuits over 150 feet in Length: Increase conductor size one size for each 150 feet of length. Increase raceway size as required in compliance with NFPA 70 (NEC).

3.2 CONDUCTOR INSULATION APPLICATIONS

A. Electrical Service Entrance: Type THHW, THWN, XHHW-2, rated 90ºC for wet locations, single conductor in raceway.

B. Underground Feeder Circuits: Type THWN-2, rated 90ºC for wet locations, single conductor in raceway.

C. Feeder Circuits: Type THHN/THWN-2, rated 90ºC for dry and wet or damp locations, single conductor in raceway.

D. Branch Circuits: Type THHN/THWN-2, rated 90ºC for dry and wet or damp locations, single conductor in raceway

E. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless steel, wire-mesh, strain relief device at terminations to suit application.

3.3 INSTALLATION OF CONDUCTORS

A. All power conductors shall be installed in conduit and raceway systems unless specifically indicated otherwise.

B. Install conductors only after:

1. Building interior is enclosed and weather-tight.
2. Raceway system installation, connection, termination and support is complete.
3. Mechanical work likely to damage conductors has been completed.

C. Use manufacturer-approved pulling compound or lubricant where necessary. Compound used shall not deteriorate conductor or insulation. Do not exceed manufacturer’s recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Support cables and conductors according to Section 260529 “Hangers and Supports for Electrical Systems.”

F. All 120V and 277V branch circuits shall have dedicated neutral conductor of same size as associated phase conductors.

G. Neatly train and lace conductors inside boxes, equipment and panelboards.

H. Branch Circuit Homeruns shall not exceed the number of circuits and conductors indicated on the drawings.

I. Wiring at Outlets: Install conductors at each outlet with a minimum of 6 inches of slack.

J. Provide crimp type lug on conductors where stranded conductors are terminated. Do not place bare stranded conductors directly under screw-type terminals.

3.4 CONNECTORS, SPLICES & TERMINALS

A. Connectors:

1. Except where equipment is furnished with bolted or screw type lug, use compression set pressure connectors with insulating covers. Use compression tools and die compatible with the connectors being installed.
2. When allowed, use compression-set type with application of insulating tape, pre-stretched or heat-shrinkable insulating tubing for splices and taps of #8 AWG conductors and larger. Install with hydraulic compression tool.
3. Use pre-insulated “twist-on” connectors (wire nuts) with integral spring for splices and taps of #10 AWG conductors and smaller. Push-on type connectors shall not be used.
4. Tighten electrical connections and terminals according to manufacturer’s published torque-tightening values. If manufacturer’s torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Splices:

1. Make splices, terminations and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

2. Make splices and connections in accessible boxes, gutters or cabinets only.

3. Conductors #8 AWG and larger shall be spliced only with specific approval from the Professional.

C. Terminals:

1. Eye type crimped terminal for removable screw type terminal. Forked torque terminal when terminal screw can not be removed.
2. Train wires to eliminate fanning of strands, crimp with proper tool and die.
3. Torque screw termination per manufacturer’s recommended values.

3.5 IDENTIFICATION

A. Conductors of 600V and less electrical service entrances, feeder circuits and branch circuits shall have conductor insulation colors as listed below.

1. Where conductor type, size, etc. does not allow specified insulation colors, conductors shall be identified using products specified in Section 260553 “Electrical Systems Identification” at each accessible location and termination.

B. Color coding for 480/277V Circuits:

1. Phase A: Brown, Phase B: Orange; Phase C: Yellow
2 Neutral Conductor: Gray
   a. Dedicated Neutral to Phase A: Gray with Brown tracer.
   b. Dedicated Neutral to Phase B: Gray with Orange tracer.
   c. Dedicated Neutral to Phase C: Gray with Yellow tracer.
3. Equipment Ground: Green

C. Color coding for 208/120V Circuits:

1. Phase A: Black, Phase B: Red; Phase C: Blue
2 Neutral Conductor: White
   a. Dedicated Neutral to Phase A: White with Black tracer.
   b. Dedicated Neutral to Phase B: White with Red tracer.
   c. Dedicated Neutral to Phase C: White with Blue tracer.
3. Equipment Ground: Green

D. Color coding for 240/120V Circuits:

1. Phase A: Black, Phase B: Orange (High Leg); Phase C: Red
2 Neutral Conductor: White
   a. Dedicated Neutral to Phase A: White with Black tracer.
   b. Dedicated Neutral to Phase C: White with Red tracer.
3. Equipment Ground: Green
4. Single phase, 240/120V Color Coding similar without Phase B.

E. Properly identify each spare conductor at each end with proper identification to locate other end and label as spare conductor.

3.6 FIELD QUALITY CONTROL

A. Conductor insulation test shall be performed on all electrical service entrance conductors, switchboard/panelboard and transformer feeder conductors and branch circuit conductors #2 AWG and larger. An insulation test shall be performed on any feeder or branch circuit as requested by the Professional for trouble shooting purposes. The “600V Conductor Insulation Test Report” found at the end of this section shall be completed with test results and shall be submitted to the Professional prior to substantial completion of the project.

B. 600 volt conductor insulation tests shall be performed using a 500 volt megger. Each conductor shall be tested with all splices made but no equipment or devices connected. Feeder/branch circuits with paralleled conductors shall have conductors tested separately prior to paralleling. The ohmic value measured shall be recorded and the results shall meet the minimum requirements of the conductor manufacturer. Conductors not meeting these minimum requirements shall be replaced or repaired as directed by the Professional.

END OF SECTION

SECTION 260526
GROUNDING & BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes grounding and bonding systems and equipment.

B. Grounding and bonding of electrical systems shall be in accordance with Article 250 of NFPA 70 (NEC).

1.2 REFERENCE STANDARDS

A. ANSI J-STD-607-A - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.

B. ASTM B 3 - Specification for Soft or Annealed Copper Wire.

C. ASTM B 8 - Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard or Soft.

D. ASTM B 33 - Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes.

E. IEEE C2 - National Electrical Safety Code (ANSI).

F. NETA MTS - Maintenance Testing Specifications.

G. NFPA 70 (NEC) - National Electrical Code.

H. UL 467 - Grounding and Bonding Equipment.

1.3 SUBMITTALS

A. Product Data - None

1.4 CLOSEOUT SUBMITTALS

A. Indicate on As-Built Drawings location and routing of Grounding Electrode System.

B. Results of Grounding System Ground Resistance Testing.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements

1. Electrical Components, Devices and Accessories shall be listed and labeled as defined in NFPA 70 (NEC).

2. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper conductor insulated for 600V with insulation characteristics similar to current-carrying conductors.

1. Insulation Color: Green or Green with Yellow Tracer.

B. Bare Conductors: Copper

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Conductor: #4 or #6 AWG, stranded copper.
5. Bonding Jumper: Copper Tape, braided conductors, terminated with copper ferrules, 1 5/8" wide and 1/16" thick.
6. Tinned Bonding Jumper: Tin coated Bonding Jumper.

C. Grounding Bus: Annealed copper with terminal screws as required for terminated conductors, ampere rating as indicated or per NEMA standards.

2.2 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to the AHJ for applications in which used and for specific types, sizes and combinations of conductors and other items connected.

B. Welded Connectors: Exothermic-welding kits of types recommended by the manufacturer for materials being joined and installation conditions.

C. Bolted Connectors for Conductors and Pipes: Copper or copper-alloy, bolted pressure type with a least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

D. Compression Connectors: Irreversible type.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel, 3/4 inch diameter by 10 foot length.

2.4 GROUNDING BUSBARS

A. Pre-drilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, 24 inches in length, with 9/32 inch connect holes per ANSI Joint Standard J-STD-607-A. Stand-off insulated mounting brackets for wall mounting.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Provide solid copper conductor for #10 AWG and smaller and stranded copper conductors for #8 AWG and larger unless indicated otherwise.

B. Underground Grounding Conductors: Provide bare copper conductor, #2/0 AWG minimum or as indicated on the drawings.

C. Grounding Busbar: Provide in telecommunication rooms and electrical room housing electrical service entrance equipment.

D. Grounding Conductor Terminations and Connections:

1. Pipe and Equipment Connections: Bolted connectors.
2. Underground Connections: Exothermic-weld.
3. Ground Rod Connections: Exothermic-weld.
4. Structural Steel Connections: Exothermic-weld or irreversible compression type connector.

3.2 GROUNDING ELECTRODE SYSTEM

A. Where new electrical service entrances are provided, provide and connect grounding electrode system consisting of grounding electrode conductor, driven ground rods, incoming metallic cold water pipe and building structural steel.

B. The number of ground rods for the grounding electrode system shall be per the following or as required to obtain the maximum resistance to ground of the grounding electrode system to 10 ohms.

1. Service Equipment Rating less than 400A: One ground rod minimum.
2. Service Equipment Rating 400A to 799A: Two ground rods minimum.
3. Service Equipment Rating 800A and greater: Three ground rods minimum.

C. Ground Rods shall be installed with top a minimum 12 inches below the finished grade with a minimum distance between interconnect ground rods of 10 feet. Install ground rods in a straight line or triangular pattern.

D. Grounding Electrode Conductor: Bare copper sized as indicated on the drawings or per NFPA 70 (NEC) Article 250 if size not indicated.

E. Interconnect all grounding electrode system driven ground rods with continuous un-spliced grounding electrode conductor. Grounding electrode conductor shall extend unspliced along the shortest path possible and connect to the Ground Bus of the associated electrical service entrance equipment. Install grounding electrode conductor a minimum of 18 inches below finished grade.

F. Route grounding electrode conductor from electrical service entrance equipment to beyond the building perimeter in Schedule 40 electrical-grade PVC conduit.

G. The incoming metallic water pipe where present and of the proper characteristics shall be bonded to the grounding electrode system. Connection shall be made within 5 feet of the pipe's point of entry into the building and shall be accessible for inspection.

H. The building's structural steel where present shall be bonded to the grounding electrode system and the connection shall be accessible for inspection.

3.3 GROUNDING AT ELECTRICAL SERVICE ENTRANCE

A. Connect Grounding Electrode Conductor to ground bus of electrical service entrance equipment.

B. Bond the electrical service entrance equipment grounded (neutral) bus and equipment grounding bus together with a Main Bonding Jumper (MBJ). MBJ shall be the same size as the indicated Grounding Electrode Conductor or equivalent factory installed bussing. The grounded (neutral) conductors and the equipment grounding conductors shall not be bonded together at any other location in the system except at separately derived systems as defined by NFPA 70 (NEC).

C. Bond all sections, cubicles, conduits and non-current carrying metallic parts of the electrical service entrance equipment shall be bonded together and connected to the equipment grounding bus using a #6 AWG bare copper conductor.

3.4 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Where separately derived systems (i.e dry-type transformers, engine generators, etc.) are being provided, provide grounding electrode system at each separately derived system.

1. Bond the grounded (neutral) bus to the equipment grounding bus or conductor by a main bonding jumper. This bonding shall occur within the equipment's enclosure at the connection terminals of each bus.

2. Bond the grounded (neutral) bus to the nearest grounding electrode by a grounding electrode conductor. The grounding electrode may be the building's structural steel where effectively grounded and bonded to the electrical service entrance grounding electrode system, the incoming metallic water pipe where the connection can be made within five (5) feet of the pipes entry into the building and/or the building's electrical service grounding electrode system.

3. The grounding electrode conductor and the main bonding jumper of each separately derived system shall be bare copper sized as indicated on the drawings or per Article 250 of NFPA 70 (NEC) whichever size is largest. The grounding electrode conductor shall run continuous without splices and utilizing the most direct path from the separately derived system's grounded (neutral) bus to the grounding electrode(s). The grounding electrode conductor shall be routed in electrical grade Schedule 40 PVC conduit to the point of connection to the grounding electrode system. All connections of the grounding electrode conductor to the grounding electrodes shall be made by exothermic weld(s).

4. All metallic piping systems (water, natural gas, fire protection, etc.) located within the area served by the separately derived system shall be bonded to the separately derived system's grounding electrode system in accordance with Article 250 of the NFPA 70 (NEC).

3.5 EQUIPMENT GROUNDING

A. Provide and connect insulated equipment grounding conductor in all feeders and branch circuits.

B. Size of equipment grounding conductor for branch circuits: For branch circuits with #12 and #10 AWG phase conductors, size equipment grounding conductor the same size as phase conductors. For branch circuits with #8 or larger phase conductors, size equipment grounding conductor as indicated or per Article 250 of NFPA 70 (NEC) if size not indicated.

C. Size of equipment grounding conductor for feeder circuits: Size as indicated or per Article 250 of NFPA 70 (NEC) if size not indicated.

D. Bond equipment grounding terminal of all grounding-type power receptacles and devices to the equipment grounding conductor and to the outlet box or enclosure housing the device.

E. Bond all metallic boxes, enclosures, wireways, etc. that are connected to the electrical power system to the equipment grounding conductor.

F. Branch circuit conduits 1 1/4 inch and larger and all feeder circuit conduits shall be provided with a grounding bushing at all connections to an enclosure. Bond bushing together using #8 AWG bare copper equipment grounding conductor and then bond to enclosure at grounding equipment conductor lug or ground bus.

G. Couple conduits together and connect to boxes, fittings and enclosures so as to provide effective electrical continuity. Assure ground continuity on all GRC feeder and GRC branch circuits 1 1/4 inch and larger by two locknuts, one inside and one outside the connected box or enclosure.

H. All metallic piping systems (water, natural gas, fire protection, etc.) within or attached to the building shall be bonded to the grounding electrode system per NFPA 70 (NEC).

I. Bond the building's structural steel to the grounding electrode system per NFPA 70 (NEC).

J. Where a lightning protection system is provided or exist on the building, the lighting protection system's grounding electrode system shall be bonded to the electrical service entrance grounding electrode system using a same size bare copper conductor as the lighting protection system grounding electrode conductor.

K. Manholes: Provide driven ground rod through floor, close to wall, and set rod depth so 4 inches will extend above the floor. Bond all exposed metallic components and parts within the manhole to the ground rod using #4 AWG bare copper conductor. Train conductors level and plumb around corners and fasten to manhole walls. Connect to medium-voltage cable armor and shields according to written instructions of manufacturer's of splicing and termination kits.

L. Pad-Mounted Transformers and Switches: Provide two driven ground rods at opposite corners and provide ground ring around the equipment pad. Ground pad-mounted equipment per manufacturer's recommendations to the ground ring at ground rod connections. Ground ring and equipment grounding taps shall be #2/0 AWG bare copper minimum. Bury ground ring not less than 12 inches from the pad perimeter and a minimum of 18 inches below finished grade.

M. Pole Supporting Outdoor Lighting Luminaires: Provide ground rod at each pole and bond to pole grounding terminal using #6 AWG copper conductor.

N. Metallic Fences Around Electrical Equipment: Comply with the requirements of IEEE C2. Bond to equipment ground grid using #8 AWG minimum size copper conductor. Provide flexible bonding jumper and bond gates to the associated fence.

O. Isolated Grounding Receptacle: In addition to the equipment grounding conductor in the serving branch circuit, provide an insulated and isolated grounding conductor and connect to the receptacle grounding terminal. Isolate the conductor from the raceway system and terminate on the isolated ground bus at the serving panelboard.

3.6 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid placing conductors where they may be subjected to strain, impact or damage.

B. Ground Rods: Drive rods until tops are 12 inches below finished grade unless otherwise indicated. Make all connections using exothermic welds.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

D. Grounding for Steel Building Structure: Provide a driven ground rod at the base of each corner column and at intermediate exterior columns at distances not mor than 60

feet apart. Bond column to ground rod using #1/0 bare copper conductor. Exothermic weld all connections.

E. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors and connection methods so metal in direct contact are galvanically compatible.

3.7 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Provide inspection of all grounding and bonding connections. Inspect physical and mechanical condition. Verify tightness of accessible, bolted electrical connections.

2. Test completed grounding system at each location where a maximum ground-resistance level is specified and at electrical service entrance equipment grounding terminal/bus.

a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means and without chemical treatment or other artificial means of reducing natural ground resistance.
b. Perform test by fall-of-potential method according to IEEE 81.

B. Provide report for inclusion in Close-Out Documents indicating measure ground-resistance at the electrical service entrance equipment and other locations where maximum ground-resistance levels are specified.

C. Where ground-resistance levels exceed specified values, promptly notify the Professional and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 260529
HANGERS & SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel slotted support systems.
2. Conduit and cable support systems.
3. Support for conductors in vertical conduit.
4. Structural steel for fabricated supports and restraints.
5. Mounting, anchoring, and attachment components including mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
6. Fabricated metal equipment support assemblies.
7. Concrete housekeeping equipment pads.

1.2 SUBMITTALS

A. Refer to Section 260500 “General Requirements for Electrical Systems” for additional requirements.

B. Shop Drawings: Provide construction details, material descriptions, dimensions, profiles and finishes for the indicated equipment support assemblies.

1.3 REFERENCED STANDARDS

A. AWS D1.1/D1.1M - Structural Welding Code - Steel.

B. ASTM A 36/A 36M - Carbon Structural Steel.

C. ASTM A 325 - Structural Bolts, Steel, Heat Treated, 827/724 MPa Minimum Tensile Strength.

D. ASTM A 780 - Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.

E. MSS SP-58 - Pipe Hangers and Supports - Materials, Design and Manufacture.

F. MSS SP-69 - Pipe Hangers and Supports - Selection and Application.

G. MFMA-4 - Metal Framing Standards Publication.

H. NECA 1 - Standard Practices for Good Workmanship in Electrical Construction.

I. NECA 101 - Standard for Installing Steel Conduits (Rigid, IMC, EMT).

J. NFPA 70 - National Electrical Code.

K. SSPC-PA 1 - Paint Application Specification No. 1: Shop, Field and Maintenance Painting of Steel.

1.4 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M.

B. Comply with NFPA 70 (NEC).

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE AND ATTACHMENT COMPONENTS

A. Rated Strength: Adequate in tension, shear and pullout force to resist maximum loads calculated or imposed with a minimum structural safety factor of 5 times the applied force.

B. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. Material for Channel, Fittings and Accessories: Galvanized Steel unless indicated otherwise.
2. Channel Width: Selected for applicable load criteria, minimum 1 5/8 inches.
3. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
4. Nonmetallic Coatings: Manufacturer’s standard PVC, polyurethane or polyester coating applied according to MFMA-4.
5. Painted Coatings: Manufacturer’s standard painted coating applies according to MFMA-4.

C. Conduit and Cable Support Devices: Steel and malleable iron hangers, clamps and associated fittings designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes and bars; black and galvanized.

F. Mounting, Anchoring and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Mechanical Expansion Anchors: Insert-wedge-type, stainless steel for use in hardened portland cement concrete with tension, shear and pullout capacities appropriate for supported loads and building materials used.
2. Concrete Inserts: Steel or malleable iron, slotted support system units similar to MSS Type 18, comply with MFMA-4 or MSS SP-58.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
4. Through Bolts: Structural type, hex head and high strength. Comply with ASTM A 325.
5. Toggle Bolts: All-steel springhead type.
6. Hanger Rods: MSS SP-58 threaded steel with adjusting and lock nuts.

2.2 FABRICATED METAL FRAMING EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural steel plates, shapes, tubes and bars. Shop or field fabricated to fit dimensions of supported equipment.

B. Assemblies Installed Outdoors: Welded, hot-dipped galvanized after fabrication.

1. Assembly Construction: Constructed of structural steel shapes, tubes and bars welded together to accommodate the equipment to be mounted. Length and height of assembly as required for mounted equipment.

a. Vertical Uprights: 6-inch steel channels, length as required, minimum 2 per mounting frame, 6-feet maximum spacing between vertical uprights. Set uprights in concrete with minimum depth 24-inches below finished grade with a minimum of 4-inches of concrete coverage on all sides.
b. Horizontal Members: 3-inch steel angle iron or tubing, length as required, minimum 2 per mounting frame, spacing as required for mounting of equipment, weld to vertical uprights.
c. Concrete Equipment Pad: Reinforced concrete pad per Specification Section “Cast In-Place Concrete”, 3000 psi, 4-inch minimum thickness with minimum 8-inch turn-downs around perimeter. Pad dimensions shall be 12-inches beyond each end of equipment frame and provide a minimum of 36-inches of working depth in front of panelboards, control panels, etc. measured from the face of the largest enclosure.

C. Assemblies Installed Indoors: Welded or bolted, galvanized components.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements of this Specification are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC and GRC as scheduled in NECA 1, where its Table 1 lists maximum spacings that are less than those stated in NFPA 70 (NEC).

1. Size steel hanger rods for individual and trapeze supports for supported load with specified structural safety factor.
2. Minimum hanger rod size shall be 3/8 inch.

C. Multiple Raceways or Cables: Provide trapeze-type supports fabricated with steel slotted or other support system. Size trapeze supports so that capacity and load can be increased by 25 percent without exceeding design load limits.

1. Secure raceways and cables to trapeze supports with single-bolt conduit clamps using spring friction action for retention in support channel.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1 1/2 inch and smaller raceways serving branch circuits and communication systems above accessible ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified herein.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load for strength determination shall be weight of supported components plus 200 pounds.

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by Code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Existing Concrete: Expansion anchor set in epoxy.
4. To Masonry: Approved toggle-type bolt on hollow masonry units and expansion anchor fasteners on solid masonry units.
5. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M with lock washers and nuts or beam clamps (MSS SP-58, Type 19,21,23,25 or 27) complying with MSS SP-69.
6. To Light Steel: Sheet metal screws.
7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes and other devices on slotted-channel racks attached to substrate.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

E. Do not support raceway by other raceway.

F. Do not support equipment or raceway from metal roof decking or floor decking.

G. Do not support or impose the weight of electrical equipment, raceways or lighting luminaires on support provided for other trade systems (i.e. suspended ceiling supports, mechanical equipment and piping supports, etc.).

H. Where raceways are indicated to be routed on the roof, provide conduit mounting pedestals as required to support conduits. Maximum spacing of supports shall be 10 feet. Install pedestal on roof deck and flash into roofing material. Contract Roofing Contractor to perform all roofing work to water proof the installation. Roofing Contractor shall be certified by roof manufacturer as required to maintain any and all warrantees.

I. Punching, drilling or welding of building structural steel or welding attachment to building structural steel is not allowed unless approved in writing by the Structural Engineer.

3.3 CONCRETE HOUSEKEEPING PADS

A. Construct concrete housekeeping pads for all floor-mounted electrical equipment except dry-type transformers 150KVA and smaller unless otherwise indicated.

B. Dimensions: 3 inches high and not less than 2 inches larger in both directions than supported equipment so that anchors will be a minimum of 10 bolt diameters from the edge of the pad.

C. Use 3000 psi, 28-day compressive-strength concrete. For concrete materials, reinforcement and placement requirements comply with Division 3 Section “Cast-In-Place Concrete”.

D. Anchor equipment to concrete pad as follows:

1. Place and secure anchorage devices. Use supported equipment manufacturer’s setting drawings, templates, diagrams, instructions and directions furnished with the items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer’s written instructions.

3.4 FINISH TOUCH-UP

A. Galvanized Surface: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 260533
RACEWAYS & BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Rigid non-metallic conduits and fittings.
3. Metal wireways and auxiliary gutters.
4. Boxes, enclosures and cabinets.
5. Handholes and boxes for exterior underground branch circuit wiring.
6. Raceway sleeves and sleeve seals.
7. Miscellaneous fittings and accessories.

B. Related Requirements:

1. Division 7 Section “Penetration Firestopping”.

1.2 DEFINITIONS

A. GRC: Galvanized rigid steel conduit.

B. IMC: Intermediate metal conduit.

C. EMT: Electrical metallic tubing.

D. FMC: Flexible metallic conduit.

E. LFMC: Liquid-tight flexible metallic conduit.

F. RNC: Rigid non-metallic conduit.

G. PVC: Polyvinyl chloride.

H. HDPE: High density poly ethylene.

I. Circuit Definitions.

1. Branch Circuit: An electrical power circuit consisting of the overcurrent protection device, the power and equipment grounding conductors, the raceway system, the safety disconnect device (when required by Code) and the final connection to the outlet, device or equipment.
2. Branch Circuit Homerun: The power and equipment grounding conductors and associated raceways connecting the branch circuit overcurrent device(s) to an outlet box for electrical connection to a device or equipment or to a homerun

junction box for separation of the individual branch circuit conductors for routing to their respective loads when conductors for multiple branch circuits are combined in the same raceway.

3. Homerun Junction Box: A junction or outlet box in a branch circuit raceway system where all of the associated branch circuit conductors are combined into a single raceway for routing to the serving electrical distribution equipment. A Homerun Junction Box shall be located in an accessible location as close to the connected outlets, devices and equipment served by the associated branch circuits as reasonably possible.
4. Feeder Circuit: An electrical power circuit consisting of the overcurrent protection device, the power and equipment grounding conductors and the raceway system connecting components of the electrical distribution system.

1.3 REFERENCED STANDARDS

A. ANSI/NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting.

B. ANSI C80-1 - Rigid Steel Conduit - Zinc Coated (GRC).

C. ANSI C80-3 - Electrical Metallic Tubing - Zinc Coated (EMT).

D. ANSI C80-6 - Intermediate Metal Conduit - Zinc Coated (IMC).

E. ANSI/SCTE 77 - Specification for Underground Enclosure Integrity.

F. ASTM A 53/A 53M - Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.

G. BICSI TDMM - Telecommunications Distribution Methods Manual, latest edition.

H. NEMA 250 - Enclosures for Electrical Equipment (1000 V Maximum).

I. NEMA FB 1 - Fittings, Cast Metal Boxes and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable.

J. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports.

K. NEMA OS 2 - Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports.

L. NEMA RN 1 - Polyvinyl Chloride Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.

M. NEMA TC 2 - Electrical Polyvinyl Chloride Conduit.

N. NEMA TC 3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing.

O. NEMA TC 7 - Standard for High Density Polyethylene (HDPE) Raceway Conduit.

P. NFPA 70 - National Electrical Code

Q. TIA-569-B - Commercial Building Standard for Telecommunication Pathways and Spaces.

R. UL 1 - Flexible Metal Conduit.

S. UL 6 - Electrical Rigid Metallic Conduit - Steel.

T. UL 360 - Liquid-Tight Flexible Steel Conduit.

U. UL 514A - Metallic Outlet Boxes.

V. UL 514B - Conduit, Tubing and Cable Fittings.

W. UL 514C - Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers.

X. UL 651 - Schedule 40 and 80 Rigid PVC Conduit and Fittings.

Y. UL 797 - Electrical Metallic Tubing - Steel.

Z. UL 870 - Wireways, Auxiliary Gutters and Associated Fittings.

AA. UL 2024 - Optical Fiber and Communication Cable Raceway.

1.4 SUBMITTALS

A. Refer to Section 260500 “General Requirements for Electrical Systems” for additional requirements.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections and attachment details.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with NFPA 70 (NEC).
2. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and indicated.

1.6 DELIVERY, STORAGE & HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris and traffic.

B. Protect PVC conduit from sunlight.

C. Comply with manufacturer’s written instructions.

PART 2 - PRODUCTS

2.1 RIGID METAL CONDUIT

A. Galvanized Rigid Steel Conduit (GRC): ANSI C80.1, UL 6; heavy wall galvanized steel.

B. Intermediate Metal Conduit (IMC): ANSI C80.6; UL 1242; thinner wall galvanized steel.

C. PVC Coated Rigid Steel Conduit: NEMA RN 1; with plastic protector caps.

D. Fittings - Couplings, Conduit Bodies, Connectors and Bushings: NEMA FB 1, UL 514B, galvanized steel, threaded, connectors with double locknuts and steel insulating bushings, thermoplastic insulating bushings for conduits 2 inches and smaller, cast metal conduit bodies with cast aluminum cover and stainless steel screws and neoprene gaskets, PVC coated to match attached conduits.

2.2 ELECTRICAL METALLIC TUBING (EMT)

A. ANSI C80.3, UL 797; galvanized steel tubing.

B. Fittings - Couplings, Conduit Bodies and Connectors: NEMA FB 1, UL 514B: steel, compression-type connectors with insulated throat. Covers for conduit bodies shall be aluminum with stainless steel screws and neoprene gasket.

2.3 FLEXIBLE METAL CONDUIT (FMC)

A. UL 1; interlocked steel.

B. Fittings: NEMA FB 1, UL 514B, steel.

2.4 LIQUID-TIGHT FLEXIBLE METAL CONDUIT (LFMC)

A. UL 360; interlocked steel with PVC jacket.

B. Fittings: NEMA FB 1, UL 514B; steel.

2.5 RIGID NON-METALLIC CONDUIT (RNC)

A. Non-metallic conduit shall be listed and labeled as defined in NFPA 70 (NEC) by a qualified listing agency and marked for the intended location and application.

B. Type EPC-40 PVC minimum, electrical-grade, comply with NEMA TC 2 and UL 651. Type EPC-80 PVC where indicated.

C. Rigid and Continuous HDPE: Schedule 40 minimum, Schedule 80 where indicated, comply with UL 651A.

D. Where raceways are indicated on the drawings to be PVC, similarly-rated HDPE may be used as a direct substitution.

2.6 OUTLET BOXES

A. Sheet Metal Outlet Boxes: NEMA OS 1, UL 514A: galvanized steel with stamped knockouts.

1. Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported, 1/2 inch male fixture studs where required.
2. Concrete Ceiling Boxes: Concrete type.

B. Cast-Metal Outlet Boxes: NEMA FB 1, cast or malleable iron, Type FD with gasketed cover and threaded hubs.

C. Trim and Extension Rings: Same material and finish as box in which attached.

2.7 PULL & JUNCTION BOXES

A. Indoor - Small Sheet Metal Pull and Junction Boxes: NEMA OS 1, UL 514A; galvanized steel.

B. Indoor/Outdoor - Large Metal Pull and Junction Boxes: NEMA 250; steel, NEMA 1 or 3R per installed location, hinged or screw cover, manufacturer's standard enamel finish inside and out.

C. Outdoor - Cast-Metal Outlet and Device Boxes: NEMA FB 1, cast or malleable iron, Type FD with gasketed cover with stainless steel screws.

2.8 METAL WIREWAYS

A. NEMA 250, UL 80: sheet metal trough with hinged or removable cover.

B. NEMA Type 1 enclosure where installed in dry indoor locations, NEMA 3R enclosure where installed outdoors or in damp or wet indoor locations, or NEMA 4X stainless steel enclosure for corrosive environments. No knockouts.

C. Provide hinged cover for surface-mounted installations and removable cover for flush-mounted installations. Provide flanged and gasketed cover for all wet locations.

D. Cross-sectional size and length as indicated or required for the installation requirements and per the box fill requirements of NFPA 70 (NEC).

E. Finish: Manufacturer's standard enamel finish inside and out.

2.9 HANDHOLES & BOXES FOR EXTERIOR UNDERGROUND WIRING

A. For Medium-Voltage and Feeder Circuits, refer to Section 260543 Underground Duct and Raceways for Electrical Systems.

B. General Requirements for Handholes and Boxes: Designed, identified, listed and labeled as defined in NFPA 70 (NEC) for intended location and application.

C. Polymer-Concrete Handholes and Boxes: Molded of sand and aggregate, bound together with polymer resin and reinforced with steel, fiberglass or a combination of the two.

1. Standard: Comply with SCTE 77.
2. Configuration: Designed for flush burial with open bottom unless indicated otherwise.
3. Cover: Weatherproof, secured by tamper-resistant locating devices and having structural load rating per the following:

   (a) Installation in areas not subject to vehicular traffic: Tier 5 (5200 pounds) load rating.
   (b) Installation in drives, parking lots, etc. or adjacent to such areas subject to occasional non-deliberate heavy-truck vehicular traffic: Tier 10 (10,400 pounds) load rating.
   (c) Installation in streets or other areas with deliberate heavy-truck vehicular traffic: AASHTO H-20 (20,800 pounds) load rating.

4. Basis of Design: Quazite Style PG or approved equal.
5. Cover Legend: Molded lettering, “ELECTRIC” or “COMMUNICATIONS” as appropriate for systems installed within.

2.10 EXPANSION FITTINGS

A. Malleable iron, hot dip galvanized allowing 2 inches of raceway movement.

B. Basis of Design: OZ/Gedney AX Series or approved equal.

2.11 RACEWAY & SLEEVE PENETRATION SEALS

A. Description: Modular sealing device, designed for field assembly to fill annular space between wall/floor penetration or sleeve and conduit or cable.

1. Sealing Elements: EPDM, NBR or Silicon per application interlocking links shaped to fit surface of conduit or cable.
2. Pressure Plates: Reinforced Nylon Polymer.
3. Connecting Bolts/Nuts: Stainless Steel.

B. Basis of Design - Thunderline Link-Seal Modular Seal or approved equal. Select Model appropriate for installed environment and probable contact elements.

2.12 RACEWAY SEALING FITTINGS

A. Non-Hazardous Locations: Basis of Design - OZ/Gedney CSB Series or approved equal.

B. Hazardous Locations: Basis of Design - OZ/Gedney EYA Series with sealing compound or approved equal.

C. Field Applied Sealant Basis of Design - American Polywater Corporation FST Foam Duct Sealant or approved equal.

2.13 SLEEVES FOR RACEWAYS

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E Grade B, Schedule 40, galvanized steel, plain ends with integral water stop.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. All power branch circuit and feeder circuit wiring and other Systems's wiring where specified shall be in metallic conduit unless specifically indicated otherwise on the drawings or herein specified.

B. Outdoor Branch Circuit Installations: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC, IMC.
2. Concealed Conduit, above ground: GRC, IMC.
3. Underground Conduit: RNC, Type EPC-40 minimum, Type EPC-80 where indicated, direct buried or concrete encased as indicated.
4. Connection to Vibrating Equipment: LFMC.
5. Boxes and Enclosures, above ground: NEMA 250, NEMA 3R.
6. Boxes and Enclosures, corrosive areas: NEMA 250, NEMA 4X.

C. Indoor Branch Circuit Installations: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT, IMC or GRC.
2. Exposed, Subject to Physical Damage: IMC, GRC.
3. Concealed in Ceilings and Interior Walls/Partitions: EMT.
4. Connection to Vibrating Equipment: FMC.
5. Damp or Wet Locations: IMC, GRC.
6. Size 1 1/4 inch or larger: IMC, GRC.
7. Within Poured Concrete: IMC, GRC.
8. Boxes and Enclosures: NEMA 250, NEMA 1 except NEMA 3R in damp or wet locations.
9. Boxes and Enclosures, corrosive areas: NEMA 250, NEMA 4X.

D. Feeder Circuit Installations: Apply raceway products as specified below unless otherwise indicated:

1. Indoor: IMC, GRC.
2. Exposed Conduit, outdoor: IMC, GRC.
3. Concealed Conduit, above ground: IMC, GRC.

4. Underground Conduit: RNC Type EPC-40 with GRC bends and vertical risers, IMC, GRC.
5. Under Slab Conduit: RNC Type EPC-40 with GRC bends and vertical risers, IMC, GRC.
6. Within Poured Concrete: IMC, GRC.
7. Concrete Encasement: Provide as indicated on drawings or herein specified.

E. Minimum Raceway Size: 1/2 inch except branch circuit homerun conduits shall be minimum 3/4 inch.

F. Homerun Raceways: Branch circuit homeruns shall not be combined in a raceway unless indicated on the Drawings to be routed in that manner. Provide the number of branch circuit homerun raceways as indicated on the Drawings unless otherwise directed by the Professional. Scheduled equipment electrical services shall have dedicated homerun branch circuits and raceways unless indicated otherwise on the Drawings.

G. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. GRC and IMC: Threaded galvanized rigid steel unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Coated GRC: Use only fittings listed for use with this type of conduit with similar coatings. Patch and seal all joints, nicks and scrapes in coating after installing conduits and fittings. Use sealant recommended by manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
4. FMC: Use fittings listed for use with flexible conduit. Comply with NEMA FB 2.10.
5. LFMC: Use fittings listed for use with liquid-tight flexible conduit that maintain liquid-tight rating.

H. Where GRC conduit is direct-buried underground, it shall be coated prior to installation with polyvinyl, polyethylene or asphaltum coating. Coating shall cover entire underground conduit and associated fittings extend a minimum of 6 inches above finished grade.

I. RNC may only be used where indicated on the drawings or herein specified.

3.2 COMMUNICATION RACEWAY APPLICATION

A. Provide outlet boxes and serving raceway to accommodate devices indicated by symbols on the drawings and as herein specified.

B. Minimum Communication Raceway Size: 3/4 inch unless otherwise indicated.

C. Minimum Communication Outlet Box Size: 4 11/16 inches square by 2 1/8 inch depth unless specifically indicated otherwise or required to accommodate wall construction. Provide single-gang trim ring unless indicated otherwise or required for installed devices.

3.3 RACEWAY INSTALLATION

A. Comply with the requirements of Section 260529 “Hangers and Supports for Electrical Systems” for hangers and supports.

B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on the drawings or herein specified are stricter. Comply with NFPA 70 (NEC).

C. Coordination: Raceway locations indicated on the drawings are approximate and representative unless dimensioned. Coordinate raceway installation with building elements, construction methods, other trades systems, etc.

D. All conduits shall be routed concealed above ceilings within walls, partitions, floors, etc. unless specifically indicated on the drawings or herein specified otherwise. Route conduits parallel or perpendicular to building lines weather concealed or exposed.

E. Size conduits as indicated on the drawings or where size is not indicated follow the requirements of NFPA 70 (NEC).

F. Install raceways with the minimum number of bends in the shortest practical distance considering building construction and obstructions and other requirements of the drawings and this specification. Provide junction/pull boxes in accessible locations per NFPA 70 (NEC) to limit distance between conductor pull points to 100 feet or in conduit runs to limit bends between pull points to a total of 360 degrees.

G. Do not route branch circuit, telecommunication or other Systems’ conduits within or under floor slab unless specifically indicated on the drawings to be installed in that manner, the adjacent building construction prohibits concealed overhead routing, or the nature of the connected device or outlet (i.e. floor box) requires this type of routing.

H. Where conduits are indicated or required to be concealed in concrete floor slabs, conduits 1/2 inch through 1 inch may be installed within floor slabs. Conduits larger than 1 inch shall be installed under floor slab.

   1. Where conduits are indicated to be concealed in floor slab and thickness of floor slab is less than 4 inches, route all conduits below floor slab.
   2. Conduits shall be routed as required so as not to compromise the structural integrity of any concrete.
   3. Arrange conduits to cross building expansion joints at right angles with proper expansion fitting.
   4. Where conduits penetrate top of floor slab, provide PVC coated GRC up to a minimum of 2 inches above the top of the floor slab.

I. Where the building floor slab and structure are elevated on pilings or other structural supports due to poor soil conditions, do not route branch circuit or feeder circuit raceways serving building outlets, devices or equipment in the earth. Raceways required to be routed under the floor slab shall be routed on the bottom of the elevated building structure.

1. Exceptions:

    a. Underground electrical and communication service entrance raceways.
    b. Raceways connecting equipment located away from the building on the adjacent site.
    c. Raceways connecting the building to other adjacent buildings or facilities.

J. Arrange conduit stub-ups so curved portion of bends are not visible above finished floor. Protect conduit stub-ups above floor slabs, finished grade, etc. from damage during and after construction. Provide temporary closures to prevent entrance of moisture, dirt and construction debris into conduits.

K. Do not route raceways horizontally on roof unless specifically indicated on the drawings to be routed in that manner or with specific approval from the Professional. Do not install raceways or boxes on or within 2 inches of the bottom side of a metal roof deck.

L. Turn-outs of concealed vertical “stub-up” raceways from outlet boxes shall be located to be above the finished ceiling line where ceilings exist or are provided. In open structure spaces with block or masonry walls, turn-outs shall occur above the bottom of the overhead structure.

M. Do not route raceways in the air space between exterior wall assemblies and the brick veneer without specific approval from the Professional. Raceways may cross air spaces perpendicular to the associated wall.

N. Make bends in raceways using large-radius preformed ells. Field bending shall be according to NFPA 70 (NEC) minimum radii requirements.

O. Support conduits within 12 inches of enclosures in which attached, within 12 inches on both sides of any bend, and maximum distance between supports per NFPA 70 (NEC) based on conduit size and material.

P. Vertical raceways runs 1 1/4 inch and larger passing through floors shall be supported at each floor with pipe riser clamps.

Q. Keep raceways at least 6 inches away from parallel runs of flues, steam, hot-water pipes or other sources of heat.

R. Complete raceway installation and ensure conduits are clear of all foreign debris prior to installing conductors.

S. Provide a nylon pull cord with not less than 200 pounds tensile strength in all empty conduits. Leave a minimum of 12 inches of slack at each end. Cap raceways at both ends.

3.4 OUTLET BOX APPLICATION & INSTALLATION

A. Provide outlet boxes and serving branch circuit to accommodate device or outlet provisions indicated by symbols on the drawings and in conformance with NFPA 70 (NEC) requirements for number and size of conductors, terminations and splices.

B. Locations of all outlets and devices indicated on the drawings are approximate and representative unless dimensioned or specifically noted as to mounting height and location. See Architectural drawings, details or shop drawings for specific outlet locations. Any outlet box and associated raceways may be moved from the location indicated on the drawings in any direction up to a distance of 10 feet by direction of the Professional if so directed before the outlet and associated raceways have been installed at no additional cost.

C. Mount outlet boxes at heights indicated on the Drawings and associated typical device mounting heights specified herein. Mounting heights may be adjusted slightly to permit cutting of masonry block to the top or bottom of the block course nearest the specified mounting height. Mounting heights shall be consistently cut above or below block coursing such that outlet boxes for similar devices will be the same height above the finished floor.

D. Size outlet boxes at interior locations in accordance with NFPA 70 (NEC) and the following minimum outlet box requirements. Minimum conductor size used to determine power wiring box size shall be #12 AWG.

1. Switch/Handy Box: Non-feed-through outlet applications with toggle switch or lighting control device, 5 conductors maximum.
2. 4 inch octagon box, 1 1/2 inch depth: feed-through and non-feed-through outlet locations, 9 conductors maximum.
3. 4 inch octagon box, 2 1/2 inch depth: feed-through and non-feed-through outlet locations, 13 conductors maximum.
4. 4 inch square box, 1 1/2 inch depth: feed-through and non-feed-through outlet locations, pull and junction box locations, 9 conductors maximum.
5. 4 inch square box, 2 1/8 inch depth: feed-through and non-feed-through outlet locations, pull and junction box locations, 13 conductors maximum.
6. 4 11/16" square, 2 1/8 inch depth: feed-through and non-feed-through outlet locations, pull and junction box locations, 18 conductors maximum.

E. Where a single outlet box is installed in a metal or wood stud wall, the box shall be attached to the studs using a metal mounting bracket with support leg to prevent movement of box in wall at unattached side. Where two or three outlet boxes are shown and/or intended to located adjacent to each other in a metal or wood stud wall, the boxes shall be attached to the studs using a common metal mounting bracket with bracket stabilizer leg to support the middle portion of the bracket.

F. Provide single or double gang trim rings as required for outlets installed in hollow walls, square corner trim rings for outlet in tile walls. Mount outlet boxes with trim ring flush with finished surface. Face of outlet box or associated trim ring shall not be installed more than 1/4 inch behind finished face of wall.

G. Outlet boxes installed in masonry wall shall be embedded in masonry grout so as to properly secure the box in place and prevent movement. Materials and labor required for this installation are the responsibility of the Division 26 Contractor.

3.5 PULL & JUNCTION BOX APPLICATION & INSTALLATION

A. Provide pull or junction boxes as required by NFPA 70 (NEC), field conditions encountered and where indicated on the Drawings. Box locations shall be fully coordinated with the Professional where boxes are to be exposed or where installation affects architectural elements, structural construction or mechanical systems.

B. Boxes sizes shall be as indicated on the Drawings; per NFPA 70 (NEC) for the conduit sizes, conductors and situation encountered; as herein specified; or as directed by the Professional.

C. Wireways or gutters shall not be used unless specifically indicated on the Drawings or with specific approval from the Professional.

D. All pull and junction boxes shall be labeled in accordance with Section 260553 “Identification for Electrical Systems” indicating system being served, branch circuit or feeder circuit identification, etc. Where installed in concealed locations (i.e. above accessible ceilings) or in unfinished areas, identification shall be made on outside of box cover. Where installed exposed in finished locations, identification shall be made on inside of box cover. Fire Alarm System pull and junction boxes where not exposed in a finished space shall have covers painted “red” in color.

E. Close all unused knockout holes in junction/pull boxes and install proper cover. Junction/pull boxes install flush or exposed in finished spaces shall be installed with the same requirements as outlet boxes.

3.6 COMMUNICATION RACEWAY INSTALLATION

A. Communication raceways shall comply with the applicable installation requirements of power raceways with the following additional requirements.

B. Regulatory Requirements:

1. Comply with TIA-569-B.
2. Comply with NFPA 70 (NEC).

C. Raceway routing shall follow most direct route possible to the designated termination point(s) within the constraints of this Section with no more than 180 degrees of bends between pull points or junction boxes. For raceway runs greater than 100 feet, provide junction box(es) sized per NFPA 70 (NEC) such that no conduit segment exceeds 100 feet.

D. Conduit minimum bend radius:

1. 6 times the internal diameter for conduits with internal diameters 2 inches or less.

2. 10 times the internal diameter for conduits with internal diameters greater than 2 inches.

E. Communication outlet raceways serving outlets located in rooms with accessible ceilings shall have 4 inch square minimum in-line junction box surface-mounted directly above the outlet and above the accessible ceiling to allow access to the raceway from within the room.

F. Conduit bends shall be smooth, even and free of kinks or other discontinuities that may have detrimental effects on pulling tension or cable integrity during or after installation.

G. Provide insulating bushing on end of each raceway.

H. Provide a nylon pull cord with not less than 200 pounds tensile strength in all empty conduits. Leave a minimum of 12 inches of slack at each end.

3.7 INSTALLATION OF UNDERGROUND CONDUIT

A. Engage Utility Locating Service to locate, mark and identify all existing underground utilities in the area of work prior to any excavation.

B. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit.
2. After installation of conduit, install select backfill, compact in 6 inch layers and mound for settlement. Start at tie-in point and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. After placing backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfill.

C. Directional-Bored Conduits:

1. Install using proper machinery using personnel fully-trained and experienced in the process and the associated machinery.
2. Use continuous-length HDPE piping of indicated rating and size.
3. Excavate significant area at raceway termination locations to install required conduit bends.
4. After installation of conduit, install select backfill, compact in 6 inch layers and mound for settlement.

D. Requirements:

1. Conduit installed under structural concrete floor slabs and other installations with sub-grade compaction requirements of other Divisions of the specifications shall be installed to meet the minimum specified compaction requirements.

2. Provide manufactured long-radius elbows for stub-ups at poles, equipment and building entrances through floor slab unless otherwise indicated or prohibited by adjacent construction or existing conditions.
3. Use GRC conduit for all bends, vertical runs and exposed sections of RNC raceways.
4. Minimum Burial Depths:

    a. Branch Circuit Raceway 1 1/4" Inch and Smaller: 18 inches to top below finished grade.
    b. Branch Circuit Raceway 1 1/2 Inch and Larger: 24 inches to top below finished grade.
    c. Feeder Circuit Raceway: 36 inches to top below finished grade.
    d. Electrical Service Entrance Raceway: 36 inches to top below finished grade.
    e. Communication Raceway: 30 inches to top below finished grade.

5. Underground Warning Tape: Provide per the requirements of Section 260553 “Identification for Electrical Systems”.

    a. Provide Warning Tape at all underground primary and secondary feeder circuits and branch circuits rated 100A and greater routed beyond the perimeter of the building’s slab.

3.8 INSTALLATION OF UNDERGROUND HANDHOLES & BOXES

A. Provide exterior in-grade handholes and boxes as indicated on the drawings, as required for the installation of the work per NFPA 70 (NEC) and as required by the serving Utility Companies.

B. Size handholes and boxes as indicated or where size is not indicated comply with the requirements of NFPA 70 (NEC).

C. Excavate as small an area as required to install box and associated raceways. Support units on a level bed of crushed stone or gravel, graded 1/2 inch sieve to #4 sieve, minimum 6 inches in depth and compacted to same density as adjacent undisturbed earth. Aggregate base shall cover entire box bottom and extend a minimum of 6 inches beyond the perimeter of the box on all sides. Backfill around box with select fill and compact to the same density as adjacent undisturbed earth.

D. Elevation: In paved areas, set so cover is flush with finished surface. In other areas, set so cover is 1 inch above the finished grade.

E. Conduits shall enter box from the bottom to prevent weakening the enclosure sides unless adjacent site conditions prevent such installation. When enclosure side walls must be field cut to accept raceways, follow manufacturer’s written instructions and use recommended tools.

F. Handholes and boxes larger than 24 inches in length or width shall be provided with 6 inch square concrete collar around the perimeter to provide added support.

3.9 APPLICATION & INSTALLATION OF FLEXIBLE CONDUIT

A. Comply with NEMA RV 3.

B. Application:

1. Dry, Indoor Locations: FMC.
2. Damp or Wet, Indoor Locations: LFMC.
3. Outdoor Locations: LFMC.
4. Connections to Vibrating Electrical Distribution Equipment: LFMC.

C. Use a maximum of 72 inches of flexible conduit for connection to lighting luminaires, equipment subject to vibration, noise transmission or movement, and for transformers and motors.

3.10 APPLICATION & INSTALLATION OF EXPANSION FITTINGS

A. Provide expansion fitting at all locations where conduits cross building or structural expansion joints, where conduits are mechanically connected to two separate structures, and where conduits pass above ground from interior to exterior of the building.

B. Provide fittings that provide expansion and contraction for at least 0.0004 inches per foot of length of straight conduit run per degree F of temperature change.

C. Install each expansion-joint fitting with position, mounting and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

3.11 APPLICATION & INSTALLATION OF RACEWAY SLEEVES

A. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

B. Use pipe sleeve unless penetration arrangement requires rectangular sleeved opening.

C. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

D. Cut sleeves to length for mounting flush with both surfaces of walls.

E. Extend sleeves installed in floors 2 inches above finished floor level.

F. Size pipe sleeves to provide 1/4 inch annular clear space between sleeve and raceway unless sleeve seal is to be installed.

G. Provide sleeve and raceway seals where penetrations are made in exterior walls, through on-grade slabs or below grade wall.

3.12 APPLICATION & INSTALLATION OF RACEWAY & SLEEVE PENETRATION SEALS

A. Seal space outside of sleeves with grout for penetrations of concrete or masonry and approved joint compound for gypsum board assemblies.

B. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.

C. Above Ground, Exterior Wall Penetration: Seal penetration using sleeves and mechanical sleeve seals. Select sleeve size as required for annular clear space between raceway and sleeve for installing mechanical sleeve seals.

D. Underground, Exterior Wall Penetration: Seal penetration using cast-iron pipe for sleeves and mechanical sleeve seals. Select sleeve size as required for annular clear space between raceway and sleeve for installing mechanical sleeve seals.

E. Sleeve Seal Installation: Use type and number of sealing elements recommended by the manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve per the manufacturer’s written instructions.

F. Provide chrome- or nickel-plated escutcheons where raceways pass through walls, floors or ceilings and are exposed in finished public areas.

3.13 APPLICATION & INSTALLATION OF RACEWAY SEALING FITTINGS

A. Provide listed watertight raceway seal-off fitting to prevent the passage of moisture and water vapor through raceway where:

1. Raceway passes from interior to exterior of the building.
2. Raceway passes from interior conditioned spaces to attic space of the building.
3. Raceway passes between areas of different temperature (i.e. cold rooms, coolers, freezer, air handling systems, etc.).

B. Provide field-applied raceway sealant to prevent the passage of moisture in all raceways that contain wiring, enter the building from below grade, and that terminate or have fittings located at an elevation that is below a horizontal line 24 inches above the adjacent exterior finished grade.

C. Provide listed raceway seal-off fitting with sealing compound where raceways enter or leave hazardous locations as defined by NFPA 70 (NEC).

3.14 FIRESTOPPING

A. Openings around electrical penetrations through smoke or fire rated wall, partition, floor or ceiling assemblies shall be smoke and/or fire stopped using an approved UL listed system designed for the materials encountered to maintain the smoke and/or fire rating of the assembly.

B. Comply with Division 07 Section “Penetration Firestopping”.

C. All firestopping of penetrations in rated walls, partitions, floors or ceiling assemblies shall be performed by a certified Fire Proofing Contractor. The Division 26 Contractor shall be responsible for procuring and coordinating with the Fire Proofing Contractor to provide the required firestopping of all electrical penetrations in or through rated assemblies.

END OF SECTION

SECTION 260553
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Identification products and methods.
2. Warning labels and signs.
3. Instruction signs and posted drawings.
4. Miscellaneous identification products.

1.2 REFERENCED STANDARDS

A. ANSI A13.1 - Scheme for the Identification of Piping Systems.

B. ANSI C2 - National Electrical Safety Code.

C. ANSI Z535.4 - National Standards for Product Safety Signs and Labels.

D. 29 CFR - Labor, Part 1910 - Occupational Safety and Health Standards, Section 1910.145 - Specifications for Accident Prevention Signs and Tags.

E. NFPA 70 - National Electrical Code.

1.3 QUALITY ASSURANCE

A. Comply with ANSI A12.1 and ANSI/IEEE C2.

B. Comply with NFPA 70 (NEC).

C. Comply with 29 CFR 1910.145.

1.4 COORDINATION

A. Coordinate identification names, abbreviations, colors and other features with Contract Documents, Shop Drawings, manufacturer’s wiring diagrams, O&M Manuals and those required by codes, standards, 29 CFR 1910.145. Use consistent designations throughout the project.

B. Coordinate installation of identifying devices with completion of covering, finishes and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors and manufacturer’s nameplates, warning labels, instruction labels, etc..

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 RACEWAY & CONDUCTOR IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather and chemical resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Snap-Around Labels: Slit, pre-tensioned, flexible, preprinted, color-coded acrylic sleeves with diameter sized to suit diameter of raceway it identifies and to stay in place by gripping action when placed in position.

D. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant, 1 or 2 inches wide, compounded for outdoor use.

E. Marker Tapes: Vinyl or vinyl cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

2.2 UNDERGROUND WARNING TAPE

A. Permanent, bright-colored, continuous-printed, polyethylene tape.

1. Not less than 6 inches wide by 4 mils thick.
2. Compounded for permanent direct-burial service.
3. Embedded continuous metallic strip or core.
4. Printed legend shall indicate type of underground line.

2.3 WARNING LABELS & SIGNS

A. Comply with NFPA 70 (NEC) and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless indicated otherwise.

C. Engraved Plastic Signs: Engraving stock, melamine plastic laminate, minimum 1/16 inch thick for signs up to 20 square inches and 1/8 inch thick for larger signs.

1. Engrave legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.

D. Baked-Enamel Warning Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners with colors, legend and size required for application. 1/4 inch grommets in corners for mounting. Nominal size - 7 inch X 10 inch.

E. Metal-Backed, Butyrate Warning Signs for Exterior Use: Weather-resistant, non-fading, preprinted, cellulose-acetate butyrate signs with 0.0396 inch galvanized-steel backing; with colors, legend and size required for application. 1/4 inch grommets in corners for mounting. Nominal size - 10 inch X 14 inch.

2.4 INSTRUCTION SIGNS & POST DRAWINGS

A. Instruction Signs: Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 square inches and 1/8 inch thick for larger signs.

1. Engrave legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.

2.5 EQUIPMENT IDENTIFICATION NAMEPLATES

A. Engraved, Three-Layer, Laminated Acrylic or Melamine Nameplate: Punched or drilled for screw mounting. Minimum legend letter height shall be 3/8 inch unless indicated or specified herein otherwise.

B. Stenciled Legend: Non-fading, waterproof ink or oil-based, alkyd enamel paint. Minimum legend letter height shall be 1 inch unless indicated or specified herein otherwise.

C. Nameplates shall be colored-coded for each system as follows:

1. Normal Power - white lettering on black field.
2. Emergency/Life-Safety Power - black lettering on a red field.
3. Legally Required/Critical Standby Power - black lettering on an orange field.
4. Optional/Equipment Standby Power - black lettering on a yellow field.

2.6 WIRING DEVICE IDENTIFICATION

A. Self-adhesive, clear label with 3/16 inch high printed black legend. Legend printed using thermal transfer.

2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS.

A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, type 6/6 nylon cable ties.

1. Minimum Width: 3/16 inch.
2. Tensile Strength: 50 pound minimum.
3. Temperature Range: -40 degrees F to 185 degrees F.
4. Color: Black, except where used for color coding.

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 APPLICATION

A. Refer to the technical Sections of the Division 26 Specification for identification requirements for the specified material, equipment, components, etc.

B. Warning Labels for Indoor Cabinets, Boxes and Enclosures: Comply with 29 CFR 1910.145 and NFPA 70 (NEC). Apply self-adhesive warning labels to exterior of door, cover or other access to equipment. Provide the following warning labels and those required by other codes, standards and regulatory agencies as a minimum.

1. Equipment with Multiple Power Sources. Including, but not limited to, the following:

    a. Power transfer switches.
    b. Controls with external control power connections.

2. Equipment Requiring Workspace Clearance per NFPA 70 (NEC): Apply to door or cover except flush-mounted equipment or equipment in finished spaces. Labeling for flush-mounted equipment or equipment in finished spaces shall be applied inside equipment door. Indicate clearance requirements per NFPA 70 (NEC) for voltage of equipment.

3. Available Fault Current Labels: Install per NFPA 70 (NEC) for each piece of electrical service entrance equipment. Locate labels so they are visible to the personnel before examination, adjustment, servicing or maintenance of the equipment.

C. Instruction Signs: Provide instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend printed in all capital letters of 12 point minimum font size where instructions are needed for system or equipment operation.

D. Equipment Identification Nameplates: Each unit of electrical equipment shall be provided with a nameplate indicating the equipment designation consistent with the Drawings, connected voltage and phase, serving equipment designation and other specified information. Refer to the technical Sections of this Specification for the specified equipment for additional requirements.

1. Nameplate: Engraved, laminated acrylic or melamine nameplate. Equipment designation legend using 1/2 inch high lettering, other legend information using 1/4 inch high lettering.

3.2 INSTALLATION

A. Verify identity of each item before producing and installing identification products.

B. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surface before application, using materials and methods recommended by manufacturer of identification device. Install parallel to equipment lines.

E. Install non-adhesive signs and plastic nameplates parallel to equipment lines. Attach with screws and auxiliary hardware appropriate for the location and substrate. Locate to inside of door where equipment is flush-mounted in finished spaces.

F. Post Drawings and Operating Instructions: Mount drawings and operating procedures on the wall immediately adjacent to the piece of equipment for which the instructions apply. If sufficient wall space is not available, mount directly to one of the sheet metal panels of the equipment as directed by the Professional.

G. Warning Signs: Install warning signs where there is hazardous exposure or danger associated with access to or operation of electrical facilities. Provide text of sufficient clarity and lettering of sufficient size to convey adequate information at each location. Mount permanently in an appropriate and effective location. Comply with ANSI A13.1 standard color and design.

H. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side-by-side. Locate bands at changes in direction, at penetrations of wall and floors, at 50 foot maximum intervals. Locate bands on conductors and cables in raceway at all accessible locations.

I. Underground Warning Tape: During backfilling of trenches install continuous underground warning tape directly above line at approximately 12 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 24 inches overall.

END OF SECTION

SECTION 262413
SWITCHBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Free-Standing, Dead-Front Type Low-Voltage Distribution Switchboards.

1.2 DEFINITIONS

A. GFCI: Ground-fault circuit interrupter.

B. GFEQ: Ground-fault equipment protection.

C. K.A.I.C.: Kilo-ampere interrupt capacity.

D. MCCB: Molded-case circuit breaker.

E. PQM: Power quality meter.

F. SCCR: Short circuit current rating.

G. SPD: Surge protection device.

1.3 REFERENCED STANDARDS

A. ANSI/IEEE C37.13 - Low-Voltage AC Power Circuit Breakers Used in Enclosures

B. ANSI/NECA 400 - Recommended Practice for Installing and Maintaining Switchboards

C. IEEE C62.41.1 - Guide on the Surges Environment in Low-Voltage (1000V and less) AC Power Circuits

D. IEEE C62.41.2 - Recommended Practice on Characterization of Surges in Low-Voltage (1000V and less) AC Power Circuits

E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volt Maximum)

F. NEMA AB 1 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures

G. NEMA AB 3 - Molded-Case Circuit Breakers and Their Application

H. NEMA PB 2 - Dead-Front Distribution Switchboards

I. NEMA PB 2.1 - General Instructions for Proper Handling, Installation and Maintenance of Dead-Front Distribution Switchboards Rated 600 Volts or Less

J. NFPA 70 - National Electrical Code

K. UL 486A-486B - Wire Connectors

L. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures

M. UL 869A - Reference Standard for Service Equipment

N. UL 891 - Dead-Front Switchboards

O. UL 1053 - Ground-Fault Sensing and Relaying Equipment

P. UL 1066 - Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures

1.4 SUBMITTALS

A. Refer to Section 260500 “General Requirements for Electrical Systems” for additional requirements.

B. Product Data: For each type of switchboard, components and indicated accessories.

1. Submit catalog data showing specified features of standard product including materials, switching and overcurrent protection devices, SPDs, accessories and components indicated.
2. Include dimensions and manufacturer’s technical data on features, performance, electrical characteristics, ratings, and finishes.
3. Features, characteristics, factory settings and time-current curves of individual protective devices, auxiliary components and ground-fault relaying.

C. Shop Drawings:

1. Submit for review prior to manufacturer.
2. For each switchboard specified in this section:

a. General Arrangement:
(1) Indicated front, plan and side views of switchboards; access requirements (front, side, rear); overall dimensions; components lists; shipping splits; and weights.
(2) Front elevation drawing indicating location of devices and instruments.
(3) Plan and section views indicating space available for conduit entry.
b. Conduit entrance locations and requirements.
c. Configuration, size and number of bus bars for each phase and current rating of buses.
d. Ground bus.
e. Neutral bus.

f. Short-circuit ratings of switchboards and overcurrent protection devices and bus withstand ratings.
g. Instrument details; enclosure types and details.
h. Wiring diagrams: power, signal and control wiring.
i. Descriptive documentation of optional barriers specified for electrical insulation and isolation.
j. Nameplate legends.

3. Contractor shall submit 1/4 inch scale floor plan drawings with switchboard and adjacent equipment located and indicating required working space clearances, dedicated electrical spaces and service space around equipment.
4. Indicate switchboard designation per Contract Drawings in minimum 10 point font on top right corner of each associated shop drawing sheet.

1.5 CLOSE-OUT SUBMITTALS

A. Manufacturer's operation and maintenance manuals on each switchboard and associated devices and instruments.

1.6 QUALITY ASSURANCE

A. Obtain switchboards, overcurrent protection devices, components and accessories from one source and by single manufacturer.

B. Regulatory Requirements:

1. Comply with NFPA 70 (NEC).
2. Furnish products listed and classified by UL as suitable for purpose specified and indicated.

1.7 DELIVERY, STORAGE & HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris and traffic. Provide temporary heaters in switchboards as required to prevent condensation.

B. Handle switchboards in accordance with NEMA PB 2.1, ANSI/NECA 400 and manufacturer's written instructions. Use factory-installed lifting provisions. Handle carefully to avoid damage to switchboard internal components, enclosure and finish.

C. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and work above panelboards is complete.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis of Design: ABB/General Electric Spectra Series.

Equal in Square D Company, Siemens or Eaton.

2.2 SWITCHBOARDS

A. Construction:

1. NEMA PB 2, UL 891. Steel, NEMA 250, Type 1 or Type 3R enclosure as indicated on Drawings or as required for installed environment.
2. Commercial-grade, free-standing, dead-front type; vertical sections bolted together; sides and rear covered with removable bolt-on covers; adequate ventilation within enclosure; supporting frame of steel angles rigidly fastened together.
3. Adequate strength and rigidity necessary to resist conditions of use to which it may be subjected and to support equipment, devices and appurtenances contained within.
4. Incoming Feeder Lugs: Size and number per phase to match indicated feeder conductors size, material and number per phase. Location as required to facilitate installation in the indicated location and conditions.
5. Connection to Supply Source: Conduit and wiring unless indicated otherwise on the Drawings.
6. Device Mounting:
   a. Front accessible switchboard for placement against wall unless indicated otherwise.
   b. Front accessible and removable devices and instruments.
   c. Feeder device lin and load connection straps shall be rated to carry current rating of device frame size (not trip rating).
7. Alignment: Front and rear aligned.
8. Finish: Manufacturer standard gray enamel finish over prime coat.

B. Buses:

1. Material: Copper with tin plating, 98% conductivity, standard density rated for 1000A per square inch.
2. Main Bus: 3 phase, 4 wire grounding; ampere rating as indicated or as required for specified main device frame size. Horizontal bus shall be fully rated for length of switchboard.
3. Neutral Bus: Insulated, 100% of main bus rating unless indicated on Drawings to be 200% rated, pressure connectors for termination of neutral conductors..
4. Ground Bus: Uninsulated, bonded to switchboard cabinet. extending the length of the switchboard with pressure connectors for termination of ground conductors.
5. Terminals: One terminal per connected conductor.
6. Support for Buses: Mounted on high-impact, non-tracking insulated supports; joints in a vertical bus are not permitted.
7. Bus Arrangement: A-B-C (left to right, top to bottom, front to rear).

C. Line and Load Terminals: Mechanical type accessible from front of switchboard, suitable for conductor materials, sizes and number as indicated on the Drawings, labeled for 75 degree C copper and aluminum conductors.

D. Supports and Barriers:

1. Cable Supports: For each vertical section.
2. Barriers: Between adjacent sections.

E. Short Circuit Current Rating:

1. Each switchboard with minimum short circuit current rating as indicated on the Drawings.
2. Fully-rated. Series-rated switchboards are not acceptable.
3. Short Circuit Withstand Rating: 65,000 amperes.

F. Future Provisions:

1. Fully equip spaces for future devices with bussing, mounting brackets, supports, and appurtenances, insulated and braced for short circuit current rating.
2. Provide provisions for bus extensions on distribution ends of switchboard.

2.3 OVERCURRENT PROTECTIVE DEVICES

A. Frame Sizes 1600A and Greater: Insulated-case power circuit breaker, 100% rated, stationary and group mounted, electronic trip unit.

1. Exception: Main Circuit Breakers shall be individually mounted.
2. Electronic Trip Unit Circuit Breakers: Solid-state microprocessor based, digital true RMS sensing trip units, field interchangeable rating plug within breaker frame size rating, field adjustable setting and the following trip functions:

a. Instantaneous trip.
b. Long- and Short-time pickup levels.
c. Long- and Short-time time delay adjustments with I^2t response.
d. 480Y/277V Systems: Ground-fault pickup level, time delay, and I^2t response.

B. Frame Sizes 1200A and Smaller: Molded-case circuit breaker, stationary and group mounted, NEMA AB 1, NEMA AB 3, UL 489.

1. Provide thermal-magnetic or electronic trip circuit breakers as indicated on the Drawings.
2. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
3. Electronic Trip Unit Circuit Breakers: Solid-state microprocessor based, digital true RMS sensing trip units, field interchangeable rating plug within breaker frame size rating, field adjustable setting and the following trip functions:

a. Instantaneous trip.
b. Long- and Short-time pickup levels.
c. Long- and Short-time time delay adjustments with I^2t response.
d. 480Y/277V Systems: Ground-fault pickup level, time delay, and I^2t response.

C. Elevators: Circuit breakers serving elevator motors shall be the shunt-trip type with auxiliary contacts.

2.4 SURGE PROTECTION DEVICES

A. Device ratings and connection per requirements of Section 264313 “Surge Protection Devices” for the installed location of the switchboard in the electrical distribution system.

B. Provide where indicated on the Drawings or herein specified.

C. Provide for all switchboards connected to an Emergency Power System.

2.5 SERVICE ENTRANCE

A. UL 869A.

B. Switchboards labeled as suitable for use as service entrance equipment where applicable and shall include connection for bonding and grounding neutral conductor.

2.6 CONTROL POWER, COMPONENTS, IDENTIFICATION AND WIRING

A. Control Circuits: 120V, where required, supplied through secondary disconnecting devices from control-power transformer.

B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

C. Control components mounted within assembly shall be suitably marked for identification corresponding to appropriate designations on manufacturer’s shop drawings.

D. Control Wiring: Factory installed with bundling, lacing and protection included; flexible conductors for #8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units; insulated spade terminals for all control connections, except where saddle type terminals, integral to device; current transformer secondary leads connected to short circuit terminal blocks; terminal blocks with suitable numbering strips for group of control wire leaving switchboard with wire markers at each end of control wiring.

2.7 METERING

A. Switchboard shall have electronic power quality meter(s) with all necessary current and potential transformers to display, monitor and/or calculate the following values measured at the main breaker(s):

1. Amperes (phase and neutral), Volts (LL & LN)
2. Watts, VARs, Volt-Amperes
3. Watt-hours, Volt-Ampere-hours, Var-hours

4. VA, VAR, and Watt demand
5. Peak VAR and peak Watt demand
6. Power factor and frequency

B. Meter(s) shall have communications to allow transmission and monitoring of all data at a remote location via BacNet with open protocol. Any and all conversion devices and programming required to provide BacNet communication shall be provided, connected, configured, etc.

C. Manufacturer: ABB/GE Power Leader Series or approved equal.

2.8 ACCESSORY COMPONENTS AND FEATURES

A. Furnish portable test set to test functions of solid-state trip devices without removal from switchboard.

B. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance and operation.

C. Furnish set of tools for manually charging circuit breaker stored energy device.

D. Heaters: Outdoor switchboards shall be provided with thermostat-control heaters for all sections. Provide integral transformer, overcurrent protection, wiring, disconnect device, etc. for heaters within the switchboard.

PART 3 - EXECUTION

3.1 COORDINATION

A. Instruct manufacturer about the location of the main lugs and main circuit breaker location based on incoming feeder entrance location.

B. Locate feeder circuit conduits and conductors within the section in which the associated circuit breaker is located.

C. Instruct manufacturer to provide multiple lugs where feeder circuit utilizes paralleled conductors and where sub-feed or feed-thru lugs are indicated or required.

D. Coordinate installation of housekeeping concrete pad with actual equipment to be supplied.

E. Coordinate with miscellaneous trades for equipment foreign to the electrical installation to be located outside the dedicated electrical space as defined by NFPA 70 (NEC).

F. Examine areas and surfaces to receive switchboard for compliance with requirements, installation tolerances, and other conditions affecting operation. Proceed with installation only after unsatisfactory conditions have been corrected.

G. Verify that space indicated for switchboard mounting will meet NFPA 70 (NEC) required working clearances with switchboard installed.

H. Verify that the egress doors to electrical room(s) containing switchboards with ampere ratings of 1200A or greater open in the direction of egress and are equipped with listed panic hardware. Switchboards in excess of 6 feet in width shall be positioned in the space such that:

1. Space egress doors are located at each end of the switchboard working space.
2. For single egress door applications: Such that there is a clear, continuous and unobstructed path of egress from the space or the NFPA 70 (NEC) required working clearance shall be increased to 2 times required distance and the closet edge of the egress door shall not be closer to any part of the switchboard than the required working clearance distance.

I. The Division 26 Contractor is responsible for coordinating the electrical space door and egress requirements with the General Contractor and providing the panic hardware if not provided with the door(s) supplied.

3.2 INSTALLATION

A. Provide and connect switchboards complete with serving source circuit, overcurrent protection devices, and distribution feeder circuits as scheduled and indicated on the Drawings.

B. Install switchboards in accordance with ANSI/NECA 404 and NEMA PB 2.1.

C. Switchboard Mounting:

1. Install switchboard on concrete equipment pad in accordance with Section 260529 “Hangers and Supports for Electrical Systems: and Division 03.
2. Anchor and fasten switchboard to its associated concrete pad by methods described in Section 260529 “Hangers and Supports for Electrical Systems.”
3. Install such that top circuit breaker handle is a maximum of 6 foot 6 inches above the finished floor or working platform with handle in its highest position.
4. Install so as to maintain minimum working space clearance in all directions and dedicated electrical equipment spaces per NFPA 70 (NEC).

D. Tighten electrical connectors and terminals according to equipment manufacturer’s published torque-tightening values. Where manufacturer’s torque values are not indicated, use those specified in UL 486A-486B.

E. Install filler plates in unused spaces.

F. Leave all spare circuit breakers in the OFF position.

3.3 CONNECTIONS

A. Ground switchboards according to Section 260526 “Grounding and Bonding for Electrical Systems.

B. Connect wiring according to Section 260519 “Low-Voltage Electrical Power Conductors”.

C. Connect SPD according to Section 264313 “Surge Protection Devices”.

3.4 IDENTIFICATION

A. Provide engraved plastic nameplates per Section 260553 “Identification for Electrical Systems”. Nameplate legend shall include switchboard designation per the Drawings; voltage, phase and wire; and “Fed From:” source designation.

B. Provide engraved plastic nameplates per Section 260553 “Identification for Electrical Systems” at each feeder circuit breaker indicating load served per the load designations indicated in the Contract Documents.

C. Label all spare circuit breakers as SPARE.

D. Provide engraved plastic nameplate with operating instructions and sequences and emergency procedures for all switchboards with main-tie-main configurations, key interlocking or other special or emergency condition operations. Instructions and sequences shall be approved by the Professional prior to posting.

E. Provide engraved plastic label, approximately 5" x 10" in size, with minimum 3/8" high, white letters on black field, lettering as follows:

SCHULTZ & WYNNE, P.A.
CONSULTING ELECTRICAL ENGINEERS
(ELECTRICAL CONTRACTOR’S COMPANY NAME)
(YEAR)
(BUILDING NAME)

3.5 FIELD QUALITY CONTROL

A. Inspect for physical damage, proper alignment, anchorage and grounding.

B. Check phase-to-phase and phase-to-ground insulation resistance levels prior to energizing switchboard.

C. Check switchboards for electrical continuity of circuits and short-circuits prior to energizing switchboards.

D. After substantial completion and with all building systems operational, perform an infrared scan of each switchboard’s components and connections. Remove front panels so joints and connections are accessible. Infrared scanning device shall be

designed to measure temperature or to detect significant deviations in temperature from normal values. Provide certified report that indicates switchboard infrared testing noting all major components and that describes scanning results of each component. All deficiencies and deviations from manufacturer's recommended operation parameters shall be corrected and repeat infrared scanning performed.

3.6 ADJUSTING

A. Adjust fronts, covers, hinges, doors and locks for proper alignment and operation. Adjust doors and locks for smooth operation.

B. Set field-adjustable circuit breaker trip settings or change the trip settings to values indicated by the overcurrent protective device coordination study required by Section 260573 "Electrical Systems Studies", indicated on the Drawings, or as directed by the Professional.

3.7 CLEANING & TOUCH-UP

A. Clean switchboard interiors and exteriors. Remove paint splatters and other spills. Completely remove dirt and debris from switchboard interior.

B. Touch-up chips, scratches or marred finishes to match original finish using manufacturer-supplied paint kit.

3.8 TRAINING & DEMONSTRATION

A. Provide training and demonstration of the Owner's selected personnel on the operation and maintenance of each type of switchboard and associated devices and instruments.

1. Training and demonstration shall be performed by a manufacturer's representative completely familiar with the equipment and accessories.
2. Allow a minimum of 4 hours of training at the job site.
3. Training session shall occur at the convenience of the Owner and shall be fully coordinated with the Owner as to the time and date of occurrence.

END OF SECTION

SECTION 262416
PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Branch-circuit panelboards.

1.2 DEFINITIONS

A. EGP: Electronic-grade panelboard.

B. GFCI: Ground-fault circuit interrupter.

C. GFEQ: Ground-fault equipment protection.

D. K.A.I.C.: Kilo-ampere interrupt capacity.

E. MCCB: Molded-case circuit breaker.

F. PQM: Power quality meter.

G. SCCR: Short circuit current rating.

H. SPD: Surge protection device.

1.3 REFERENCED STANDARDS

A. NECA 407 - Recommended Practice for Installing and Maintaining Panelboards

B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volt Maximum)

C. NEMA AB 1 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures

D. NEMA PB 1 - Panelboards

E. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less

F. NFPA 70 - National Electrical Code

G. UL 50 - Enclosures for Electrical Equipment

H. UL 67 - Panelboards

I. UL 486A-486B - Wire Connectors

J. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures

K. UL 869A - Reference Standard for Service Equipment

1.4 SUBMITTALS

A. Refer to Section 260500 “General Requirements for Electrical Systems” for additional requirements.

B. Product Data: For each type of panelboard.

1. Submit catalog data showing specified features of standard product including materials, switching and overcurrent protection devices, SPDs, accessories and components indicated.
2. Include dimensions and manufacturer’s technical data on features, performance, electrical characteristics, ratings, and finishes.

C. Shop Drawings:

1. Submit for review prior to manufacturer. For each panelboard, include complete description, front view, dimensions, voltage, phase, wire, main bus ampacity, neutral bus rating, circuit breaker arrangement and sizes, short circuit current rating, and factory settings of protection devices.
2. Indicate panelboard designation per Contract Drawings in minimum 10 point font on top right corner of each associated shop drawing sheet.

1.5 QUALITY ASSURANCE

A. Obtain panelboards, overcurrent protection devices, components and accessories from one source and by single manufacturer.

B. Regulatory Requirements:

1. Comply with NFPA 70 (NEC).
2. Furnish products listed and classified by UL as suitable for purpose specified and indicated.

1.6 DELIVERY, STORAGE & HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris and traffic.

B. Comply with NEMA PB 1.1 and manufacturer’s written instructions.

C. Do not deliver or install panelboard interiors until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and work above panelboards is complete.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Branch Circuit Panelboards

1. Basis of Design: ABB/General Electric Types AQ, AE or AD.
2. Equal in Square D Company, Siemens or Eaton.

B. Distribution Panelboards

1. Basis of Design: ABB/General Electric Spectra Series.
2. Equal in Square D Company, Siemens or Eaton.

2.2 BRANCH CIRCUIT PANELBOARDS

A. NEMA PB 1, UL 67.

B. Fabrication:

1. Commercial-grade, dead-front, factory assembled.
2. Incoming Feeder Lugs: Size and number per phase to match indicated feeder conductors size, material and number per phase.
3. Sub-feed or feed-thru lugs where indicated or required for multi-section panelboards.
4. Wiring terminals for field installed conductors: Pressure wire connectors except wire-binding screws for #10 AWG or smaller conductors.

C. Panelboard Buses:

1. Material: Copper.
2. Ampere rating as indicated.
3. Neutral Bus: Insulated, 100% of main bus rating unless indicated on Drawings to be 200% rated.
4. Ground Bus: Uninsulated, bonded to panelboard cabinet.
5. Terminals: One terminal per connected conductor.

D. Cabinet:

1. NEMA 250, UL 50.
2. NEMA Type 1 or Type 3R enclosure as indicated on Drawings or as required for installed environment.
3. Surface- or flush-mounted as indicated on Drawings.
4. Front: Door and trim with concealed hardware and cylinder-type lock and catch.

5. Boxes and fronts made of code-gauge steel.
6. Manufacturer standard gray enamel finish over prime coat.

E. Molded-Case Circuit Breakers:

1. NEMA AB 1, UL 489.
2. Bolt-On Type, labeled for 75 degree C copper and aluminum conductors.
3. Quick-make, quick-break, with thermal-magnetic trip.
4. Common internal trip on multi-pole breakers. Handle ties are not permitted.
5. Ampere rating and number of poles as scheduled.
6. Listed as Type SWD for lighting circuits.
7. Listed as Type HACR for air-conditioning equipment circuits.
8. Bussing, device mounting hardware and steel knockouts in dead front where space is indicated.
9. Tandem circuit breakers are not permitted.
10. Locks on trip handles with red device for circuits serving Fire Alarm Systems.
11. Shunt-trip device with 120V coil and auxiliary contacts where specified or indicated.
12. GFCI device, rated at 4-6 mA trip for protection of personnel where specified or indicated.
13. GFEP device, rated 30 mA trip to provide equipment protection where specified or indicated and for branch circuits serving heat tracing.

F. Short Circuit Current Rating:

1. Each panelboard with minimum short circuit current rating as indicated on the Drawings.
2. Fully-rated. Series-rated panelboards are not acceptable.

G. Surge Protection Device:

1. Device ratings and connection per requirements of Section 264313 “Surge Protection Devices” for the installed location of the panelboard in the electrical distribution system.
2. Provide where indicated on the Drawings or herein specified.
3. Provide for all panelboards connected to an Emergency Power System.

2.3 DISTRIBUTION PANELBOARDS

A. NEMA PB 1, UL 67.

B. Fabrication:

1. Commercial-grade, dead-front, factory assembled.
2. Incoming Feeder Lugs: Size and number per phase to match indicated feeder conductors size, material and number per phase.
3. Sub-feed or feed-thru lugs where indicated or required for multi-section panelboards.

4. Wiring terminals for field installed conductors: Pressure wire connectors except wire-binding screws for #10 AWG or smaller conductors.

C. Panelboard Buses:

1. Material: Copper.
2. Ampere rating as indicated.
3. Neutral Bus: Insulated, 100% of main bus rating unless indicated on Drawings to be 200% rated.
4. Ground Bus: Uninsulated, bonded to panelboard cabinet.
5. Terminals: One terminal per connected conductor.

D. Cabinet:

1. NEMA 250, UL 50.
2. NEMA Type 1 or Type 3R enclosure as indicated on Drawings or as required for installed environment.
3. Surface- or flush-mounted as indicated on the Drawings.
4. Front: Door and trim with concealed hardware and cylinder-type lock and catch.
5. Boxes and fronts made of code-gauge steel.
6. Manufacturer standard gray enamel finish over prime coat.

E. Molded-Case Circuit Breakers:

1. NEMA AB 1, UL 489.
2. Bolt-On or I-LineType, labeled for 75 degree C copper and aluminum conductors.
3. Quick-make, quick-break, with thermal-magnetic trip.
4. Common internal trip on multi-pole breakers. Handle ties are not permitted.
5. Ampere rating and number of poles as scheduled.
6. Listed as Type HACR for air-conditioning equipment circuits.
7. Bussing, device mounting hardware and steel knockouts in dead front where space is indicated.
8. Shunt-trip device with 120V coil and auxiliary contacts where specified or indicated.

F. Short Circuit Current Rating:

1. Each panelboard with minimum short circuit current rating as indicated on the Drawings.
2. Fully-rated. Series-rated panelboards are not acceptable.

G. Surge Protection Device:

1. Device ratings and connection per requirements of Section 264313 “Surge Protection Devices” for the installed location of the panelboard in the electrical distribution system.
2. Provide where indicated on the Drawings or herein specified.

2.4 SERVICE ENTRANCE

A. UL 869A.

B. Panelboards labeled as suitable for use as service entrance equipment where applicable and shall include connection for bonding and grounding neutral conductor.

2.5 EXISTING PANELBOARDS

A. Existing Panelboards Indicated for New Branch/Feeder Circuits: Provide and connect new branch circuits as indicated on the Drawings to be served from the existing equipment in available space(s) per the following:

1. Circuit breaker(s) be from the same manufacturer of the existing equipment and fully compatible with the equipment.
2. Short Circuit Current Rating: New circuit breakers shall have the same short circuit interrupt capacity (KAIC rating) as the existing breakers in the equipment.
3. Existing Spare Circuit Breakers: Existing spare circuit breakers of proper ratings may be used for new branch/feeder circuits unless indicated otherwise.
4. Circuit Breaker Hardware: Provide and connect all required hardware and accessories necessary for the installation of the new circuit breaker(s) including but not limited to mounting kits, strap kits, panelboard trim pieces, etc.
5. Inadequate Space for New Circuit Breaker(s): Provide and connect new panelboard section with sufficient pole capacity and same ratings as the existing panelboard and serve by tapping the bus of the existing panelboard. Provide and connect tap connection conductors sized per NFPA-70 (NEC).
6. Identification: Provide new panelboard labeling and/or directory properly identifying new connected electrical loads.
7. Existing Conditions: The Contractor shall be responsible for visiting the site and verifying the existing conditions prior to bidding.

PART 3 - EXECUTION

3.1 COORDINATION WITH MANUFACTURER

A. Instruct manufacturer about the requirement and location for additional gutter space when required for wiring or specified accessories.

B. Instruct manufacturer about the location of the main lugs or main circuit breaker location based on incoming feeder entrance location.

C. Instruct manufacturer to provide multiple lugs where feeder circuit utilizes paralleled conductors and where sub-feed or feed-thru lugs are indicated or required.

3.2 INSTALLATION

A. Provide panelboards complete with feeder circuit, circuit breakers and branch circuits as scheduled and indicated on the Drawings.

B. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.

C. Panelboard Mounting:

1. Fasten panelboards firmly to walls and structural surfaces ensuring they are permanently and mechanically anchored.
2. Anchor and fasten panelboards and their supports to building structural elements by methods described in Section 260529 “Hangers and Supports for Electrical Systems.”
3. Install two rows minimum of steel slotted channel with a minimum of 4 attachment points for each panelboard section.
4. When not directly located on structural wall, provide support frame of steel slotted channel anchored to floor and ceiling structure.
5. Install such that top circuit breaker handle is a maximum of 6 foot 6 inches above the finished floor or working platform with handle in its highest position.
6. Install so as to maintain minimum working space clearance in all directions and dedicated electrical equipment spaces per NFPA 70 (NEC).
7. Flammable surfaces used for mounting panelboards shall be painted with 2 coats of flame resistant paint.

D. Tighten electrical connectors and terminals according to equipment manufacturer’s published torque-tightening values. Where manufacturer’s torque values are not indicated, use those specified in UL 486A-486B.

E. Install filler plates in unused spaces.

F. Leave all spare circuit breakers in the OFF position.

G. At all flush-mounted branch circuit panelboards, install four 3/4 inch spare conduits stubbed into ceiling space or above the bottom of the overhead structural steel

H. At flush-mounted distribution panelboards, provide spare conduit(s) routed to accessible ceiling location for each spare circuit breaker provided properly sized for a four conductor feeder and associated grounding conductor of the same ampere rating as the associated spare circuit breaker

I. Verify that the egress doors to electrical room(s) containing panelboardswith ampere ratings of 800A or greater open in the direction of egress and are equipped with listed panic hardware.

1. The Division 26 Contractor is responsible for coordinating the electrical space door and egress requirements with the General Contractor and providing the panic hardware if not provided with the door(s) supplied.

3.3 CONNECTIONS

A. Ground panelboards according to Section 260526 “Grounding and Bonding for Electrical Systems.

B. Connect wiring according to Section 260519 “Low-Voltage Electrical Power Conductors”.

C. Connect SPD according to Section 264313 “Surge Protection Devices”.

3.4 IDENTIFICATION

A. Provide engrave plastic nameplates per Section 260553 “Identification for Electrical Systems”. Nameplate legend shall include panelboard designation per the Drawings; voltage, phase and wire; and “Fed From:” source designation.

1. Attach to face of trim for panelboards located in non-public or non-finished spaces and inside door for panelboards located in public or finish spaces.
2. Attach to panelboard using small metal screws or rivets.

B. Branch Circuit Panelboards: Provide typewritten directory with transparent plastic cover indicating all connected circuit loads and install in directory frame mounted inside panelboard door. Directory shall also include listing of panelboard designation, voltage, phase, wire and “Fed From:” source.

C. Distribution Panelboards: Provide self-adhesive, engraved plastic nameplates at each circuit breaker indicating load served per the load designations indicated in the Contract Documents.

D. Circuit Numbering: Branch circuit panelboard circuits shall be numbered in sequence vertically down the left side then vertically down the right side and all circuits shall be arranged in the panelboard exactly as they are shown on the Drawings. Numbering to be consecutive across double and triple section panelboards.

E. Label all spare circuit breakers as SPARE.

3.5 SPECIAL CONDITIONS & ACCESSORIES

A. Verify that the egress doors to electrical room(s) containing panelboards with ampere ratings of 800A or greater shall open in the direction of egress and shall be equipped with panic hardware. The Division 26 Contractor is responsible for coordinating the door requirements with the General Contractor and providing the panic hardware if not provided with the door(s) supplied.

B. Panelboards served from the secondary side of a dry-type transformer constituting a separately derived system per NFPA 70 (NEC) shall be provided with a main circuit breaker sized as indicated on the Drawings or per the NFPA 70 (NEC) if size not indicated.

C. Branch circuit breakers serving outlets and equipment located under a kitchen exhaust hood equipped with at fire suppression system shall be the shunt-trip type.

D. Branch circuit breakers serving elevator motors shall be the shunt-trip type with auxiliary contacts.

3.6 FIELD QUALITY CONTROL

A. Inspect for physical damage, proper alignment, anchorage and grounding.

B. Check phase-to-phase and phase-to-ground insulation resistance levels prior to energizing panelboard.

C. Check panelboards for electrical continuity of circuits and short-circuits prior to energizing panelboard.

3.7 ADJUSTING

A. Adjust fronts, covers, hinges, doors and locks for proper alignment and operation. Adjust doors and locks for smooth operation.

3.8 CLEANING & TOUCH-UP

A. Clean panelboard interiors and exteriors. Remove paint splatters and other spills. Completely remove dirt and debris from panelboard interior.

B. Touch-up chips, scratches or marred finishes to match original finish using manufacturer-supplied paint kit.

END OF SECTION

SECTION 262726
WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. General-Use Snap (Toggle) Switches.
2. Power Receptacles.
3. Device Covers and Plates.

1.2 DEFINITIONS

A. AFCI: Arc-fault circuit interrupter.

B. GFCI: Ground-fault circuit interrupter.

C. GFEQ: Ground-fault equipment protection.

D. Pigtail: Short wiring lead used to connect a device to a branch circuit conductor.

E. SPD: Surge protection device.

1.3 REFERENCED STANDARDS

A. ANSI/NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting.

B. IEEE C62.41.2 - Characterization of Surges in Low-Voltage (1000V and less) AC Power Circuits.

C. IEEE C62.45 - Surge Testing for Equipment Connected to Low-Voltage (1000V and less) AC Power Circuits.

D. NFPA 70 - National Electrical Code.

E. NFPA 99 - Health Care Facilities Code.

F. NEMA FB 11 - Plugs, Receptacles, and Connector of the Pin and Sleeve Type for Hazardous Locations.

G. NEMA WD-1 - General Color Requirements for Wiring Devices.

H. NEMA WD-6 - Wiring Devices - Dimensional Requirements.

I. NEMA 250 - Enclosures for Electrical Equipment (1000 Volt Maximum).

J. UL 20 - General-Use Snap Switches.

K. UL 498 - Attachment Plugs and Receptacles.

L. UL 943 - Ground-Fault Circuit-Interrupters.

M. UL 1010 - Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations.

N. UL 1436 - Outlet Circuit Testers and Similar Indicating Devices.

O. UL 1449 - Standard for Surge Protection Devices.

P. UL 1472 - Solid State Dimming Controls.

Q. UL 1917 - Solid-State Fan Speed Controls.

1.4 SUBMITTALS

A. Refer to Section 260500 “General Requirements for Electrical Systems” for additional requirements.

B. Product Data: For each type of product.

1.5 QUALITY ASSURANCE

A. Obtain wiring devices from one source and by single manufacturer.

B. Regulatory Requirements:

1. Comply with NFPA 70 (NEC) for components and installation.
2. Furnish products listed and classified by UL as suitable for purpose specified and indicated.

1.6 DELIVERY, STORAGE & HANDLING

A. Store in clean, dry space.

B. Maintain factory unopened packaging until ready for installation.

PART 2 - PRODUCTS

2.1 GENERAL-USE (TOGGLE) SWITCHES

A. Manufacturers:

1. Hubbell Incorporated
2. Legrand/Pass & Seymour
3. Cooper Wiring Devices

4. Leviton Manufacturing Company

B. Comply with NEMA WD-1 and UL 20.

C. Switches: Heavy-duty, specification-grade; back and side wired; flush or surface mounting; for connection to copper conductors.
Body and Handle: Thermoplastic with toggle handle

1. Ratings: 120-277 Volts AC, 20 A minimum.
2. Single pole, double pole as indicated.
3. Three- or Four-way where indicated.
4. Key-operated where indicated.

2.2 RECEPTACLES

A. Manufacturers:

1. Hubbell Incorporated
2. Legrand/Pass & Seymour
3. Cooper Wiring Devices
4. Leviton Manufacturing Company

B. Comply with NEMA WD-1, NEMA WD-6 configuration 5-20R, and UL 498.

C. Receptacle: Heavy-duty, specification-grade; back and side wired; flush or surface mounting; straight-blade; 2 pole, 3 wire grounding; for connection to copper conductors.
Body: Thermoplastic.

1. Ratings: 125 Volts AC, 20 A minimum.
2. Single, duplex or double-duplex as indicated.
3. Special features and types and combination of types as indicated on the Drawings.
4. GFCI Type:

a. Additional compliance with UL 943 Class A.
b. Leakage current trip level: 4 to 6 mA.
c. Trip Time: 0.025 seconds nominal.
d. Test and reset buttons.
e. Reverse line-load function to prevent device from functioning if wired incorrectly.
f. Self-test feature to prevent device from delivering power if GFCI protection is lost.
g. Indicator Light: Illuminated when device is tripped.

5. Tamper Resistant (TR) Type:

a. Requires insertion of object in both left and right contacts to energize.

6. Twist-Locking Type:

    a. NEMA WD-6 configuration as indicated on Drawings.

7. Hospital-Grade:

    a. Listed and labeled “Hospital Grade” with UL green dot symbol on face of device.
    b. Provide in all patient-care rooms and spaces and as indicated on the Drawings in health care facilities governed by NFPA 99.

8. Switched Receptacles for Automatic Control:

    a. NFPA 70 (NEC) required marking on device face indicating outlets controlled.

9. USB Charging Type:

    a. Duplex receptacle with duplex, Type-A, 5V, 5A USB charging ports.

10. Isolated-Ground Type:

    a. Insulation-barrier to isolate device from metallic raceway system.
    b. Isolated-ground “triangle” symbol on face of device.

11. Surge-Protection Type:

    a. Integral surge protection within device.
    b. SPD indication symbol on face of device.

D. Special Purpose Receptacles: Heavy-duty, specification-grade device, rated for voltage and amperage with NEMA configuration as indicated on the Drawings.

E. Hazardous Location Receptacles: Comply with NEMA FB 11 and UL 1010.

2.3 CORD & PLUG DROPS

A. Receptacle: Voltage and ampere rating and NEMA configuration as indicated on the drawings. Nylon body with integral cable-clamping jaws.

B. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW jacket. Phase and neutral conductors as required with insulated green equipment grounding conductor.

C. Provide properly-sized kellems cable grips at each end of cord.

2.4 DEVICE COVERS & PLATES

A. Plates: Single and combination types to match corresponding wiring devices.

1. Material for Finished Spaces: stainless steel, satin finish, 0.035 inch thick.
2. Material for Unfinished Spaces: galvanized steel.

B. Weatherproof Covers: NEMA 250 complying with Type 3R, die-cast aluminum, weather-resistant.

1. Covered Exterior Spaces: Spring-loaded and gasketed snap-shut outlet covers.
2. Uncovered Exterior Spaces: Die-cast aluminum “In-Use” hinged cover with exit holes in bottom for wiring and locking provisions.

C. Tamper Resistant (TR): Slide cover over receptacle.

2.5 FINISHES

A. Color of Switch Handles and Receptacle Face: Gray except as listed below or manufacturer’s standard color as selected by the Professional. Verify device color with the Professional prior to ordering equipment.

1. Switches and Receptacles connected to a Standby or Emergency Power System: Red; plate shall be engraved with red lettering “EMERGENCY”.

a. Where the entire electrical system of a facility is connected to a Standby or Emergency Power System only the devices connected to the Life-Safety Branch of the System shall be Red in color.

2. Receptacles connected to UPS System: Orange

PART 3 - EXECUTION

3.1 COORDINATION

A. Verify location of wiring devices with Architectural interior elevation drawings, furniture drawings and millwork/casework drawings prior to rough-in.

B. Special Purpose Receptacles: Coordinate final selection of NEMA configuration of device with configuration of plug on utilization equipment.

C. Receptacle for Owner-Furnished Equipment and Equipment Furnished under other Divisions of the Specification: Verify and coordinate final selection of NEMA configuration of device with configuration of plug on utilization equipment.

D. Coordination with Other Trades:

1. Take steps to ensure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers guided by riding against outside edge of box.

2. Keep outlets free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint and other foreign material that may contaminate the raceway system, conductors and cables.
3. Install device boxes in brick or block walls so that the device cover plate does not cross a masonry joint unless the joint is troweled flush with the face of the wall.

4. Verify wall openings are neatly cut around outlet boxes in a manner that they will be completely covered by wall plates. Notify General Contractor of openings that require correction. Do not use oversize plates.

3.2 PREPARATION

A. Verify that outlet boxes are firmly attached and secured to prevent movement prior to installing wiring and device.

B. Clean all debris from outlet boxes.

3.3 DEVICE APPLICATION

A. Provide and connect wiring devices as specified herein and as indicated on the Drawings by symbols with associated serving branch circuits.

B. GFCI Receptacles: Provide GFCI type device as indicated on the Drawings and per the following:

1. Within 6 feet of a counter-top or floor-mounted sink, bathtub or shower stall.
2. Toilets/Restrooms.
3. Kitchens.
4. Indoor damp or wet locations.
5. Locker rooms with showering facilities.
6. Garages including vehicle maintenance facilities.
7. Crawl spaces and unfinished areas of basements.
8. Laundry areas.
9. Electric drinking fountains.
10. Elevator machine rooms.

C. Weatherproof GFCI Receptacles: Provide weatherproof GFCI receptacles with proper cover per installed location as indicated on the Drawings and per the following:

1. Outdoors.
2. Rooftops within 25 feet of roof-top mechanical equipment without integral convenience outlet.
3. Elevator pits.

D. Tamper-Resistant Receptacles: Provide tamper-resistant type device as indicated on the Drawings and per the following:

1. Dwelling Units including apartments, condominiums, etc.
2. Guest Rooms and Guest Suites of hotels, motels and their commons spaces.

3. Child Care Facilities.
4. Preschools and Educational Facilities.
5. Business offices, corridors, waiting rooms and the like in Clinics, Medical and Dental Offices, and Outpatient Facilities.
6. Assembly Occupancies: Places of Awaiting Transportation, Gymnasiums, Skating Rinks and Auditoriums.
7. Dormitory Units.
8. Assisted Living Facilities.

E. AFCI protected Receptacles: Provide AFCI type circuit breaker for protection of wiring device branch circuits as indicated on the Drawings and per the following:

1. Dwelling Units including apartments, condominiums, etc.
2. Dormitory Units.
3. Guest Rooms, Guest Suites and Patient Sleeping Rooms in Nursing Homes and Limited-Care Facilities.

3.4 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise specified, scheduled or indicated. Indicated mounting heights shall be to center of device.

B. Conductors:

1. Do not strip insulation from conductors until just before they are splice or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking solid wire or cutting strands of stranded wire.
3. Length of free conductors at outlets for devices shall meet provisions of NFPA 70 (NEC) without pigtails.
4. Do not use stranded conductors for termination to devices unless crimp-on fork terminals are used for terminations.

C. Device Installation:

1. Keep device in its manufacturer’s package or otherwise protected until it is installed.
2. Do not remove surface protection, such as plastic film and smudge covers until last possible moment.
3. Devices shall be connected to serving branch circuit using pigtails a minimum of 6 inches in length. Do not connect receptacles in a feed-through manner.
4. Terminate conductors for all devices using side terminal binding-head screw terminals. Wrap solid conductor tightly clockwise around terminal screw.
5. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
6. When conductor larger than #12 AWG are installed for 15A or 20A branch circuits, splice #12 AWG pigtails to branch circuit for device connections.
7. Tighten unused terminal screws on the device.

8. When mounting devices in metal boxes, remove fiber or plastic washers to hold device mounting screws in yoke, allowing metal-to-metal contact.
9. Install devices plumb, level with finished surfaces and free from blemishes.
10. Install lighting switches vertically on latch side of door. Where adequate space for switch installation does not exist on latch side of door, mount switch on hinge side of door so switch is not located behind door in open position. First switch of single or ganged switch bank shall be mounted within 12 inches of door frame or edge of door.
11. Install devices above counters, 4 inches to centerline of the device above the countertop or backsplash where present. Install all devices at same height above any one counter or fixed cabinet.
12. Group adjacent switches under single, multigang wall plate.
13. Connect wiring device grounding terminal to outlet box with bonding jumper and branch circuit equipment grounding conduct. Ground per the requirements in Section 260526 “Grounding and Bonding for Electrical Systems”.

D. Device Mounting Heights:

1. Switches: 48 inches to center above finished floor unless indicated otherwise.
2. Receptacles: 18 inches to center above finished floor unless indicated otherwise.
3. Receptacles at Counter Top: 4 inches to center above top of counter or backsplash unless indicated otherwise.
4. Receptacles in Shops/Garages: 48 inches to center above finished floor unless indicated otherwise.
5. Equipment Receptacles: Height and location as directed by equipment provider for proper equipment connection with supplied equipment power cord and for concealment behind equipment in public spaces (i.e. electric drinking fountains).
6. Comply with requirements of ADA-2010.
7. Device mounting heights may be adjusted slightly to allow cutting of masonry block to the top or bottom of the nearest block course maintaining specified mounting height and ADA-2010 requirements.

E. Device Installation Orientations:

1. Install ground pin of vertically-mounted receptacles up, and on horizontally-mounted receptacles to the right.
2. Install switches with handle operating vertically with “ON” position up.
3. Unless otherwise indicated or where adequate space is not available due to adjacent construction, mount devices flush with long dimension vertical.

F. Device Cover Plates:

1. Provide cover plate on all outlet boxes whether or not a device is installed. Provide blank plate on empty, spare or future outlet boxes.
2. Plates shall be properly secured to outlet box with all four corners in contact with wall finish and oriented parallel/perpendicular to adjacent building surfaces.
3. Plates shall not be installed such that corners are protruding from edge of outlet box or wall surface creating a snagging or sharp edge condition.

3.5 IDENTIFICATION

A. Provide self-adhesive clear label with black lettering on the face of all receptacles indicating serving panelboard and branch circuit number.

B. Receptacles connected to standby power system shall have engrave plates as herein specified.

3.6 FIELD QUALITY CONTROL

A. Inspect wiring devices for defects and replace as required.

B. Operate wall switches with connected circuits energized and verify proper operation and equipment controlled.

C. Perform the following tests:

1. Test all receptacles with receptacle circuit tester. Tester shall test for open ground, reverse polarity, open hot, open neutral, hot and ground reversed neutral and ground reversed. Rewire receptacles with faults and retest.
2. Test each GFCI receptacle for proper operation. Perform testing with an instrument specifically designed and manufactured for testing ground-fault circuit interrupters. Test for compliance with specified functions.

D. Adjust devices and associated plates to be flush with wall finish, level and plumb.

3.7 CLEANING

A. Clean devices and cover plates after painting is complete. Replace stained or improperly painted devices and cover plates.

B. Clean all devices and plates of dust, dirt, stains, spills and construction debris.

END OF SECTION

SECTION 262816
ENCLOSED SWITCHES & CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fusible and non-fusible disconnect switches.
2. Circuit breakers in individual enclosures.
3. Toggle-switch disconnects.

1.2 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. K.A.I.C.: Kilo-ampere interrupt capacity.

D. MCCB: Molded-case circuit breaker.

E. MMS: Manual motor switch. For the purpose of the Division 26 Specifications, a manual motor switch shall be a toggle-switch disconnect with lockout bracket.

F. SCCR: Short circuit current rating.

G. SPDT: Single-pole, double throw.

1.3 REFERENCED STANDARDS

A. ANSI/NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting.

B. NEMA AB 1 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.

C. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

D. NFPA 70 - National Electrical Code.

E. UL 98 - Enclosed and Dead Front Switches.

F. UL 486A - 486B - Wire Connectors.

G. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.

H. UL 869A - Reference Standard for Service Equipment.

1.4 SUBMITTALS

A. Refer to Section 260500 “General Requirements for Electrical Systems” for additional requirements.

B. Product Data: For each type and rating of switch or enclosed circuit breaker.

1. Submit catalog cut sheet of manufacturer’s standard product indicating voltage, amperage, HP ratings, enclosure type, dimensions, fuse clip features, terminal lugs and all accessories including interlock devices, short circuit current ampere rating and factory settings of individual protective devices.

1.5 QUALITY ASSURANCE

A. Obtain disconnect switches and enclosed circuit breakers and accessories from one source and by single manufacturer.

B. Regulatory Requirements:

1. Comply with NFPA 70 (NEC).
2. Furnish products listed and classified by UL as suitable for purpose specified and indicated.

1.6 DELIVERY, STORAGE & HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris and traffic.

B. Comply with manufacturer’s written instructions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Disconnect Switches

1. Basis of Design: ABB/General Electric.
2. Equal in Square D Company, Siemens or Eaton.

B. Enclosed Circuit Breakers

1. Basis of Design: ABB/General Electric.
2. Equal in Square D Company, Siemens or Eaton.

2.2 DISCONNECT SWITCHES

A. NEMA KS 1, UL 98.

B. Load interrupter enclosed knife switch, heavy-duty type.

C. Fusible or non-fusible type as indicated on the Drawings or specified herein.

D. Switch Interiors:

1. Switch blades that are visible in “OFF” position when enclosure door is open.
2. Plated current carrying parts.
3. Removable arc suppressors to permit easy access to line-side lugs.

E. Switch Mechanism:

1. Quick-make, quick-break with visible blades and externally operable handle.
2. Lockable only in “OFF” position.
3. Dual cover interlock to prevent unauthorized opening of enclosure door when operating handle is in the “ON” position and to prevent closing of switch mechanism with enclosure door open.
4. Defeater mechanism to bypass interlock.
5. Operating handle integral part of enclosure.
6. Handle to physically indicate “ON” and “OFF” position.

F. Ratings:

1. Ampere rating as indicated on Drawings.
2. Horsepower rated.

G. Fusible Switches:

1. Rejection clips for Class R fuses.
2. Provisions for Class J or Class L fuses as applicable.
3. Where indicated to be fused, provide current-limiting, dual-element, time-delay fuses of indicated ampere rating.

a. Basis of Design: Bussman Fusetron Series or approved equal.

2.3 ENCLOSED CIRCUIT BREAKERS

A. NEMA AB 1, UL 489.

B. Enclosed molded-case circuit breakers:

1. Tripped indication clearly shown on breaker handle taking position between “ON” and “OFF” positions.
2. Thermal-magnetic trip unless indicated otherwise.

C. Breaker Mechanism:

1. Quick-make, quick-break.

D. Ratings:

1. Ampacity and number of poles as indicated on the Drawings.
2. Breaker ampere rating shall be visible with enclosure door open and all interior covers in place.
3. Listed as Type HACR for air conditioning equipment circuits.
4. Listed as Type SWD for lighting circuits.

2.4 TOGGLE-SWITCH DISCONNECT

A. Comply with the requirements of Section 262726 “Wiring Devices” for device.

B. Toggle-switch ratings:

1. Ampere Rating: As indicated, minimum 20 amperes.
2. Voltage Rating: 120/277V.

C. Enclosure: Standard 4" square box with galvanized surface cover with permanently attached lockout bracket.

1. Lockout Bracket: Equal to Leviton LKOUT-40, stainless steel construction, tamper-resistant attachment screws.

D. Use Limitations:

1. Where indicated on the Drawings
2. Motors: Rated 1 HP or less, 250 volt maximum, single or three phase.
3. Equipment: Rated 16 full-load amperes or less, 250 volt maximum, single or three phase.
4. Indoor, dry location use only.
5. Do not use where disconnect switch is specified unless directed by the Professional.

2.5 LUGS

A. Front removable lugs.

B. Labeled for 75 degree C copper and aluminum conductors.

C. Multiple lugs to match indicated number of conductors per phase.

D. Termination of field installed conductors: Pressure wire connectors, except wire-binding screws for #10 AWG or smaller conductors.

2.6 ACCESSORIES

A. Equipment ground kit.

B. Solid Neutral Assembly, where required.

C. Auxiliary Contacts, NO/NC, where indicated or required.

1. Elevators: Switches serving elevator motor and control circuits shall be provided with auxiliary contacts.

D. Shunt-trip circuit breaker, 120 volt coil, where indicated or required.

2.7 ENCLOSURES

A. NEMA KS 1, NEMA AB 1, UL 98, UL 489, as applicable.

B. NEMA Type 1, NEMA Type 3R, NEMA Type 4X stainless-steel as required by NFPA 70 (NEC) for the installed environment and the following:

1. Indoor, dry locations: NEMA Type 1
2. Indoor, wet locations: NEMA Type 3R
3. Indoor, corrosive locations: NEMA Type 4X
4. Indoor, commercial kitchen areas: NEMA Type 4X
5. Outdoor, covered or uncovered locations: NEMA 3R
6. Outdoor, near cooling towers: NEMA 4X

C. Code-gauge galvanized steel with manufacturer’s standard gray enamel finish over prime coat. All NEMA Type 4X enclosures shall be stainless steel.

D. Surface-mounted. Flush-mounted circuit breaker enclosure where indicated.

2.8 SERVICE ENTRANCE

A. UL 869A.

B. Switches and circuit breakers indicated to be used for electrical service entrance equipment shall be labeled for this application and shall be provided with solid neutral assembly and equipment ground bar and shall include connection for bonding and grounding neutral conductor.

2.9 SHORT CIRCUIT CURRENT RATING

A. Each circuit breaker shall have minimum K.A.I.C. rating as indicated on the drawings. If rating not indicated, use same rating as serving electrical distribution equipment.

PART 3 - EXECUTION

3.1 EXAMINATION & COORDINATION

A. Examine areas and surfaces to receive disconnect switches, enclosed circuit breakers and manual motor switches for compliance with requirements, installation tolerances and other conditions affecting performance.

B. Verify that space indicated for mounting devices meets access and working space clearances required by NFPA 70 (NEC).

1. Coordinate mounting location of devices with the work of other trades to ensure accessibility and working clearances are maintained after installation of other work.

3.2 INSTALLATION

A. Provide and connect enclosed circuit breakers and switches as specified herein and as indicated on the drawings by symbols and schedules.

B. Install in accordance with ANSI/NECA 1.

C. Install disconnect switches, enclosed circuit breakers and toggle-switch disconnects level and plumb in accordance with manufacturer's written instructions.

D. Mounting of Disconnect Switches and Enclosed Circuit Breakers:

1. Fasten devices firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
2. Comply with Section 260529 "Hangers and Supports for Electrical Systems".
3. Install two rows of steel slotted channel with a minimum of four attachment points for each device. Gang multiple devices mounted at same location on common mounting channel where possible.
4. Where suitable mounting substrate is not available or properly located, provide support frame of steel slotted channel anchored to floor and ceiling structure.

E. Do not support disconnect switches or enclosed circuit breakers by raceway system.

F. Install disconnect switch, enclosed circuit breaker and toggle-switch disconnect with centerline of operating handle 54 inches above finished floor or work platform where possible. Adjust mounting height as required for field conditions maintaining NFPA 70 (NEC) accessibility, clearance and operation requirements.

G. Tighten electrical connectors and terminals according to equipment manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

H. Install proper fuses in fusible switches.

3.3 IDENTIFICATION

A. Provide engraved plastic nameplates per Section 260553 “Identification for Electrical Systems”. Attach nameplate to exterior of enclosure of surface-mounted switches and enclosed circuit breakers using small stainless steel screws or rivets. Do not use self-adhesive backing as sole fastening means.

B. Switch or enclosed circuit breaker nameplate shall include: Equipment Designation for connected equipment, circuit voltage and phase, branch circuit designation (panelboard name and circuit number).

3.4 CONNECTIONS

A. Ground equipment according to Section 260526 “Grounding and Bonding for Electrical Systems”.

B. Connect wiring according to Section 260519 “Low-Voltage Electrical Power Conductors”.

3.5 FIELD QUALITY CONTROL

A. Inspect for physical damage, proper alignment, anchorage and grounding.

B. Check phase-to-phase and phase-to-ground insulation resistance levels prior to energizing equipment.

C. Check for electrical continuity of circuits and short-circuits prior to energizing.

3.6 ADJUSTING

A. Adjust fronts, covers, hinges, doors and locks for proper alignment and operation. Adjust doors and locks for smooth operation.

3.7 CLEANING & TOUCH-UP

A. Clean interiors and exteriors. Remove paint splatters and other spills. Completely remove dirt and debris from enclosure interior.

B. Touch-up chips, scratches or marred finishes to match original finish using manufacturer-supplied paint kit.

END OF SECTION

DIVISION 31

EARTHWORK

SECTION 312000 – EARTH MOVING

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. Excavating and backfilling trenches for utilities.
2. Backfilling trenches with bedding material as specified and filling trenches with suitable material to proposed subgrade.
3. Compacting backfill materials in acceptable manner.

1.3 QUALITY ASSURANCE

A. An independent testing laboratory will perform testing at intervals not exceeding 200-feet of trench for first and every other 6-inch lift of compacted trench backfill and furnish copies of results as specified herein.

1.4 SUBMITTALS

A. See Section 230010 – Mechanical General Provisions.

B. Submit product data, O&M data, and samples and show item on shop drawings (where shop drawings are required) according to the following table.

1. “R” means required.
2. “R2” means required only for products and equipment differing for the specified manufacturer and model and for “or equals” where specified.

Item	Product Data	O&M Manual	Samples	Shop Drawing
Backfill material	R			
Warning tapes	R			

1.5 FIELD CONDITIONS

A. Utility Locator Service: Notify utility locator service for area where Project is located before beginning earth-moving operations.

B. Do not commence earth-moving operations until temporary site fencing and erosion- and sedimentation-control measures specified in Section 015000 "Temporary Facilities and Controls" are in place.

C. The following practices are prohibited within protection zones:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Foot traffic.
4. Erection of sheds or structures.
5. Impoundment of water.
6. Excavation or other digging unless otherwise indicated.
7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.

D. Do not direct vehicle or equipment exhaust towards protection zones.

E. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

PART 2 - PRODUCTS

2.1 BEDDING AND BACKFILL MATERIALS

A. Type S1 – Select Fill

1. Material shall consist of select, non-organic, debris-free silty clays or sandy clays with no more than 55 percent fines passing a No. 200 sieve.
2. The plasticity index shall be within the range of 8 to 20.
3. The liquid limit shall be less than 40.

B. Type S2 – Coarse Aggregate.

1. Material shall consist of washed stone free of shale, clay, friable material, sand and debris.
2. The aggregate shall be graded in accordance with ANSI/ASTM C33, size number 467.

C. Type S3 – Pea Gravel.

1. Material shall consist of natural stone free of shale, clay, friable material, sand and debris.
2. The material shall be graded to be between a minimum of 1/4-inch and a maximum of 5/8-inch in size.

D. Type S4 – Sand.

1. Material shall consist of natural river or bank sand, washed free of silt, clay, or organic matter, loam friable or soluble materials.
2. The material shall be graded in accordance with ANSI/ASTM C33.

E. Type S5 – Crushed Stone.

1. Crushed limestone, No. 610 gradation.

2.2 MATERIAL QUALITY CONTROL

A. Tests and analysis of soil material shall be performed in accordance with ASTM D4318 or ASTM C136.

B. Materials tested which do not meet the specified requirements shall be removed and replaced with acceptable material at no cost to Owner.

C. Maximum dry density of the soil materials shall be determined by ASTM D698 and field density of in-place materials by ASTM D2922.

2.3 EQUIPMENT

A. Transport off-site materials to project using well maintained and operating vehicles. Once on-site, transporting vehicles shall stay on designated haul roads and shall at no time endanger improvements by rutting, overloading, or pumping.

2.4 ACCESSORIES

A. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored as follows:

1. Red: Electric.
2. Yellow: Gas, oil, steam, and dangerous materials.
3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

PART 3 - EXECUTION

3.1 PREPARATION

A. Prior to excavation, investigation shall be made to the extent necessary to determine the location of existing underground structures and conflicts. This Contractor shall coordinate and utilize the services of public and private “locators” to determine the whereabouts of all underground utilities in the area where work is to be performed.

B. When obstructions that are not shown on the Contract Drawings are encountered during the progress of work and interfere so that an alteration of the Drawings is required, the Architect will alter the Drawings or order a deviation in line and grade or arrange for removal, relocation, or reconstruction of the obstructions.

C. Appropriate traffic control devices shall be provided in accordance with federal, state, or local regulations to regulate, warn, and guide traffic at the work site.

D. Trees, shrubs, fences, and all other property and surface structures shall be protected during construction unless their removal is shown on the Contract Drawings and Specifications or approved by the Owner.

E. Set lines, elevations, and grades for proposed systems.

F. Protect benchmarks, property corners, and other survey monuments from damage or displacement. If marker needs to be removed it shall be referenced by licensed land surveyor and replaced, as necessary, by same.

G. Maintain in operating condition existing utilities, previously installed utilities, and drainage systems encountered in utility installation. Repair surface or subsurface improvements.

H. Verify location, size, elevation, and other pertinent date required to make connections to existing utilities.

I. Over excavate and properly prepare areas of subgrade that are not capable of supporting proposed systems.

J. Provide dewatering systems as required for utility excavations.

3.2 EXCAVATION

A. Verify locations of all existing utilities before excavation begins. Verification shall be by contact with local utilities agencies or by hand excavation in area of known utilities to determine exact location of existing utility. Contractor is to notify local utilities before excavation begins. Dig trench at proper width and depth for laying pipe, conduit, or cable. Cut trench banks vertical, if possible, and remove stones from bottom of trench as necessary to avoid point-bearing. Over excavate wet or unstable soil, if encountered, from trench bottom as necessary to provide suitable base for continuous and uniform bedding.

B. During excavation, material meeting the Type S1 requirements shall be stockpiled in an orderly manner and at a sufficient distance from the banks of the trench to avoid over-loading and to prevent slides or cave-ins. Submit test reports to verify soil properties.

C. All excavated materials not required or suitable for backfill shall be removed and disposed of off-site at Contractor's expense.

D. Excavation and trenching shall be performed to allow utilities to be installed to lines and grades established by the Contract Drawings and Specifications with fittings and valves at the required locations unless otherwise approved by the Architect.

E. All excavation of every description and of whatever substances encountered shall be performed to the depths indicated or as otherwise specified.

F. Excavated material shall be placed in a manner that will not obstruct sidewalks, driveways, or other structures.

G. Care should be exercised by the Contractor during excavation to avoid damage to existing structures and utilities.

H. When excavation of rock is encountered, all rock shall be removed to provide a clearance of at least 9 inches below and on each side of all pipes, valves, and fittings. The same shall also be performed when pieces of concrete or masonry and other debris or subterranean structures, such as masonry walls, piers, or foundations are encountered during excavation.

I. When crossing existing pipelines or other structures, alignment and grade shall be adjusted as necessary, with the approval of the Architect, to provide clearance as required by federal, state,

or local regulations or as deemed necessary by the Architect to prevent future damage or contamination of either structure.

J. Removal of pavement and road surfaces shall be a part of the trench excavation and the amount removed shall depend upon the width of trench required for the installation of structures. The dimensions of pavement removed shall not exceed the dimensions of the opening required for installation of pipe and other structures by more than 6 inches in any direction unless required or approved by the Owner.

K. Should the trench pass over a sewer or other excavation, the trench bottom shall be sufficiently compacted to provide support equal to that of the native soil or conform to other regulatory requirements in a manner that will prevent damage to the existing installation.

L. Temporary support, adequate protection, and maintenance of all underground and surface structures, drains, sewers, and other obstructions encountered in the progress of the work shall be furnished by the Contractor. All properties that have been disturbed shall be restored as nearly as practical to their original condition.

M. When the sub grade is found to be unstable or to include ashes, cinders, refuse, organic material, or other unsuitable material, such material shall be removed, to a minimum of at least 12 inches below the pipe level and backfilled up to original trench depth with Type S1 material.

N. Ditches shall be kept free of water during piping installation. Grading shall be done as necessary to prevent surface water from flowing into trenches or other excavations, and any water accumulating therein shall be removed by pumping or by other approved methods. Discharge from any trench dewatering pumps shall be conducted to natural drainage channels, storm sewers, or an approved reservoir.

3.3 PIPE BEDDING AND BACKFILLLING

A. General Requirements:

1. The trenches shall not be backfilled until the installation conforms to the requirements specified.
2. Do not install backfill over porous, wet, frozen, or spongy sub-grade surfaces.
3. In areas where less than 16-inches of ground cover exists, the piping shall be encased in concrete. Concrete shall be minimum 3000 PSI with reinforcing as indicated or required. Backfill shall be provided above concrete to original grade or sub-grade.
4. Pavement, base course, and compacted sub grade disturbed by trenching operations shall be replaced in an acceptable manner with materials equal to the adjacent compacted sub grade, base course, and pavement for a minimum distance of 12 inches on each side of the trench.
5. If compaction tests indicate Work does not meet specified requirements, Contractor shall remove Work, replace, and retest until specified requirements are met.

B. Bedding and Backfilling Requirements:

1. Bedding shall be provided for all piping, valves, etc.
2. Bedding material shall be either Type S3 or S4.
3. Bedding shall extend from 4-inches below bottom of pipe to 12-inches above top of pipe.
4. Backfill shall extend from 12-inches above top of pipe up to top of trench or original grade/sub-grade.
5. Placement and compaction of bedding and backfilling materials under roads, parking areas, etc. shall be performed as follows:

a. Place materials in continuous 6-inch thick horizontally placed loose layers and compact to 98% ASTM D698 maximum density with stability (stability shall be the absence of significant pumping or yielding of the soils while compaction is being performed).
b. Adjust moisture content of materials utilized for bedding and backfilling with lime or other Architect approved method of restoring stability as required to obtain specified compaction requirements.
c. Compaction tests shall be performed for each lift of bedding and/or backfilling per 200 linear foot of piping length.

6. Placement and compaction of bedding and backfilling materials under grassy areas, sidewalks, etc. shall be performed as follows:

a. Place materials in continuous 9-inch thick horizontally placed loose layers and compact to 95% ASTM D698 maximum density with stability (stability shall be the absence of significant pumping or yielding of the soils while compaction is being performed).
b. Adjust moisture content of materials utilized for bedding and backfilling with lime or other Professional approved method of restoring stability as required to obtain specified compaction requirements.
c. Compaction tests shall be performed for each lift of bedding and/or backfilling per 200 linear foot of piping length.

3.4 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.5 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.6 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances, where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompact.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.7 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

B. Transport surplus satisfactory soil to designated storage areas on Owner's property. Stockpile or spread soil as directed by Architect.

1. Remove waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 312000