PROJECT MANUAL

2nd Floor AHU Replacement

Skokie Public Library
Skokie, IL

This Project Manual contains Bidding Requirements, Contract Form, Conditions of the Contract and the Specifications for the Project. The contents of this Project Manual, the accompanying Drawings and any Addenda constitute the Bidding Documents for this Project.

GBA #P25-1226-00

GRUMMAN|BUTKUS
ENERGY EFFICIENCY CONSULTANTS
AND SUSTAINABLE DESIGN ENGINEERS

PROJECT MANUAL CONTENTS

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Construction Table of Contents.docx

SECTION 00 2113
INSTRUCTIONS TO BIDDERS

This is a standard Grumman|Butkus Associates document based on, but not identical to, EJCDC No. C 200 (2002 Edition), "Suggested Instructions to Bidders for Construction Contracts."

1. DEFINED TERMS

1.1 Certain terms used in these Instructions to Bidders are defined in the Standard General Conditions of the Construction Contract (No. C-700, 2002 Edition) and have the meanings assigned to them therein.

2. COPIES OF BIDDING DOCUMENTS

2.1 Complete sets of the Bidding Documents in the number and for the deposit sum, if any, stated in the Advertisement or Invitation to Bid may be obtained from the Issuing Office. The deposit will be refunded to each document holder of record who returns a complete set of Bidding Documents in good condition within 30 calendar days after opening of Bids.

2.2 Complete sets of Bidding Documents shall be used in preparing Bids; neither Owner nor Engineer assumes any responsibility for errors or misinterpretations resulting from the use of incomplete sets of Bidding Documents.

2.3 Owner and Engineer, in making copies of Bidding Documents available on the above terms, do so only for the purpose of obtaining Bids for the Work and do not confer a license or grant for any other use.

3. QUALIFICATIONS OF BIDDERS

3.1 To demonstrate Bidder's qualifications to perform the Work, within five business days of Owner's request, Bidder may be required to submit written evidence such as financial data, previous experience, present commitments, and such other data as may be called for below:

A. List of projects (preferably local, minimum of five) involving similar work, including names and telephone numbers of appropriate contact at each.

B. Current Financial Statement

C. Evidence of authority (listing of appropriate licenses, etc.) to perform all specified work in the jurisdiction where the project is located.

D. Listing of manufacturers or suppliers of components, devices or major material categories not fabricated by the bidder itself.

E. Project organization, including anticipated manpower scheduling plus identity and experience of Project Superintendent.

F. Project Schedule, including indication of the start and completion times of each major task and critical equipment delivery dates; shall incorporate also targeted Substantial Completion, final checkout and Owner instruction.

G. In addition, the Apparent Successful Bidder may be requested to answer certain technical questions about its proposal as well as to permit a sample (or similar installation) of the proposed system to be observed by Owner and/or Engineer.

4. EXAMINATION OF BIDDING DOCUMENTS, OTHER RELATED DATA, AND SITE

4.1 On request, Owner will provide Bidder access to the Site to conduct such examinations, investigations, explorations, tests, and studies as Bidder deems necessary for submission of a Bid. Bidder shall fill all

holes and clean up and restore the Site to its former condition upon completion of such explorations, investigations, tests, and studies. Bidder shall comply with all applicable Laws and Regulations relative to excavation and utility locates.

4.2 Reference is made to Article 7 of the Supplementary Conditions for the identification of the general nature of other work that is to be performed at the Site by Owner or others (such as utilities and other prime contractors) that relates to the Work contemplated by these Bidding Documents. On request, Owner will provide to each Bidder for examination access to or copies of Contract Documents (other than portions thereof related to price) for such other work.

4.3 It is the responsibility of each Bidder before submitting a Bid to:

A. examine and carefully study the Bidding Documents, the other related data identified in the Bidding Documents, and any Addenda;

B. visit the Site and become familiar with and satisfy Bidder as to the general, local, and Site conditions that may affect cost, progress, and performance of the Work;

C. become familiar with and satisfy Bidder as to all federal, state, and local Laws and Regulations that may affect cost, progress, and performance of the Work;

D. carefully study all: (1) reports of explorations and tests of subsurface conditions at or contiguous to the Site and all drawings of physical conditions in or relating to existing surface or subsurface structures at or contiguous to the Site (except Underground Facilities) which have been identified in the Supplementary Conditions as provided in Paragraph 4.02 of the General Conditions, and (2) reports and drawings of Hazardous Environmental Conditions at the Site which have been identified in the Supplementary Conditions as provided in Paragraph 4.06 of the General Conditions;

E. obtain and carefully study (or accept consequences of not doing so) all additional or supplementary examinations, investigations, explorations, tests, studies, and data concerning conditions (surface, subsurface, and Underground Facilities) at or contiguous to the Site which may affect cost, progress, or performance of the Work or which relate to any aspect of the means, methods, techniques, sequences, and procedures of construction to be employed by Bidder, including applying any specific means, methods, techniques, sequences, and procedures of construction expressly required by the Bidding Documents, and safety precautions and programs incident thereto;

F. agree at the time of submitting its Bid that no further examinations, investigations, explorations, tests, studies, or data are necessary for the determination of its Bid for performance of the Work at the price(s) bid and within the times and in accordance with the other terms and conditions of the Bidding Documents;

G. become aware of the general nature of the work to be performed by Owner and others at the Site that relates to the Work as indicated in the Bidding Documents;

H. correlate the information known to Bidder, information and observations obtained from visits to the Site, reports and drawings identified in the Bidding Documents, and all additional examinations, investigations, explorations, tests, studies, and data with the Bidding Documents;

I. promptly give Engineer written notice of all conflicts, errors, ambiguities, or discrepancies that Bidder discovers in the Bidding Documents and confirm that the written resolution thereof by Engineer is acceptable to Bidder; and

J. determine that the Bidding Documents are generally sufficient to indicate and convey understanding of all terms and conditions for the performance of the Work.

4.4 Documents relating to existing facilities, systems and equipment are available for examination at the location indicated in the Invitation to Bid. While these documents should be helpful in surveying and comprehending the existing conditions, their accuracy in every detail cannot be guaranteed. It is up to the Bidder to verify to his satisfaction that the building and/or its systems are the same as (or different from) what is shown in those respects that affect the Work and to verify by direct observations the correct configurations.

4.5 The submission of a Bid will constitute an incontrovertible representation by Bidder that Bidder has complied with every requirement of this Article 4, that without exception the Bid is premised upon performing and furnishing the Work required by the Bidding Documents and applying any specific means, methods, techniques, sequences, and procedures of construction that may be shown or indicated or expressly required by the Bidding Documents, that Bidder has given Engineer written notice of all conflicts, errors, ambiguities, and discrepancies that Bidder has discovered in the Bidding Documents and the written resolutions thereof by Engineer are acceptable to Bidder, and that the Bidding Documents are generally sufficient to indicate and convey understanding of all terms and conditions for performing and furnishing the Work.

5. PRE-BID CONFERENCE

5.1 A pre-Bid conference may be held. Refer to the Invitation to Bid for time and location. Representatives of Owner and Engineer will be present to discuss the Project. Bidders are encouraged (or may be required – refer to Invitation to Bid) to attend and participate in the conference. Engineer will transmit to all prospective Bidders of record such Addenda as Engineer considers necessary in response to questions arising at the conference. Oral statements may not be relied upon and will not be binding or legally effective.

6. SITE AND OTHER AREAS

6.1 The Site is identified in the Bidding Documents. Easements for permanent structures or permanent changes in existing facilities are to be obtained and paid for by Owner unless otherwise provided in the Bidding Documents. All additional lands and access thereto required for temporary construction facilities, construction equipment, or storage of materials and equipment to be incorporated in the Work are to be obtained and paid for by Contractor.

7. INTERPRETATIONS AND ADDENDA

7.1 All questions about the meaning or intent of the Bidding Documents are to be submitted to Engineer in writing. Interpretations or clarifications considered necessary by Engineer in response to such questions will be issued by Addenda mailed or delivered to all parties recorded by Engineer as having received the Bidding Documents. Questions received less than ten business days prior to the date for opening of Bids may not be answered. Only questions answered by Addenda will be binding. Oral and other interpretations or clarifications will be without legal effect.

7.2 Addenda may be issued to clarify, correct, or change the Bidding Documents as deemed advisable by Owner or Engineer.

8. BID SECURITY

8.1 If Bid Security is required by the Invitation to Bid:

A. Each Bid must be accompanied by Bid security made payable to Owner in an amount of 10% of Bidder's maximum Bid price and in the form of a certified check or bank money order or a Bid bond (on the form attached, if a form is prescribed) issued by a surety meeting the requirements of Paragraphs 5.01 and 5.02 of the General Conditions.

B. The Bid Security of the Successful Bidder will be retained until such Bidder has executed the Agreement and furnished the required Contract Security (Performance Bond and Payment Bond), whereupon the Bid Security will be returned. If the Successful Bidder fails to execute and deliver the Agreement and furnish the required Contract Security within 15 business days after the Notice of Award, Owner may annul the Notice of Award and the Bid Security of that Bidder will be forfeited as liquidated damages.

C. The Bid Security of other Bidders whom Owner believes to have a reasonable chance of receiving the award may be retained by Owner until the earlier of the seventh calendar day after the Effective Date of the Agreement or the forty sixth calendar day after the Bid opening, whereupon Bid Security furnished by such Bidders will be returned. Bid Security with Bids which are not competitive will be returned within seven calendar days after the bid opening.

9. CONTRACT TIMES

9.1 The number of days within which, or the dates by which, the Work is to be substantially completed and ready for final payment are set forth in the Agreement.

10. LIQUIDATED DAMAGES

10.1 Provisions for liquidated damages, if any, are set forth in the Agreement.

11. SUBSTITUTE AND "OR-EQUAL" ITEMS

11.1 The Contract, if awarded, will be on the basis of materials and equipment specified or described in the Bidding Documents without consideration of possible substitute or "or-equal" items. Whenever it is specified or described in the Bidding Documents that a substitute or "or-equal" item of material or equipment may be furnished or used by Contractor if acceptable to Engineer, application for such acceptance will not be considered by Engineer until after the Effective Date of the Agreement.

12. SUBCONTRACTORS, SUPPLIERS, AND OTHERS

12.1 If the Supplementary Conditions require the identity of certain Subcontractors, Suppliers, individuals, or entities to be submitted to Owner in advance of a specified date prior to the Effective Date of the Agreement, the apparent Successful Bidder, and any other Bidder so requested, shall within five business days after Bid opening, submit to Owner a list of all such Subcontractors, Suppliers, individuals, or entities proposed for those portions of the Work for which such identification is required. Such list shall be accompanied by an experience statement with pertinent information regarding similar projects and other evidence of qualification for each such Subcontractor, Supplier, individual, or entity if requested by Owner. If Owner or Engineer, after due investigation, has reasonable objection to any proposed Subcontractor, Supplier, individual, or entity, Owner may, before the Notice of Award is given, request apparent Successful Bidder to submit a substitute, in which case apparent Successful Bidder shall submit an acceptable substitute, Bidder's Bid price will be increased (or decreased) by the difference in cost occasioned by such substitution, and Owner may consider such price adjustment in evaluating Bids and making the Contract award.

12.2 If apparent Successful Bidder declines to make any such substitution, Owner may award the Contract to the next lowest Bidder that proposes to use acceptable Subcontractors, Suppliers, individuals, or entities. Declining to make requested substitutions will not constitute grounds for forfeiture of the Bid security of any Bidder. Any Subcontractor, Supplier, individual, or entity so listed and against which Owner or Engineer makes no written objection prior to the giving of the Notice of Award will be deemed acceptable to Owner and Engineer subject to revocation of such acceptance after the Effective Date of the Agreement as provided in Paragraph 6.06 of the General Conditions.

12.3 Contractor shall not be required to employ any Subcontractor, Supplier, individual, or entity against whom Contractor has reasonable objection.

13. PREPARATION OF BID

13.1 The Bid Form is included with the Bidding Documents. Additional copies may be obtained from the Engineer or from the issuing office.

13.2 All blanks on the Bid Form shall be completed by printing in ink or by typewriter and the Bid signed in ink. Erasures or alterations shall be initialed in ink by the person signing the Bid Form. A Bid price shall be indicated for each Bid item, alternative, adjustment unit price item, and unit price item listed therein, or the words "No Bid," "No Change," or "Not Applicable" entered.

13.3 A Bid by a corporation shall be executed in the corporate name by the president or a vice-president or other corporate officer accompanied by evidence of authority to sign. The corporate seal shall be affixed and attested by the secretary or an assistant secretary. The corporate address and state of incorporation shall be shown below the signature.

13.4 A Bid by a partnership shall be executed in the partnership name and signed by a partner (whose title must appear under the signature), accompanied by evidence of authority to sign. The official address of the partnership shall be shown below the signature.

13.5 A Bid by a limited liability company shall be executed in the name of the firm by a member and accompanied by evidence of authority to sign. The state of formation of the firm and the official address of the firm shall be shown below the signature.

13.6 A Bid by an individual shall show the Bidder's name and official address.

13.7 A Bid by a joint venture shall be executed by each joint venturer in the manner indicated on the Bid Form. The official address of the joint venture shall be shown below the signature.

13.8 All names shall be typed or printed in ink below the signatures.

13.9 The Bid shall contain an acknowledgment of receipt of all Addenda, the numbers of which shall be filled in on the Bid Form.

13.10 The address and telephone number for communications regarding the Bid shall be shown.

13.11 The Bid shall contain evidence of Bidder's authority and qualification to do business in the state where the Project is located or covenant to obtain such qualification prior to award of the Contract. Bidder's state contractor license number, if any, shall also be shown on the Bid Form.

14. BASIS OF BID; COMPARISON OF BIDS

14.1 Lump Sum

A. Bidders shall submit a Bid on individual sections or any combination of sections as set forth in the Bid Form.

1. Bidders may submit a Bid for any of the separate sections or any combination of sections as provided in the Bid Form. Submission of a Bid on any section signifies Bidder's willingness to enter into a Contract for that section alone at the price offered.

2. Bidders offering a Bid on one or more sections shall be capable of completing the Work within the time period stated in the Agreement.

14.2 The Bid price shall include such amounts as the Bidder deems proper for overhead and profit on account of cash allowances, if any, named in the Contract Documents as provided in Paragraph 11.02 of the General Conditions.

14.3 Bid prices will be compared after adjusting for differences in the time designated by Bidders for Substantial Completion. The adjusting amount will be determined at the rate set forth in the Contract Documents for liquidated damages for failing to achieve Substantial Completion for each day before or after the desired date appearing in Article 9.

15. SUBMITTAL OF BID

15.1 With each copy of the Bidding Documents, a Bidder is furnished one separate unbound copy of the Bid Form, and, if required, the Bid Bond Form. The unbound copy of the Bid Form is to be completed and submitted with the Bid security and other information indicated in the Invitation to Bid.

15.2 A Bid shall be submitted no later than the date and time prescribed and at the place indicated in the Advertisement or Invitation to Bid and shall be enclosed in an opaque sealed envelope plainly marked with the Project title (and, if applicable, the designated portion of the Project for which the Bid is submitted), the name and address of Bidder, and shall be accompanied by the Bid security and other required documents. If a Bid is sent by mail or other delivery system, the sealed envelope containing the Bid shall be enclosed in a separate envelope plainly marked on the outside with the notation "BID ENCLOSED." A mailed Bid shall be addressed to the entity identified in the Invitation to Bid.

16. MODIFICATION AND WITHDRAWAL OF BID

16.1 A Bid may be modified or withdrawn by an appropriate document duly executed in the manner that a Bid must be executed and delivered to the place where Bids are to be submitted prior to the date and time for the opening of Bids.

16.2 If within 24 hours after Bids are opened, any Bidder files a duly signed written notice with Owner and promptly thereafter demonstrates to the reasonable satisfaction of Owner that there was a material and substantial mistake in the preparation of its Bid, that Bidder may withdraw its Bid, and the Bid security will be returned. Thereafter, if the Work is rebid, that Bidder will be disqualified from further bidding on the Work.

17. OPENING OF BIDS

17.1 Bids will be opened at the time and place indicated in the Advertisement or Invitation to Bid and, unless obviously non-responsive, read aloud publicly. An abstract of the amounts of the base Bids and major alternates, if any, will be made available to Bidders after the opening of Bids.

18. BIDS TO REMAIN SUBJECT TO ACCEPTANCE

18.1 18.1 All Bids will remain subject to acceptance for the period of time stated in the Bid Form (or 45 calendar days if no period is specified on the bid form), but Owner may, in its sole discretion, release any Bid and return the Bid security prior to the end of this period.

19. EVALUATION OF BIDS AND AWARD OF CONTRACT

19.1 Owner reserves the right to reject any or all Bids, including without limitation, nonconforming, nonresponsive, unbalanced, or conditional Bids. Owner further reserves the right to reject the Bid of any Bidder whom it finds, after reasonable inquiry and evaluation, to not be responsible. Owner may also reject the Bid of any Bidder if Owner believes that it would not be in the best interest of the Project to make an award to that Bidder. Owner also reserves the right to waive all informalities not involving price, time, or changes in the Work and to negotiate contract terms with the Successful Bidder.

19.2 More than one Bid for the same Work from an individual or entity under the same or different names will not be considered. Reasonable grounds for believing that any Bidder has an interest in more than one Bid

for the Work may be cause for disqualification of that Bidder and the rejection of all Bids in which that Bidder has an interest.

19.3 In evaluating Bids, Owner will consider whether or not the Bids comply with the prescribed requirements, and such alternates, unit prices and other data, as may be requested in the Bid Form or prior to the Notice of Award.

19.4 In evaluating Bidders, Owner will consider the qualifications of Bidders and may consider the qualifications and experience of Subcontractors, Suppliers, and other individuals or entities proposed for those portions of the Work for which the identity of Subcontractors, Suppliers, and other individuals or entities must be submitted as provided in the Supplementary Conditions.

19.5 Owner may conduct such investigations as Owner deems necessary to establish the responsibility, qualifications, and financial ability of Bidders, proposed Subcontractors, Suppliers, individuals, or entities to perform the Work in accordance with the Contract Documents.

19.6 If the Contract is to be awarded, Owner will award the Contract to the Bidder whose Bid is in the best interests of the Project.

20. INSURANCE

20.1 Article 5 of the General Conditions, as may be modified by the Supplementary Conditions, sets forth Owner's requirements as to insurance.

21. PERFORMANCE AND PAYMENT BONDS

21.1 Before commencing the Work, the Contractor shall obtain and supply a Surety Bond (Performance Bond and a Labor and Material Bond). The Performance Bond shall be in an amount equal to 100% of the full amount of the Contract Sum as security for the faithful performance of the obligation of the Contract Documents, and the Labor and Material Payment Bond shall be in an amount equal to 100% of the full amount of the Contract Sum as security for the payment of all persons performing labor and furnishing materials in connection with the Contract Documents. Such bonds shall be on standard Documents issued by a surety authorized by the Illinois Department of Insurance to issue surety bonds in Illinois and otherwise satisfactory to the Owner, and shall name the Owner as a primary co-obligee. The cost of the bonds is to be included in the Bid Proposal. The Performance Bond and Labor and Material Payment Bond will become a part of the Contract. Each Bidder shall list the name of the surety company that will be furnishing the Bonds on its Bid Proposal. The failure of a Bidder to list the name of its surety company on its Bid Proposal shall be a non-responsive bid. The failure of the successful Bidder to enter into a Contract and supply the required Bonds within ten (10) days after the Notice of Award or within such extended period as the Owner may grant if the forms do not meet its approval shall constitute a default, and the Owner may either award the Contract to the next responsible, responsive Bidder or re-advertise for bids. A charge against the defaulting Bidder may be made for the difference between the amount of the bid and the amount for which a contract for the work is subsequently executed, irrespective of whether the amount thus due exceeds the amount of the bid guarantee.

22. SIGNING OF AGREEMENT

22.1 When Owner gives a Notice of Award to the Successful Bidder, it shall be accompanied by the required number of unsigned counterparts of the Agreement with the other Contract Documents which are identified in the Agreement as attached thereto. Within 15 business days thereafter, Successful Bidder shall sign and deliver the required number of counterparts of the Agreement and attached documents to Owner. Within ten business days thereafter, Owner shall deliver one fully signed counterpart to Successful Bidder with a complete set of the drawings with appropriate identification.

23. PREVAILING WAGE NOTICE

23.1 The Owner has determined that the Illinois Prevailing Wage Act applies to this Contract. Contractor shall therefore comply with the Illinois Prevailing Wage Act and shall pay, and require every Subcontractor to pay, the prevailing rates of wages as established by the Illinois Department of Labor for each craft or type of work needed to execute the contract in accordance with 820 ILCS 130/.01 et seq. Contractor shall prominently post the current schedule of prevailing wages at the Contract site and shall notify immediately in writing all of its Subcontractors, of all changes in the schedule of prevailing wages. Any increases in costs to Contractor due to changes in the prevailing rate of wage during the terms of any contract shall be at the expense of Contractor and not at the expense of the Owner. Change orders shall, however, be computed using the prevailing wage rates applicable at the time the change order work is scheduled to be performed. Contractor shall be solely responsible to maintain accurate records as required by the Prevailing Wage Act and to obtain and furnish all such certified records to Department of Labor as required by Statute or Regulation, in the manner specified by the Department of Labor (e.g., through the Department's portal) including certified payroll. Contractor shall be solely liable for paying the difference between prevailing wages and any wages actually received by laborers, workmen and/or mechanics engaged in the Work and in every way defend and indemnify Owner against any claims arising under or related to the payment of wages in accordance with the Prevailing Wage Act. The Owner agrees to notify the Contractor or Subcontractor of the pendency of any such claim, demand, lien or suit.

23.2 The Contractor is advised that the Illinois Department of Labor revises the prevailing wage rates and the Contractor/subcontractor has an obligation to check the Department's web site for revisions to prevailing wage rates. For information regarding current prevailing wage rates, please refer to the Illinois Department of Labor's website: **http://www.illinois.gov/idol/Laws-Rules/CONMED/Pages/Rates.aspx.**

23.3 The Contractor shall also:

A. Insert into each subcontract and the project specifications for each subcontract, a written stipulation that the subcontractor shall not pay less than the prevailing rate of wages to all laborers, workers, and mechanics performing work under the contract.

B. Require each subcontractor to insert into each lower-tiered contract and the project specifications for each lower tiered subcontract, a stipulation that the subcontractor shall not pay less than the prevailing rate of wages to all laborers, workers, and mechanics performing work under the contract.

24. SUBSTANCE ABUSE PREVENTION ACT

24.1 The Contractor shall comply with and cause all subcontractors to comply with the requirements and provisions of the Illinois Substance Abuse Prevention on Public Works Projects Act (820 ILCS 265/1 *et. seq.*) (the "Act") by:

A. Prohibiting the use, possession, distribution or delivery of any drug or alcohol (as defined under the Act) or allowing any employee to be under the influence of any said drug or alcohol while performing the Work;

B. Filing a written substance abuse prevention program with the Owner for the prevention of substance abuse among its employees prior to the commencement of the Work. Said program shall be available to the general public and, at a minimum, contain the following:

1. A minimum requirement of a 9 panel urine drug test plus a test for alcohol. Testing an employee's blood may only be used for post-accident testing, however, blood testing is not mandatory for the employer where a urine test is sufficient;

2. A prohibition against the actions for the use, possession, distribution or delivery of any drug or alcohol (as defined under the Act) or any employee under the influence of any said drug or alcohol while performing the Work;

3. A requirement that employees performing the Work submit to pre-hire, random, reasonable suspicion, and post-accident drug and alcohol testing. Testing of an employee before commencement of the Work is not required if the employee participated in a random testing program during the 90 days preceding the date on which the employee commenced work hereunder; and

4. A procedure for notifying an employee that he or she may not perform any of the Work if he or she: 1) uses, possess, delivers or is under the influence of a drug or alcohol as prohibited under the Act; 2) tests positive for the presence of a drug as outlined in the Act; or 3) refuses to submit to drug or alcohol testing as required under the Contractor's substance abuse program until the employee tests negative for the presence of drugs or alcohol as outlined in the Act or has been approved to commence or return to work in accordance with the Contractor's substance abuse program.

C. Immediately removing and/or prohibiting access to the Work site of any employee who: 1) uses, possess, delivers or is under the influence of a drug or alcohol as prohibited under the Act; 2) tests positive for the presence of a drug as outlined in the Act; or 3) refuses to submit to drug or alcohol testing as required under the Contractor's substance abuse program. Said employee shall be prohibited from the Work site until he or she tests negative for the presence of drugs or alcohol as outlined in the Act or has been approved to commence or return to work in accordance with the Contractor's substance abuse program; and

D. Complying with all other requirements of the Act.

24.2 Failure by the Contractor to comply with the requirements of the Illinois Substance Abuse Prevention on Public Works Projects Act shall constitute a material default of the Contract and shall give the Owner the right to pursue any remedy available to it at law or in equity, including termination of this Contract for cause in the Owner's sole discretion and any other remedy as provided in this Contract. In the event of a default hereunder, Contractor shall also pay to the Owner all damages Owner is entitled to under this Contract that arise from the default, together with interest, costs, and the Owner's reasonable attorney fees."

25. COMPLIANCE WITH ALL LAWS NOTICE

25.1 Contractor shall comply with all applicable laws, regulations, and rules promulgated by any Federal, State, County, Municipal and or other governmental unit or regulatory body now in effect during the performance of the work, and the orders and decrees of any courts or administrative bodies or tribunals in any manner affecting the performance of this Contract. By way of example, the following are included within the scope of the laws, regulations and rules referred to in this paragraph, but in no way operate as a limitation on the laws, regulations and rules with which Contractor must comply: all forms of Workers Compensation Laws, all terms of the Equal Employment Opportunity Clause of the Illinois Fair Employment Practices Commission, the Illinois Preference Act, Illinois Substance Abuse Prevention on Works Projects Act, the Social Security Act, Statutes relating to contracts let by units of government, all applicable Civil Rights and Anti-Discrimination Laws and Regulations, and traffic and public utility regulations.

END OF SECTION

SECTION 00 4100
BID FORM

1. PROJECT, BID RECIPIENT, AND BIDDER

1.1 This bid is for the following project:

Skokie Public Library
2nd Floor AHU Replacement
GBA#P25-1226-00

1.2 This bid is submitted to:

Skokie Public Library
5215 Oakton St.
Skokie, IL 60077
Vinny Tangerlini
Building Services Manager

1.3 This bid is submitted by:

Bidder's Name: _____

Address: _____

_____

Contact/Title: _____

Telephone: _____

1.4 The undersigned Bidder proposes and agrees, if this Bid is accepted, to enter into an Agreement with Owner in the form included in the Bidding Documents to perform all Work as specified or indicated in the Bidding Documents for the prices and within the times indicated in this Bid and in accordance with the other terms and conditions of the Bidding Documents.

2. BIDDER'S ACKNOWLEDGEMENTS AND REPRESENTATIONS

2.1 Bidder accepts all the terms and conditions of the Instructions to Bidders, including without limitation those dealing with the disposition of Bid security. This Bid will remain subject to acceptance for 60 calendar days after the Bid opening, or for such longer period of time that Bidder may agree to in writing upon request of Owner.

2.2 In submitting this Bid, Bidder represents that:

A. Bidder has examined and carefully studied the Bidding Documents, the other related data identified in the Bidding Documents, and the following Addenda, receipt of which is hereby acknowledged:

Number	Date

B. Bidder has visited the Site and become familiar with and is satisfied as to the general, local and Site conditions that may affect cost, progress, and performance of the Work.

C. Bidder is familiar with and is satisfied as to all federal, state and local Laws and Regulations that may affect cost, progress and performance of the Work.

D. Bidder is aware of the general nature of work to be performed by Owner and others at the Site that relates to the Work as indicated in the Bidding Documents.

E. Bidder has correlated the information known to Bidder, information and observations obtained from visits to the Site, reports and drawings identified in the Bidding Documents, and all additional examinations, investigations, explorations, tests, studies, and data with the Bidding Documents.

F. Bidder has given Engineer written notice of all conflicts, errors, ambiguities, or discrepancies that Bidder has discovered in the Bidding Documents, and the written resolution thereof by Engineer is acceptable to Bidder.

G. The Bidding Documents are generally sufficient to indicate and convey understanding of all terms and conditions for the performance of the Work for which this Bid is submitted.

H. Bidder will submit written evidence of its authority to do business in the state where the Project is located not later than the date of its execution of the Agreement.

3. FURTHER REPRESENTATIONS

3.1 Bidder further represents that:

A. This Bid is genuine and not made in the interest of or on behalf of any undisclosed individual or entity and is not submitted in conformity with any agreement or rules of any group, association, organization or corporation;

B. Bidder has not directly or indirectly induced or solicited any other Bidder to submit a false or sham Bid;

C. Bidder has not solicited or induced any individual or entity to refrain from bidding; and

D. Bidder has not sought by collusion to obtain for itself any advantage over any other Bidder or over Owner.

4. BASIS OF BID

4.1 Bidder will complete the Work in accordance with the Contract Documents for the following price(s):

A. BASE BID 1 (All Work required by the Bidding Documents except that designated Additive Alternate, Deductive Alternate, Maintenance Contract or Future for BASE BID 1.)

Lump Sum Bid Price: $_____

5. TIME OF COMPLETION

5.1 Bidder agrees that the Work will be substantially complete on or before _____, 20___, and will be completed and ready for final payment in accordance with Paragraph 14.07.B of the General Conditions on or before _____, 20 ____

5.2 Premium time, if required to meet the above dates, should be included in the Bid(s).

6. DEFINED TERMS

6.1 The terms used in this Bid with initial capital letters have the meanings stated in the Instructions to Bidders, the General Conditions, and the Supplementary Conditions.

7. BID SUBMITTAL

7.1 The Bidder declares its legal entity as indicated by check mark (x) and inserted information as follows:

☐ Individual

☐ Partnership (List full names, titles and addresses of all responsible principals or partners.)

_____

_____

_____

☐ Corporation (List state of incorporation)

_____

_____

☐ Joint Venture (List all parties to venture)

_____

_____

7.2 Execution:

_____

Name (Legal name of bidding entry)

_____

By (Individual authorized to act for entity)

_____

Title

Seal (if corporation)

_____

Date

_____

Attest (Corporation Secretary or Notary)

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 00\Construction 00 4100 Bid Form.docx

SECTION 00 7300
SUPPLEMENTARY CONDITIONS

These Conditions amend or supplement the Standard General Conditions of the Construction Contract (EJCDC C-700, 2002 Edition). All provisions which are not so amended or supplemented remain in full force and effect.

The following are additional General Conditions:

PREVAILING WAGE NOTICE

The Owner has determined that the Illinois Prevailing Wage Act applies to this Contract. Contractor shall therefore comply with the Illinois Prevailing Wage Act and shall pay, and require every Subcontractor to pay, the prevailing rates of wages as established by the Illinois Department of Labor for each craft or type of work needed to execute the contract in accordance with 820 ILCS 130/.01 et seq. Contractor shall prominently post the current schedule of prevailing wages at the Contract site and shall notify immediately in writing all of its Subcontractors, of all changes in the schedule of prevailing wages. Any increases in costs to Contractor due to changes in the prevailing rate of wage during the terms of any contract shall be at the expense of Contractor and not at the expense of the Owner. Change orders shall, however, be computed using the prevailing wage rates applicable at the time the change order work is scheduled to be performed. Contractor shall be solely responsible to maintain accurate records as required by the Prevailing Wage Act and to obtain and furnish all such certified records to Department of Labor as required by Statute or Regulation, in the manner specified by the Department of Labor (e.g., through the Department's portal) including certified payroll. Contractor shall be solely liable for paying the difference between prevailing wages and any wages actually received by laborers, workmen and/or mechanics engaged in the Work and in every way defend and indemnify Owner against any claims arising under or related to the payment of wages in accordance with the Prevailing Wage Act. The Owner agrees to notify the Contractor or Subcontractor of the pendency of any such claim, demand, lien or suit.

The Contractor is advised that the Illinois Department of Labor revises the prevailing wage rates and the Contractor/subcontractor has an obligation to check the Department's web site for revisions to prevailing wage rates. For information regarding current prevailing wage rates, please refer to the Illinois Department of Labor's website: http://www.illinois.gov/idol/Laws-Rules/CONMED/Pages/Rates.aspx.

The Contractor shall also:

1. Insert into each subcontract and the project specifications for each subcontract, a written stipulation that the subcontractor shall not pay less than the prevailing rate of wages to all laborers, workers, and mechanics performing work under the contract.
2. Require each subcontractor to insert into each lower-tiered contract and the project specifications for each lower tiered subcontract, a stipulation that the subcontractor shall not pay less than the prevailing rate of wages to all laborers, workers, and mechanics performing work under the contract.

SUBSTANCE ABUSE AND PREVENTION ACT

The Contractor shall comply with and cause all subcontractors to comply with the requirements and provisions of the Illinois Substance Abuse Prevention on Public Works Projects Act (820 ILCS 265/1 et. seq.) (the "Act") by:

1. Prohibiting the use, possession, distribution or delivery of any drug or alcohol (as defined under the Act) or allowing any employee to be under the influence of any said drug or alcohol while performing the Work;

2. Filing a written substance abuse prevention program with the Owner for the prevention of substance abuse among its employees prior to the commencement of the Work. Said program shall be available to the general public and, at a minimum, contain the following:
    a. A minimum requirement of a 9 panel urine drug test plus a test for alcohol. Testing an employee's blood may only be used for post-accident testing, however, blood testing is not mandatory for the employer where a urine test is sufficient;
    b. A prohibition against the actions for the use, possession, distribution or delivery of any drug or alcohol (as defined under the Act) or any employee under the influence of any said drug or alcohol while performing the Work;
    c. A requirement that employees performing the Work submit to pre-hire, random, reasonable suspicion, and post-accident drug and alcohol testing. Testing of an employee before commencement of the Work is not required if the employee participated in a random testing program during the 90 days preceding the date on which the employee commenced work hereunder; and
    d. A procedure for notifying an employee that he or she may not perform any of the Work if he or she: 1) uses, possess, delivers or is under the influence of a drug or alcohol as prohibited under the Act; 2) tests positive for the presence of a drug as outlined in the Act; or 3) refuses to submit to drug or alcohol testing as required under the Contractor's substance abuse program until the employee tests negative for the presence of drugs or alcohol as outlined in the Act or has been approved to commence or return to work in accordance with the Contractor's substance abuse program.
3. Immediately removing and/or prohibiting access to the Work site of any employee who: 1) uses, possess, delivers or is under the influence of a drug or alcohol as prohibited under the Act; 2) tests positive for the presence of a drug as outlined in the Act; or 3) refuses to submit to drug or alcohol testing as required under the Contractor's substance abuse program. Said employee shall be prohibited from the Work site until he or she tests negative for the presence of drugs or alcohol as outlined in the Act or has been approved to commence or return to work in accordance with the Contractor's substance abuse program; and
4. Complying with all other requirements of the Act.

Failure by the Contractor to comply with the requirements of the Illinois Substance Abuse Prevention on Public Works Projects Act shall constitute a material default of the Contract and shall give the Owner the right to pursue any remedy available to it at law or in equity, including termination of this Contract for cause in the Owner's sole discretion and any other remedy as provided in this Contract. In the event of a default hereunder, Contractor shall also pay to the Owner all damages Owner is entitled to under this Contract that arise from the default, together with interest, costs, and the Owner's reasonable attorney fees."

COMPLIANCE WITH ALL LAWS NOTICE

Contractor shall comply with all applicable laws, regulations, and rules promulgated by any Federal, State, County, Municipal and or other governmental unit or regulatory body now in effect during the performance of the work, and the orders and decrees of any courts or administrative bodies or tribunals in any manner affecting the performance of this Contract. By way of example, the following are included within the scope of the laws, regulations and rules referred to in this paragraph, but in no way operate as a limitation on the laws, regulations and rules with which Contractor must comply: all forms of Workers Compensation Laws, all terms of the Equal Employment Opportunity Clause of the Illinois Fair Employment Practices Commission, the Illinois Preference Act, Illinois Substance Abuse Prevention on Works Projects Act, the Social Security Act, Statutes relating to contracts let by units of government, all applicable Civil Rights and Anti-Discrimination Laws and Regulations, and traffic and public utility regulations.

PERFORMANCE AND PAYMENT BONDS

Before commencing the Work, the Contractor shall obtain and supply a Surety Bond (Performance Bond and a Labor and Material Bond). The Performance Bond shall be in an amount equal to 100% of the full amount of the Contract Sum as security for the faithful performance of the obligation of the Contract Documents, and the Labor and Material Payment Bond shall be in an amount equal to 100% of the full amount of the Contract Sum as security for the payment of all persons performing labor and furnishing materials in connection with the Contract Documents. Such bonds shall be on standard Documents issued by a surety authorized by the Illinois Department of Insurance to issue surety bonds in Illinois and otherwise satisfactory to the Owner, and shall name the Owner as a primary co-obligee. The cost of the bonds is to be included in the Bid Proposal. The Performance Bond and Labor and Material Payment Bond will become a part of the Contract. Each Bidder shall list the name of the surety company that will be furnishing the Bonds on its Bid Proposal. The failure of a Bidder to list the name of its surety company on its Bid Proposal shall be a non-responsive bid. The failure of the successful Bidder to enter into a Contract and supply the required Bonds within ten (10) days after the Notice of Award or within such extended period as the Owner may grant if the forms do not meet its approval shall constitute a default, and the Owner may either award the Contract to the next responsible, responsive Bidder or re-advertise for bids. A charge against the defaulting Bidder may be made for the difference between the amount of the bid and the amount for which a contract for the work is subsequently executed, irrespective of whether the amount thus due exceeds the amount of the bid guarantee.

EVIDENCE OF CONTRACTOR'S INSURANCE:

When Contractor delivers the signed counterparts of the Agreement to Owner, Contractor shall also deliver to Owner copies of the policies (including all endorsements, and identification of applicable self-insured retentions and deductibles) of insurance required to be provided by Contractor in this Contract. Contractor may block out (redact) any confidential premium or pricing information contained in any policy or endorsement furnished under this provision.

USE OF SITE

Contractor shall confine equipment, material storage and workers operations to limits indicated by law, ordinances, plans, permits or directions of the Owner and as per plans. Contractor shall not unreasonably encumber the site with materials or cause inconvenience to the Owner, public or other contractors. Contractor's responsibilities for usage of the site shall include:

1. Utilities: Contractor shall obtain permits, provide and make payment for such utilities as water, electricity, heat/air, telephone and waste disposal when necessary in performing the work.
2. Buildings: Contractor shall obtain permits, provide and make payment for temporary structures such as offices, sheds, trailers, and sanitary facilities, and necessary maintenance of structures in performing the work.
3. Pumping: When during construction, standing water caused by heavy rains or poor drainage becomes a hazard to the work, Contractor shall provide and make payment for removal of water to existing drainage swales, storm sewers or other natural or manufactured drainage ways. See Erosion and Sediment Control in Specifications in Special Provisions.
4. Storage: Materials and equipment shall be stored in a manner that preserves their quality. When necessary, materials and equipment shall be placed under cover, on wooden platforms or other hard, clean surfaces, and not on the ground. Private property shall not be used for storage purposes without written permission from the owner of the property. Location of any storage area is subject to approval by the Owner.
5. Parking Contractor's construction vehicles parked on the site shall not inhibit construction or prevent access for emergency or other official vehicles. Parking areas are subject to Owner's Representative's approval. Parking is prohibited under the dripline of trees to be saved.

EXISTING CONDITIONS

The furnishing of surveys by the Owner is not a guarantee of the accuracy of the information contained therein, and shall not relieve the Contractor from its duties under the Contract Documents in general. The submission of a bid for the Work implies that the Contractor has examined the site, taking into consideration all such conditions that may affect the Work, regardless of the information contained in the surveys. Any information furnished by the Owner shall not constitute a representation concerning site conditions and the Contractor shall bear, solely and exclusively, all costs due to concealed, unknown, unusual or otherwise unforeseen conditions at the site. Contractor is aware that all such risk concerning site conditions is borne by it, has considered such in making its bid, and therefore freely waives all of its rights under the Illinois Public Construction Contract Act of 1999.

WORK SITE SAFETY

Contractor shall be solely responsible for providing and maintaining safe conditions at the work site, including the safety of persons and property and shall comply with applicable laws and safety regulations to prevent injury to persons or damage to property. Contractor is responsible for protecting public from dangerous situations on the site during Construction. This requirement shall apply continuously and shall not be limited to normal working hours.

Whenever public or private property is damaged, Contractor shall at his/her own expense, restore such property to a condition equal to that existing before the damage was done. Contractor shall also be responsible for damage to the work by actions of the elements or from any other cause whatsoever and shall restore the work at his/her own expense.

Contractor shall have no claim against the Owner or Engineer/Architect because of any damage or loss to the work or to Contractor's equipment, materials or supplies from any cause, including damage or loss due to simultaneous work by others.

INDEMNIFICATION

To the fullest extent permitted by law, to waive any and all rights of contribution against Owner and to indemnify and hold harmless and its officers, officials, employees, volunteers and agents from and against all claims, damages, losses and expenses, including, but not limited to, legal fees (attorney's and paralegal's fees, expert fees and court costs) arising out of or resulting from the performance of the Contractor's work, provided that any such claim, damage, loss or expense is attributable to bodily injury, sickness, disease or death, or injury to or destruction of property, other than the work itself, including the loss of use resulting therefrom, or is attributable to misuse or improper use of trademark or copyright protected material or otherwise protected intellectual property, to the extent it is caused in whole or in part by any wrongful or negligent act or omission of the Contractor, any Subcontractor, anyone directly or indirectly employed by any of them or anyone for whose acts any of them may be liable. Such obligation shall not be construed to negate, abridge or otherwise reduce any other right to indemnity which Owner would otherwise have. Contractor shall similarly, protect, indemnify and hold and save harmless, Owner, its officers, officials, employee, volunteers and agents against and from any and all claims, costs, causes, actions and expenses, including, but not limited to, legal fees, incurred by reason of Contractor's breach of any of its obligations under, or Contractor's default of any provisions of the Contract. The indemnification obligations under this paragraph shall not be limited in any way by any limitation on the amount or type of damages, compensation, or benefits payable by or for Contractor or any subcontractor under Workers' Compensation or Disability Benefit Acts or Employee Benefit Acts.

Accordingly, the Commercial General Liability Policy shall provide for coverage of contractual indemnification obligations.

LABOR, EQUIPMENT AND METHODS

Contractor shall at all times employ sufficient labor and equipment for prosecuting the work in the manner and time specified. Workers shall have sufficient experience and skill to properly perform the Work and operate the equipment.

Equipment used shall be of such type, size and amount and in such mechanical condition as to meet the requirements of the work and produce a satisfactory quality of work. Contractor shall replace unsatisfactory equipment and furnish additional equipment when deemed necessary by Owner's Representative.'

Contractor alone shall bear the responsibility for safety of the persons and property and shall immediately notify Owner of any specified method that creates any risk of injury or damage to persons or property. Contractor may make a written request to Owner's Representative to use a method or type of equipment other than those specified. The request shall include a description of the proposed methods, equipment and an explanation of the reasons for the substitution. When Owner's Representative authorizes trial use of the substitution, Contractor shall be responsible for producing the work in conformance with the Contract. If Owner's Representative determines that the trial method or equipment does not conform to the Contract requirements, Contractor shall discontinue use of the substitute method or equipment and shall complete the remaining work with the specified methods or equipment. Contractor shall remove defective work and replace it with work meeting the Contract requirements or take other corrective action as directed by Owner's Representative. No increase will be made in payment or in contract time as a result of authorizing a change in methods or equipment under these provisions.

The following are specific paragraphs to be modified to the Standard General Conditions of the Construction Contract. Each paragraph designation below (e.g., SC 1.01) reflects the number of the General Conditions article the paragraph modifies.

SC-1.01 DEFINITIONS

The terms used in these Supplementary Conditions, which are defined in the Standard General Conditions, have the meanings assigned to them in the Standard General Conditions. The definitions indicated below are to be added to the end of the article:

Furnish	Purchase and deliver the specified materials or items, which may then be consigned to another party.
Install	Supply the labor required to incorporate materials or items, including receiving, unloading, storing and protecting such materials or items; shall include final mechanical and electrical connections, unless such work is specifically excluded.
Provide[1]	Furnish and install the specified materials or items complete, in place and ready for use, including any final connections.
Project Manual	Bound volume which includes Bidding Requirements, unexecuted Contract Form, Conditions of the Contract and Specifications.
As Selected or As Approved	Refers to selection or approval by ENGINEER.

[1]Note: The words "CONTRACTOR shall" are implied and shall be so understood wherever the directions "furnish," "install" or "provide" are used

SC-2.02 PRELIMINARY MATTERS: COPIES OF DOCUMENTS

Delete Paragraph 2.02.A in its entirety and insert the following in its place:

Owner shall furnish to Contractor up to three printed or hard copies of the drawings and Project Manual and one set in electronic format. Additional copies will be furnished upon request at the cost of reproduction.

SC-2.05 PRELIMINARY MATTERS: BEFORE STARTING CONSTRUCTION

Amend the first sentence of paragraph 2.05.A of the Standard General Conditions to read as follows:

"2.05.A Within 30 days after the Effective Date of the Agreement…."

SC-3.01 CONTRACT DOCUMENTS: INTENT, AMENDING, REUSE: INTENT

Add the following new subparagraph after Paragraph 3.01.C:

"3.01.D In case of any conflict, discrepancy or ambiguity in the Contract Documents, it will be assumed that CONTRACTOR has included in the proposal and agrees to provide the greater quantity or better quality of materials, equipment, means, method, technique or procedure of construction unless, before submission of the proposal, CONTRACTOR shall have requested and/or received a written interpretation or clarification from ENGINEER that allows otherwise."

Add the following new subparagraph after Paragraph 3.01.D:

"3.01.E Wherever a provision of the Specifications conflicts with any agreements or regulations in force among members of trade associations, unions or councils which regulate or distinguish what work shall or shall not be included in the work or a particular trade, CONTRACTOR shall make all necessary arrangements to reconcile such conflicts. If progress of the Work is affected by a delay in providing materials or equipment because of such agreements or regulations, ENGINEER may require that other materials or equipment of equal kind and quality be provided at no charge to the CONTRACT."

SC-4.02 AVAILABILITY OF LANDS; SUBSURFACE AND PHYSICAL CONDITIONS; HAZARDOUS ENVIRONMENTAL CONDITIONS; REFERENCE POINTS: SUBSURFACE AND PHYSICAL CONDITIONS

Delete Paragraphs 4.02.A and 4.02.B in their entirety and insert the following:

"4.02.A No reports of explorations or tests of subsurface conditions at or contiguous to the Site are known to the Owner or Engineer."

SC-4.06 AVAILABILITY OF LANDS; SUBSURFACE AND PHYSICAL CONDITIONS; HAZARDOUS ENVIRONMENTAL CONDITIONS; REFERENCE POINTS: HAZARDOUS ENVIRONMENTAL CONDITIONS AT SITE

Delete Paragraphs 4.06.A and 4.06.B in their entirety and insert the following:

"4.06.A No reports or drawings related to Hazardous Environmental Conditions are known to Owner or Engineer."

SC-5.01 BONDS AND INSURANCE: PERFORMANCE, PAYMENT, AND OTHER BONDS

Amend the first sentence of paragraph 5.01.A of the Standard General Conditions to read as follows:

"5.01.A If required in the Invitation to Bid,…"

SC-5.04 BONDS AND INSURANCE: CONTRACTOR'S LIABILITY INSURANCE

Add the following new paragraph after paragraph 5.04.B:

"5.04.C The limits of liability for the insurance required by Paragraph 5.04 of the General Conditions shall provide coverage for not less than the following amounts or greater where required by Laws and Regulations:

5. Workers' Compensation, and related coverages under Paragraphs 5.04.A.1 and A.2 of the General Conditions:

a.	State:	Statutory
b.	Applicable Federal:	Statutory
c.	Employer's Liability:	$1,000,000

6. Contractor's General Liability under Paragraphs 5.04.A.3 through A.6 of the General Conditions which shall include completed operations and product liability coverages and eliminate the exclusion with respect to property under the care, custody and control of Contractor:
    a. General Aggregate: $2,000,000
    b. Products - Completed Operations Aggregate: $2,000,000
    c. Personal and Advertising Injury: $2,000,000
    d. Each Occurrence (Bodily Injury and Property Damage): $1,000,000
    e. Property Damage liability insurance will provide Explosion, Collapse, and Under-ground coverages where applicable.
    f. Excess or Umbrella Liability
        (1) General Aggregate $5,000,000
        (2) Each Occurrence $5,000,000
7. Automobile Liability under Paragraph 5.04.A.6 of the General Conditions:
    a. Bodily Injury (each person): $1,000,000
    b. Bodily Injury (each accident): $1,000,000
    c. Property Damage (each accident): $1,000,000
    d. Combined Single limit of: $2,000,000
8. The Contractual Liability coverage required by Paragraph 5.04.B.4 of the General Conditions shall provide coverage for not less than the following amounts:
    a. Bodily Injury (each accident): $1,000,000
    b. Bodily Injury (annual aggregate): $1,000,000
    c. Property Damage (each accident): $1,000,000
    d. Property Damage (annual aggregate): $2,000,000
9. The insurance coverage described in this Article shall be provided by a company or companies licensed to do business in the State of Illinois and acceptable to Owner.
10. The Owner, Grumman/Butkus Associates, and Grumman/Butkus Associates' consultants shall be named as additional insureds.
11. CONTRACTOR(s) shall obtain and maintain Comprehensive General Liability Insurance with broad form Property Damage coverage and contractual liability endorsement insuring the indemnity required of CONTRACTOR(s). The Indemnitees will be named as additional insureds on CONTRACTOR(s)' Comprehensive General Liability insurance policy. The additional insured endorsement included on CONTRACTOR(s)' Comprehensive General Liability policy will provide the following: (1) that the coverage afforded the additional insureds will be primary insurance for the additional insureds with respect to claims arising out of operations performed by or on behalf of CONTRACTOR(s), (2) that if the additional insureds have other insurance which is applicable to the loss, such other insurance will be on an excess or contingent basis, (3) that the amount of the company's liability under the insurance policy will not be reduced by the existence of such other insurance, and (4) that the additional insureds will be given not less than 30 days prior written notice of any cancellation thereof. CONTRACTOR shall furnish to ENGINEER certificates of insurance evidencing the foregoing.
12. CONTRACTOR shall furnish three certified copies of Certificate of Insurance, and shall include copies of any endorsements that may be subsequently issued that amend the types or limits of coverage.

13. CONTRACTOR shall forward notice of any policy cancellation by registered mail, with postage prepaid, addressed to Skokie Public Library, Attn: Andy Garcia, 5215 Oakton St., Skokie, IL 60077 and T. Chad Luning, President, c/o Grumman/Butkus Associates, 820 Davis Street, Suite 300, Evanston, Illinois 60201."

SC-6.08 CONTRACTOR'S RESPONSIBILITIES: PERMITS

Add the following new subparagraphs after paragraph 6.08.A as follows:

"6.08.B CONTRACTOR shall submit the project drawings and specifications to authorities having jurisdiction and shall make all cash deposits and payments required by said authorities.

6.08.C A photocopy of the building permit and one complete set of drawings bearing the approval of the Department of Buildings and/or other departments or authorities having jurisdiction shall be delivered to OWNER as soon as the permit is obtained.

6.08.D Upon completion of the Contract, CONTRACTOR shall deliver the originals of all permits, certificates of inspection and the like to OWNER with the final application for payment."

SC-6.17 CONTRACTOR'S RESPONSIBILITIES: SHOP DRAWINGS AND SAMPLES

Add the following new paragraphs immediately after Paragraph 6.17.E:

"6.17.F Contractor shall furnish required submittals with sufficient information and accuracy in order to obtain required approval of an item with no more than two submittals. Engineer will record Engineer's time for reviewing subsequent submittals of shop drawings, samples or other items requiring approval and Contractor shall reimburse Owner for Engineer's charges for such time.

6.17.G In the event that Contractor requests a substitution for a previously approved item, Contractor shall reimburse Owner for Engineer's charges for such time unless the need for such substitution is beyond the control of Contractor."

SC-12.01 CHANGE OF CONTRACT PRICE: CONTRACTOR'S FEE

Delete paragraph 12.01.C.2.a in its entirety and substitute the following:

"12.01.C.2.a For costs incurred under paragraph 11.01.A.1 and 11.01.A.2, the Contractor's fee shall be 10 percent;"

Amend paragraph 12.01.C.2.c to read "...will be paid a fee of 10 percent of the costs..."

SC-17.07 MISCELLANEOUS: SIGNS, ADS, REFERENCES

Add new paragraph immediately after paragraph 17.06 as follows:

"17.07 Signs, Ads, References

A. CONTRACTOR shall not place or maintain any signs, bills, posters or other advertisements in or about the building, site or on CONTRACTOR's equipment without express written permission from OWNER. Also, OWNER shall not be used as a reference in any publication without express written permission from OWNER."

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 00\Construction 00 7300 Supplementary Conditions.docx

This document has important legal consequences; consultation with an attorney is encouraged with respect to its use or modification. This document should be adapted to the particular circumstances of the contemplated Project and the Controlling Law.

STANDARD GENERAL CONDITIONS OF THE CONSTRUCTION CONTRACT

Prepared by

ENGINEERS JOINT CONTRACT DOCUMENTS COMMITTEE

and

Issued and Published Jointly By

ACEC
American Council of Engineering Companies

National Society of Professional Engineers
Professional Engineers in Private Practice

ASCE American Society of Civil Engineers

PROFESSIONAL ENGINEERS IN PRIVATE PRACTICE
a practice division of the
NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS

_____

AMERICAN COUNCIL OF ENGINEERING COMPANIES

_____

AMERICAN SOCIETY OF CIVIL ENGINEERS

This document has been approved and endorsed by

The Associated General Contractors of America

Knowledge for Creating and Sustaining the Built Environment

Construction Specifications Institute

National Society of Professional Engineers
1420 King Street, Alexandria, VA 22314

American Council of Engineering Companies
1015 15th Street, N.W., Washington, DC 20005

American Society of Civil Engineers
1801 Alexander Bell Drive, Reston, VA 20191-4400

These General Conditions have been prepared for use with the Suggested Forms of Agreement Between Owner and Contractor Nos. C-520 or C-525 (2002 Editions). Their provisions are interrelated and a change in one may necessitate a change in the other. Comments concerning their usage are contained in the EJCDC Construction Documents, General and Instructions (No. C-001) (2002 Edition). For guidance in the preparation of Supplementary Conditions, see Guide to the Preparation of Supplementary Conditions (No. C-800) (2002 Edition).

TABLE OF CONTENTS

Page

GENERAL CONDITIONS

ARTICLE 1 - DEFINITIONS AND TERMINOLOGY

1.01 *Defined Terms*

A. Wherever used in the Bidding Requirements or Contract Documents and printed with initial capital letters, the terms listed below will have the meanings indicated which are applicable to both the singular and plural thereof. In addition to terms specifically defined, terms with initial capital letters in the Contract Documents include references to identified articles and paragraphs, and the titles of other documents or forms.

1. *Addenda*--Written or graphic instruments issued prior to the opening of Bids which clarify, correct, or change the Bidding Requirements or the proposed Contract Documents.

2. *Agreement*--The written instrument which is evidence of the agreement between Owner and Contractor covering the Work.

3. *Application for Payment*--The form acceptable to Engineer which is to be used by Contractor during the course of the Work in requesting progress or final payments and which is to be accompanied by such supporting documentation as is required by the Contract Documents.

4. *Asbestos*--Any material that contains more than one percent asbestos and is friable or is releasing asbestos fibers into the air above current action levels established by the United States Occupational Safety and Health Administration.

5. *Bid*--The offer or proposal of a Bidder submitted on the prescribed form setting forth the prices for the Work to be performed.

6. *Bidder*--The individual or entity who submits a Bid directly to Owner.

7. *Bidding Documents*--The Bidding Requirements and the proposed Contract Documents (including all Addenda).

8. *Bidding Requirements*--The Advertisement or Invitation to Bid, Instructions to Bidders, bid security of acceptable form, if any, and the Bid Form with any supplements.

9. *Change Order*--A document recommended by Engineer which is signed by Contractor and Owner and authorizes an addition, deletion, or revision in the Work or an adjustment in the Contract Price or the Contract Times, issued on or after the Effective Date of the Agreement.

10. *Claim*--A demand or assertion by Owner or Contractor seeking an adjustment of Contract Price or Contract Times, or both, or other relief with respect to the terms of the Contract. A demand for money or services by a third party is not a Claim.

11. *Contract*--The entire and integrated written agreement between the Owner and Contractor concerning the Work. The Contract supersedes prior negotiations, representations, or agreements, whether written or oral.

12. *Contract Documents*-- Those items so designated in the Agreement. Only printed or hard copies of the items listed in the Agreement are Contract Documents. Approved Shop Drawings, other Contractor's submittals, and the reports and drawings of subsurface and physical conditions are not Contract Documents.

13. *Contract Price*--The moneys payable by Owner to Contractor for completion of the Work in accordance with the Contract Documents as stated in the Agreement (subject to the provisions of Paragraph 11.03 in the case of Unit Price Work).

14. *Contract Times*--The number of days or the dates stated in the Agreement to: (i) achieve Milestones, if any, (ii) achieve Substantial Completion; and (iii) complete the Work so that it is ready for final payment as evidenced by Engineer's written recommendation of final payment.

15. *Contractor*--The individual or entity with whom Owner has entered into the Agreement.

16. *Cost of the Work*--See Paragraph 11.01.A for definition.

17. *Drawings*--That part of the Contract Documents prepared or approved by Engineer which graphically shows the scope, extent, and character of the Work to be performed by Contractor. Shop Drawings and other Contractor submittals are not Drawings as so defined.

18. *Effective Date of the Agreement*--The date indicated in the Agreement on which it becomes effective, but if no such date is indicated, it means the date on which the Agreement is signed and delivered by the last of the two parties to sign and deliver.

19. *Engineer*--The individual or entity named as such in the Agreement.

20. *Field Order*--A written order issued by Engineer which requires minor changes in the Work but which does not involve a change in the Contract Price or the Contract Times.

21. *General Requirements*--Sections of Division 1 of the Specifications. The General Requirements pertain to all sections of the Specifications.

22. *Hazardous Environmental Condition*--The presence at the Site of Asbestos, PCBs, Petroleum, Hazardous Waste, or Radioactive Material in such quantities or circumstances that may present a substantial danger to persons or property exposed thereto in connection with the Work.

23. *Hazardous Waste*--The term Hazardous Waste shall have the meaning provided in Section 1004 of the Solid Waste Disposal Act (42 USC Section 6903) as amended from time to time.

24. *Laws and Regulations; Laws or Regulations*--Any and all applicable laws, rules, regulations, ordinances, codes, and orders of any and all governmental bodies, agencies, authorities, and courts having jurisdiction.

25. *Liens*--Charges, security interests, or encumbrances upon Project funds, real property, or personal property.

26. *Milestone*--A principal event specified in the Contract Documents relating to an intermediate completion date or time prior to Substantial Completion of all the Work.

27. *Notice of Award*--The written notice by Owner to the Successful Bidder stating that upon timely compliance by the Successful Bidder with the conditions precedent listed therein, Owner will sign and deliver the Agreement.

28. *Notice to Proceed*--A written notice given by Owner to Contractor fixing the date on which the Contract Times will commence to run and on which Contractor shall start to perform the Work under the Contract Documents.

29. *Owner*--The individual or entity with whom Contractor has entered into the Agreement and for whom the Work is to be performed.

30. *PCBs*--Polychlorinated biphenyls.

31. *Petroleum*--Petroleum, including crude oil or any fraction thereof which is liquid at standard conditions of temperature and pressure (60 degrees Fahrenheit and 14.7 pounds per square inch absolute), such as oil, petroleum, fuel oil, oil sludge, oil refuse, gasoline, kerosene, and oil mixed with other non-Hazardous Waste and crude oils.

32. *Progress Schedule*--A schedule, prepared and maintained by Contractor, describing the sequence and duration of the activities comprising the Contractor's plan to accomplish the Work within the Contract Times.

33. *Project*--The total construction of which the Work to be performed under the Contract Documents may be the whole, or a part.

34. *Project Manual*--The bound documentary information prepared for bidding and constructing the Work. A listing of the contents of the Project Manual, which may be bound in one or more volumes, is contained in the table(s) of contents.

35. *Radioactive Material*--Source, special nuclear, or byproduct material as defined by the Atomic Energy Act of 1954 (42 USC Section 2011 et seq.) as amended from time to time.

36. *Related Entity* -- An officer, director, partner, employee, agent, consultant, or subcontractor.

37. *Resident Project Representative*--The authorized representative of Engineer who may be assigned to the Site or any part thereof.

38. *Samples*--Physical examples of materials, equipment, or workmanship that are representative of some portion of the Work and which establish the standards by which such portion of the Work will be judged.

39. *Schedule of Submittals*--A schedule, prepared and maintained by Contractor, of required submittals and the time requirements to support scheduled performance of related construction activities.

40. *Schedule of Values*--A schedule, prepared and maintained by Contractor, allocating portions of the Contract Price to various portions of the Work and used as the basis for reviewing Contractor's Applications for Payment.

41. *Shop Drawings*--All drawings, diagrams, illustrations, schedules, and other data or information which are specifically prepared or assembled by or for Contractor and submitted by Contractor to illustrate some portion of the Work.

42. *Site*--Lands or areas indicated in the Contract Documents as being furnished by Owner upon which the Work is to be performed, including rights-of-way and easements for access thereto, and such other lands furnished by Owner which are designated for the use of Contractor.

43. *Specifications*--That part of the Contract Documents consisting of written requirements for materials, equipment, systems, standards and workmanship as applied to the Work, and certain administrative requirements and procedural matters applicable thereto.

44. *Subcontractor*--An individual or entity having a direct contract with Contractor or with any other Subcontractor for the performance of a part of the Work at the Site.

45. *Substantial Completion*--The time at which the Work (or a specified part thereof) has progressed to the point where, in the opinion of Engineer, the Work (or a specified part thereof) is sufficiently complete, in accordance with the Contract Documents, so that the Work (or a specified part thereof) can be utilized for the purposes for which it is intended. The terms "substantially complete" and "substantially completed" as applied to all or part of the Work refer to Substantial Completion thereof.

46. *Successful Bidder*--The Bidder submitting a responsive Bid to whom Owner makes an award.

47. *Supplementary Conditions*--That part of the Contract Documents which amends or supplements these General Conditions.

48. *Supplier*--A manufacturer, fabricator, supplier, distributor, materialman, or vendor having a direct contract with Contractor or with any Subcontractor to furnish materials or equipment to be incorporated in the Work by Contractor or any Subcontractor.

49. *Underground Facilities*--All underground pipelines, conduits, ducts, cables, wires, manholes, vaults, tanks, tunnels, or other such facilities or attachments, and any encasements containing such facilities, including those that convey electricity, gases, steam, liquid petroleum products, telephone or other communications, cable television, water, wastewater, storm water, other liquids or chemicals, or traffic or other control systems.

50. *Unit Price Work*--Work to be paid for on the basis of unit prices.

51. *Work*--The entire construction or the various separately identifiable parts thereof required to be provided under the Contract Documents. Work includes and is the result of performing or providing all labor, services, and documentation necessary to produce such construction, and furnishing, installing, and incorporating all materials and equipment into such construction, all as required by the Contract Documents.

52. *Work Change Directive*--A written statement to Contractor issued on or after the Effective Date of the Agreement and signed by Owner and recommended by Engineer ordering an addition, deletion, or revision in the Work, or responding to differing or unforeseen subsurface or physical conditions under which the Work is to be performed or to emergencies. A Work Change Directive will not change the Contract Price or the Contract Times but is evidence that the parties expect that the change ordered or documented by a Work Change Directive will be incorporated in a subsequently issued Change Order following negotiations by the parties as to its effect, if any, on the Contract Price or Contract Times.

1.02 *Terminology*

A. The following words or terms are not defined but, when used in the Bidding Requirements or Contract Documents, have the following meaning.

B. *Intent of Certain Terms or Adjectives*

1. The Contract Documents include the terms "as allowed," "as approved," "as ordered", "as directed" or terms of like effect or import to authorize an exercise of professional judgment by Engineer. In addition, the adjectives "reasonable," "suitable," "acceptable," "proper," "satisfactory," or adjectives of like effect or import are used to describe an action or determination of Engineer as to the Work. It is intended that such exercise

of professional judgment, action or determination will be solely to evaluate, in general, the Work for compliance with the requirements of and information in the Contract Documents and conformance with the design concept of the completed Project as a functioning whole as shown or indicated in the Contract Documents (unless there is a specific statement indicating otherwise). The use of any such term or adjective is not intended to and shall not be effective to assign to Engineer any duty or authority to supervise or direct the performance of the Work or any duty or authority to undertake responsibility contrary to the provisions of Paragraph 9.09 or any other provision of the Contract Documents.

C. *Day*

1. The word "day" means a calendar day of 24 hours measured from midnight to the next midnight.

D. *Defective*

1. The word "defective," when modifying the word "Work," refers to Work that is unsatisfactory, faulty, or deficient in that it:

a. does not conform to the Contract Documents, or

b. does not meet the requirements of any applicable inspection, reference standard, test, or approval referred to in the Contract Documents, or

c. has been damaged prior to Engineer's recommendation of final payment (unless responsibility for the protection thereof has been assumed by Owner at Substantial Completion in accordance with Paragraph 14.04 or 14.05).

E. *Furnish, Install, Perform, Provide*

1. The word "furnish," when used in connection with services, materials, or equipment, shall mean to supply and deliver said services, materials, or equipment to the Site (or some other specified location) ready for use or installation and in usable or operable condition.

2. The word "install," when used in connection with services, materials, or equipment, shall mean to put into use or place in final position said services, materials, or equipment complete and ready for intended use.

3. The words "perform" or "provide," when used in connection with services, materials, or equipment, shall mean to furnish and install said services, materials, or equipment complete and ready for intended use.

4. When "furnish," "install," "perform," or "provide" is not used in connection with services, materials, or equipment in a context clearly requiring an obligation of Contractor, "provide" is implied.

F. Unless stated otherwise in the Contract Documents, words or phrases which have a well-known technical or construction industry or trade meaning are used in the Contract Documents in accordance with such recognized meaning.

ARTICLE 2 - PRELIMINARY MATTERS

2.01 *Delivery of Bonds and Evidence of Insurance*

A. When Contractor delivers the executed counterparts of the Agreement to Owner, Contractor shall also deliver to Owner such bonds as Contractor may be required to furnish.

B. *Evidence of Insurance:* Before any Work at the Site is started, Contractor and Owner shall each deliver to the other, with copies to each additional insured identified in the Supplementary Conditions, certificates of insurance (and other evidence of insurance which either of them or any additional insured may reasonably request) which Contractor and Owner respectively are required to purchase and maintain in accordance with Article 5.

2.02 *Copies of Documents*

A. Owner shall furnish to Contractor up to ten printed or hard copies of the Drawings and Project Manual. Additional copies will be furnished upon request at the cost of reproduction.

2.03 *Commencement of Contract Times; Notice to Proceed*

A. The Contract Times will commence to run on the thirtieth day after the Effective Date of the Agreement or, if a Notice to Proceed is given, on the day indicated in the Notice to Proceed. A Notice to Proceed may be given at any time within 30 days after the Effective Date of the Agreement. In no event will the Contract Times commence to run later than the sixtieth day after the day of Bid opening or the thirtieth day after the Effective Date of the Agreement, whichever date is earlier.

2.04 *Starting the Work*

A. Contractor shall start to perform the Work on the date when the Contract Times commence to run. No Work shall be done at the Site prior to the date on which the Contract Times commence to run.

2.05 *Before Starting Construction*

A. *Preliminary Schedules:* Within 10 days after the Effective Date of the Agreement (unless otherwise specified in the General Requirements), Contractor shall submit to Engineer for timely review**:**

1. a preliminary Progress Schedule; indicating the times (numbers of days or dates) for starting and completing the various stages of the Work, including any Milestones specified in the Contract Documents;

2. a preliminary Schedule of Submittals; and

3. a preliminary Schedule of Values for all of the Work which includes quantities and prices of items which when added together equal the Contract Price and subdivides the Work into component parts in sufficient detail to serve as the basis for progress payments during performance of the Work. Such prices will include an appropriate amount of overhead and profit applicable to each item of Work.

2.06 *Preconstruction Conference*

A. Before any Work at the Site is started, a conference attended by Owner, Contractor, Engineer, and others as appropriate will be held to establish a working understanding among the parties as to the Work and to discuss the schedules referred to in Paragraph 2.05.A, procedures for handling Shop Drawings and other submittals, processing Applications for Payment, and maintaining required records.

2.07 *Initial Acceptance of Schedules*

A. At least 10 days before submission of the first Application for Payment a conference attended by Contractor, Engineer, and others as appropriate will be held to review for acceptability to Engineer as provided below the schedules submitted in accordance with Paragraph 2.05.A. Contractor shall have an additional 10 days to make corrections and adjustments and to complete and resubmit the schedules. No progress payment shall be made to Contractor until acceptable schedules are submitted to Engineer.

1. The Progress Schedule will be acceptable to Engineer if it provides an orderly progression of the Work to completion within the Contract Times. Such acceptance will not impose on Engineer responsibility for the Progress Schedule, for sequencing, scheduling, or progress of the Work nor interfere with or relieve Contractor from Contractor's full responsibility therefor.

2. Contractor's Schedule of Submittals will be acceptable to Engineer if it provides a workable arrangement for reviewing and processing the required submittals.

3. Contractor's Schedule of Values will be acceptable to Engineer as to form and substance if it provides a reasonable allocation of the Contract Price to component parts of the Work.

ARTICLE 3 - CONTRACT DOCUMENTS: INTENT, AMENDING, REUSE

3.01 *Intent*

A. The Contract Documents are complementary; what is required by one is as binding as if required by all.

B. It is the intent of the Contract Documents to describe a functionally complete Project (or part thereof) to be constructed in accordance with the Contract Documents. Any labor, documentation, services, materials, or equipment that may reasonably be inferred from the Contract Documents or from prevailing custom or trade usage as being required to produce the intended result will be provided whether or not specifically called for at no additional cost to Owner.

C. Clarifications and interpretations of the Contract Documents shall be issued by Engineer as provided in Article 9.

3.02 *Reference Standards*

A. Standards, Specifications, Codes, Laws, and Regulations

1. Reference to standards, specifications, manuals, or codes of any technical society, organization, or association, or to Laws or Regulations, whether such reference be specific or by implication, shall mean the standard, specification, manual, code, or Laws or Regulations in effect at the time of opening of Bids (or on the Effective Date of the Agreement if there were no Bids), except as may be otherwise specifically stated in the Contract Documents.

2. No provision of any such standard, specification, manual or code, or any instruction of a Supplier shall be effective to change the duties or responsibilities of Owner, Contractor, or Engineer, or any of their subcontractors, consultants, agents, or employees from those set forth in the Contract Documents. No such provision or instruction shall be effective to assign to Owner, or Engineer, or any of, their Related Entities, any duty or authority to supervise or direct the performance of the Work or any duty or authority to undertake responsibility inconsistent with the provisions of the Contract Documents.

3.03 *Reporting and Resolving Discrepancies*

A. Reporting Discrepancies

1. *Contractor's Review of Contract Documents Before Starting Work*: Before undertaking each part of the

Work, Contractor shall carefully study and compare the Contract Documents and check and verify pertinent figures therein and all applicable field measurements. Contractor shall promptly report in writing to Engineer any conflict, error, ambiguity, or discrepancy which Contractor may discover and shall obtain a written interpretation or clarification from Engineer before proceeding with any Work affected thereby.

2. *Contractor's Review of Contract Documents During Performance of Work*: If, during the performance of the Work, Contractor discovers any conflict, error, ambiguity, or discrepancy within the Contract Documents or between the Contract Documents and any provision of any Law or Regulation applicable to the performance of the Work or of any standard, specification, manual or code, or of any instruction of any Supplier, Contractor shall promptly report it to Engineer in writing. Contractor shall not proceed with the Work affected thereby (except in an emergency as required by Paragraph 6.16.A) until an amendment or supplement to the Contract Documents has been issued by one of the methods indicated in Paragraph 3.04.

3. Contractor shall not be liable to Owner or Engineer for failure to report any conflict, error, ambiguity, or discrepancy in the Contract Documents unless Contractor knew or reasonably should have known thereof.

B. Resolving Discrepancies

1. Except as may be otherwise specifically stated in the Contract Documents, the provisions of the Contract Documents shall take precedence in resolving any conflict, error, ambiguity, or discrepancy between the provisions of the Contract Documents and:

a. the provisions of any standard, specification, manual, code, or instruction (whether or not specifically incorporated by reference in the Contract Documents); or

b. the provisions of any Laws or Regulations applicable to the performance of the Work (unless such an interpretation of the provisions of the Contract Documents would result in violation of such Law or Regulation).

3.04 *Amending and Supplementing Contract Documents*

A. The Contract Documents may be amended to provide for additions, deletions, and revisions in the Work or to modify the terms and conditions thereof by either a Change Order or a Work Change Directive.

B. The requirements of the Contract Documents may be supplemented, and minor variations and deviations in the Work may be authorized, by one or more of the following ways:

1. A Field Order;

2. Engineer's approval of a Shop Drawing or Sample; (Subject to the provisions of Paragraph 6.17.D.3); or

3. Engineer's written interpretation or clarification.

3.05 *Reuse of Documents*

A. Contractor and any Subcontractor or Supplier or other individual or entity performing or furnishing all of the Work under a direct or indirect contract with Contractor, shall not:

1. have or acquire any title to or ownership rights in any of the Drawings, Specifications, or other documents (or copies of any thereof) prepared by or bearing the seal of Engineer or Engineer's consultants, including electronic media editions; or

2. reuse any of such Drawings, Specifications, other documents, or copies thereof on extensions of the Project or any other project without written consent of Owner and Engineer and specific written verification or adaption by Engineer.

B. The prohibition of this Paragraph 3.05 will survive final payment, or termination of the Contract. Nothing herein shall preclude Contractor from retaining copies of the Contract Documents for record purposes.

3.06 *Electronic Data*

A. Copies of data furnished by Owner or Engineer to Contractor or Contractor to Owner or Engineer that may be relied upon are limited to the printed copies (also known as hard copies). Files in electronic media format of text, data, graphics, or other types are furnished only for the convenience of the receiving party. Any conclusion or information obtained or derived from such electronic files will be at the user's sole risk. If there is a discrepancy between the electronic files and the hard copies, the hard copies govern.

B. Because data stored in electronic media format can deteriorate or be modified inadvertently or otherwise without authorization of the data's creator, the party receiving electronic files agrees that it will perform acceptance tests or procedures within 60 days, after which the receiving party shall be deemed to have accepted the data thus transferred. Any errors detected within the 60-day acceptance period will be corrected by the transferring party..

C. When transferring documents in electronic media format, the transferring party makes no representations as to long term compatibility, usability, or readability of documents resulting from the use of

software application packages, operating systems, or computer hardware differing from those used by the data's creator.

ARTICLE 4 - AVAILABILITY OF LANDS; SUBSURFACE AND PHYSICAL CONDITIONS; HAZARDOUS ENVIRONMENTAL CONDITIONS; REFERENCE POINTS

4.01 *Availability of Lands*

A. Owner shall furnish the Site. Owner shall notify Contractor of any encumbrances or restrictions not of general application but specifically related to use of the Site with which Contractor must comply in performing the Work. Owner will obtain in a timely manner and pay for easements for permanent structures or permanent changes in existing facilities. If Contractor and Owner are unable to agree on entitlement to or on the amount or extent, if any, of any adjustment in the Contract Price or Contract Times, or both, as a result of any delay in Owner's furnishing the Site or a part thereof, Contractor may make a Claim therefor as provided in Paragraph 10.05.

B. Upon reasonable written request, Owner shall furnish Contractor with a current statement of record legal title and legal description of the lands upon which the Work is to be performed and Owner's interest therein as necessary for giving notice of or filing a mechanic's or construction lien against such lands in accordance with applicable Laws and Regulations.

C. Contractor shall provide for all additional lands and access thereto that may be required for temporary construction facilities or storage of materials and equipment.

4.02 *Subsurface and Physical Conditions*

A. *Reports and Drawings:* The Supplementary Conditions identify:

1. those reports of explorations and tests of subsurface conditions at or contiguous to the Site that Engineer has used in preparing the Contract Documents; and

2. those drawings of physical conditions in or relating to existing surface or subsurface structures at or contiguous to the Site (except Underground Facilities) that Engineer has used in preparing the Contract Documents.

B. *Limited Reliance by Contractor on Technical Data Authorized:* Contractor may rely upon the general accuracy of the "technical data" contained in such reports and drawings, but such reports and drawings are not Contract Documents. Such "technical data" is identified in the Supplementary Conditions. Except for such reliance on such "technical data," Contractor may not rely upon or make any claim against Owner or Engineer, or any of their Related Entities with respect to:

1. the completeness of such reports and drawings for Contractor's purposes, including, but not limited to, any aspects of the means, methods, techniques, sequences, and procedures of construction to be employed by Contractor, and safety precautions and programs incident thereto; or

2. other data, interpretations, opinions, and information contained in such reports or shown or indicated in such drawings; or

3. any Contractor interpretation of or conclusion drawn from any "technical data" or any such other data, interpretations, opinions, or information.

4.03 *Differing Subsurface or Physical Conditions*

A. *Notice:* If Contractor believes that any subsurface or physical condition at or contiguous to the Site that is uncovered or revealed either:

1. is of such a nature as to establish that any "technical data" on which Contractor is entitled to rely as provided in Paragraph 4.02 is materially inaccurate; or

2. is of such a nature as to require a change in the Contract Documents; or

3. differs materially from that shown or indicated in the Contract Documents; or

4. is of an unusual nature, and differs materially from conditions ordinarily encountered and generally recognized as inherent in work of the character provided for in the Contract Documents;

then Contractor shall, promptly after becoming aware thereof and before further disturbing the subsurface or physical conditions or performing any Work in connection therewith (except in an emergency as required by Paragraph 6.16.A), notify Owner and Engineer in writing about such condition. Contractor shall not further disturb such condition or perform any Work in connection therewith (except as aforesaid) until receipt of written order to do so.

B. *Engineer's Review*: After receipt of written notice as required by Paragraph 4.03.A, Engineer will promptly review the pertinent condition, determine the necessity of Owner's obtaining additional exploration or tests with respect thereto, and advise Owner in writing (with a copy to Contractor) of Engineer's findings and conclusions.

C. Possible Price and Times Adjustments

1. The Contract Price or the Contract Times, or both, will be equitably adjusted to the extent that the existence of such differing subsurface or physical condition causes an increase or decrease in Contractor's cost of, or time required for, performance of the Work; subject, however, to the following:

a. such condition must meet any one or more of the categories described in Paragraph 4.03.A; and

b. with respect to Work that is paid for on a Unit Price Basis, any adjustment in Contract Price will be subject to the provisions of Paragraphs 9.07 and 11.03.

2. Contractor shall not be entitled to any adjustment in the Contract Price or Contract Times if:

a. Contractor knew of the existence of such conditions at the time Contractor made a final commitment to Owner with respect to Contract Price and Contract Times by the submission of a Bid or becoming bound under a negotiated contract; or

b. the existence of such condition could reasonably have been discovered or revealed as a result of any examination, investigation, exploration, test, or study of the Site and contiguous areas required by the Bidding Requirements or Contract Documents to be conducted by or for Contractor prior to Contractor's making such final commitment; or

c. Contractor failed to give the written notice as required by Paragraph 4.03.A.

3. If Owner and Contractor are unable to agree on entitlement to or on the amount or extent, if any, of any adjustment in the Contract Price or Contract Times, or both, a Claim may be made therefor as provided in Paragraph 10.05. However, Owner and Engineer, and any of their Related Entities shall not be liable to Contractor for any claims, costs, losses, or damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) sustained by Contractor on or in connection with any other project or anticipated project.

4.04 *Underground Facilities*

A. *Shown or Indicated:* The information and data shown or indicated in the Contract Documents with respect to existing Underground Facilities at or contiguous to the Site is based on information and data furnished to Owner or Engineer by the owners of such Underground Facilities, including Owner, or by others. Unless it is otherwise expressly provided in the Supplementary Conditions:

1. Owner and Engineer shall not be responsible for the accuracy or completeness of any such information or data; and

2. the cost of all of the following will be included in the Contract Price, and Contractor shall have full responsibility for:

a. reviewing and checking all such information and data,

b. locating all Underground Facilities shown or indicated in the Contract Documents,

c. coordination of the Work with the owners of such Underground Facilities, including Owner, during construction, and

d. the safety and protection of all such Underground Facilities and repairing any damage thereto resulting from the Work.

B. *Not Shown or Indicated*

1. If an Underground Facility is uncovered or revealed at or contiguous to the Site which was not shown or indicated, or not shown or indicated with reasonable accuracy in the Contract Documents, Contractor shall, promptly after becoming aware thereof and before further disturbing conditions affected thereby or performing any Work in connection therewith (except in an emergency as required by Paragraph 6.16.A), identify the owner of such Underground Facility and give written notice to that owner and to Owner and Engineer. Engineer will promptly review the Underground Facility and determine the extent, if any, to which a change is required in the Contract Documents to reflect and document the consequences of the existence or location of the Underground Facility. During such time, Contractor shall be responsible for the safety and protection of such Underground Facility.

2. If Engineer concludes that a change in the Contract Documents is required, a Work Change Directive or a Change Order will be issued to reflect and document such consequences. An equitable adjustment shall be made in the Contract Price or Contract Times, or both, to the extent that they are attributable to the existence or location of any Underground Facility that was not shown or indicated or not shown or indicated with reasonable accuracy in the Contract Documents and that Contractor did not know of and could not reasonably have been expected to be aware of or to have anticipated. If Owner and Contractor are unable to agree on entitlement to or on the amount or extent, if any, of any such adjustment in Contract Price or Contract Times, Owner or Contractor may make a Claim therefor as provided in Paragraph 10.05.

4.05 *Reference Points*

A. Owner shall provide engineering surveys to establish reference points for construction which in Engineer's judgment are necessary to enable Contractor to proceed with the Work. Contractor shall be responsible for laying out the Work, shall protect and preserve the established reference points and property monuments, and shall make no changes or relocations without the prior written approval of Owner. Contractor shall report to Engineer whenever any reference point or property monument is lost or destroyed or requires relocation because of necessary changes in grades or locations, and shall be responsible for the accurate replacement or relocation of such reference points or property monuments by professionally qualified personnel.

4.06 *Hazardous Environmental Condition at Site*

A. *Reports and Drawings:* Reference is made to the Supplementary Conditions for the identification of those reports and drawings relating to a Hazardous Environmental Condition identified at the Site, if any, that have been utilized by the Engineer in the preparation of the Contract Documents.

B. *Limited Reliance by Contractor on Technical Data Authorized:* Contractor may rely upon the general accuracy of the "technical data" contained in such reports and drawings, but such reports and drawings are not Contract Documents. Such "technical data" is identified in the Supplementary Conditions. Except for such reliance on such "technical data," Contractor may not rely upon or make any claim against Owner or Engineer, or any of their Related Entities with respect to:

1. the completeness of such reports and drawings for Contractor's purposes, including, but not limited to, any aspects of the means, methods, techniques, sequences and procedures of construction to be employed by Contractor and safety precautions and programs incident thereto; or

2. other data, interpretations, opinions and information contained in such reports or shown or indicated in such drawings; or

3. any Contractor interpretation of or conclusion drawn from any "technical data" or any such other data, interpretations, opinions or information.

C. Contractor shall not be responsible for any Hazardous Environmental Condition uncovered or revealed at the Site which was not shown or indicated in Drawings or Specifications or identified in the Contract Documents to be within the scope of the Work. Contractor shall be responsible for a Hazardous Environmental Condition created with any materials brought to the Site by Contractor, Subcontractors, Suppliers, or anyone else for whom Contractor is responsible.

D. If Contractor encounters a Hazardous Environmental Condition or if Contractor or anyone for whom Contractor is responsible creates a Hazardous Environmental Condition, Contractor shall immediately: (i) secure or otherwise isolate such condition; (ii) stop all Work in connection with such condition and in any area affected thereby (except in an emergency as required by Paragraph 6.16.A); and (iii) notify Owner and Engineer (and promptly thereafter confirm such notice in writing). Owner shall promptly consult with Engineer concerning the necessity for Owner to retain a qualified expert to evaluate such condition or take corrective action, if any.

E. Contractor shall not be required to resume Work in connection with such condition or in any affected area until after Owner has obtained any required permits related thereto and delivered to Contractor written notice: (i) specifying that such condition and any affected area is or has been rendered safe for the resumption of Work; or (ii) specifying any special conditions under which such Work may be resumed safely. If Owner and Contractor cannot agree as to entitlement to or on the amount or extent, if any, of any adjustment in Contract Price or Contract Times, or both, as a result of such Work stoppage or such special conditions under which Work is agreed to be resumed by Contractor, either party may make a Claim therefor as provided in Paragraph 10.05.

F. If after receipt of such written notice Contractor does not agree to resume such Work based on a reasonable belief it is unsafe, or does not agree to resume such Work under such special conditions, then Owner may order the portion of the Work that is in the area affected by such condition to be deleted from the Work. If Owner and Contractor cannot agree as to entitlement to or on the amount or extent, if any, of an adjustment in Contract Price or Contract Times as a result of deleting such portion of the Work, then either party may make a Claim therefor as provided in Paragraph 10.05. Owner may have such deleted portion of the Work performed by Owner's own forces or others in accordance with Article 7.

G. To the fullest extent permitted by Laws and Regulations, Owner shall indemnify and hold harmless Contractor, Subcontractors, and Engineer, and the officers, directors, partners, employees, agents, consultants, and subcontractors of each and any of them from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to a Hazardous Environmental Condition, provided that such Hazardous Environmental Condition: (i) was not shown or indicated in the Drawings or Specifications or identified in the Contract Documents to be included within the scope of the Work, and (ii) was not created by Contractor or by anyone for whom Contractor is responsible. Nothing in this Paragraph 4.06. G shall obligate Owner to indemnify

any individual or entity from and against the consequences of that individual's or entity's own negligence.

H. To the fullest extent permitted by Laws and Regulations, Contractor shall indemnify and hold harmless Owner and Engineer, and the officers, directors, partners, employees, agents, consultants, and subcontractors of each and any of them from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to a Hazardous Environmental Condition created by Contractor or by anyone for whom Contractor is responsible. Nothing in this Paragraph 4.06.H shall obligate Contractor to indemnify any individual or entity from and against the consequences of that individual's or entity's own negligence.

I. The provisions of Paragraphs 4.02, 4.03, and 4.04 do not apply to a Hazardous Environmental Condition uncovered or revealed at the Site.

ARTICLE 5 - BONDS AND INSURANCE

5.01 *Performance, Payment, and Other Bonds*

A. Contractor shall furnish performance and payment bonds, each in an amount at least equal to the Contract Price as security for the faithful performance and payment of all of Contractor's obligations under the Contract Documents. These bonds shall remain in effect until one year after the date when final payment becomes due or until completion of the correction period specified in Paragraph 13.07, whichever is later, except as provided otherwise by Laws or Regulations or by the Contract Documents. Contractor shall also furnish such other bonds as are required by the Contract Documents.

B. All bonds shall be in the form prescribed by the Contract Documents except as provided otherwise by Laws or Regulations, and shall be executed by such sureties as are named in the current list of "Companies Holding Certificates of Authority as Acceptable Sureties on Federal Bonds and as Acceptable Reinsuring Companies" as published in Circular 570 (amended) by the Financial Management Service, Surety Bond Branch, U.S. Department of the Treasury. All bonds signed by an agent must be accompanied by a certified copy of the agent's authority to act.

C. If the surety on any bond furnished by Contractor is declared bankrupt or becomes insolvent or its right to do business is terminated in any state where any part of the Project is located or it ceases to meet the requirements of Paragraph 5.01.B, Contractor shall promptly notify Owner and Engineer and shall, within 20 days after the event giving rise to such notification, provide another bond and surety, both of which shall comply with the requirements of Paragraphs 5.01.B and 5.02.

5.02 *Licensed Sureties and Insurers*

A. All bonds and insurance required by the Contract Documents to be purchased and maintained by Owner or Contractor shall be obtained from surety or insurance companies that are duly licensed or authorized in the jurisdiction in which the Project is located to issue bonds or insurance policies for the limits and coverages so required. Such surety and insurance companies shall also meet such additional requirements and qualifications as may be provided in the Supplementary Conditions.

5.03 *Certificates of Insurance*

A. Contractor shall deliver to Owner, with copies to each additional insured identified in the Supplementary Conditions, certificates of insurance (and other evidence of insurance requested by Owner or any other additional insured) which Contractor is required to purchase and maintain.

B. Owner shall deliver to Contractor, with copies to each additional insured identified in the Supplementary Conditions, certificates of insurance (and other evidence of insurance requested by Contractor or any other additional insured) which Owner is required to purchase and maintain.

5.04 *Contractor's Liability Insurance*

A. Contractor shall purchase and maintain such liability and other insurance as is appropriate for the Work being performed and as will provide protection from claims set forth below which may arise out of or result from Contractor's performance of the Work and Contractor's other obligations under the Contract Documents, whether it is to be performed by Contractor, any Subcontractor or Supplier, or by anyone directly or indirectly employed by any of them to perform any of the Work, or by anyone for whose acts any of them may be liable:

1. claims under workers' compensation, disability benefits, and other similar employee benefit acts;

2. claims for damages because of bodily injury, occupational sickness or disease, or death of Contractor's employees;

3. claims for damages because of bodily injury, sickness or disease, or death of any person other than Contractor's employees;

4. claims for damages insured by reasonably available personal injury liability coverage which are sustained:

a. by any person as a result of an offense directly or indirectly related to the employment of such person by Contractor, or

b. by any other person for any other reason;

5. claims for damages, other than to the Work itself, because of injury to or destruction of tangible property wherever located, including loss of use resulting therefrom; and

6. claims for damages because of bodily injury or death of any person or property damage arising out of the ownership, maintenance or use of any motor vehicle.

B. The policies of insurance required by this Paragraph 5.04 shall:

1. with respect to insurance required by Paragraphs 5.04.A.3 through 5.04.A.6 inclusive, include as additional insured (subject to any customary exclusion regarding professional liability) Owner and Engineer, and any other individuals or entities identified in the Supplementary Conditions, all of whom shall be listed as additional insureds, and include coverage for the respective officers, directors, partners, employees, agents, consultants and subcontractors of each and any of all such additional insureds, and the insurance afforded to these additional insureds shall provide primary coverage for all claims covered thereby;

2. include at least the specific coverages and be written for not less than the limits of liability provided in the Supplementary Conditions or required by Laws or Regulations, whichever is greater;

3. include completed operations insurance;

4. include contractual liability insurance covering Contractor's indemnity obligations under Paragraphs 6.11 and 6.20;

5. contain a provision or endorsement that the coverage afforded will not be canceled, materially changed or renewal refused until at least 30 days prior written notice has been given to Owner and Contractor and to each other additional insured identified in the Supplementary Conditions to whom a certificate of insurance has been issued (and the certificates of insurance furnished by the Contractor pursuant to Paragraph 5.03 will so provide);

6. remain in effect at least until final payment and at all times thereafter when Contractor may be correcting, removing, or replacing defective Work in accordance with Paragraph 13.07; and

7. with respect to completed operations insurance, and any insurance coverage written on a claims-made basis, remain in effect for at least two years after final payment.

a. Contractor shall furnish Owner and each other additional insured identified in the Supplementary Conditions, to whom a certificate of insurance has been issued, evidence satisfactory to Owner and any such additional insured of continuation of such insurance at final payment and one year thereafter.

5.05 *Owner's Liability Insurance*

A. In addition to the insurance required to be provided by Contractor under Paragraph 5.04, Owner, at Owner's option, may purchase and maintain at Owner's expense Owner's own liability insurance as will protect Owner against claims which may arise from operations under the Contract Documents.

5.06 *Property Insurance*

A. Unless otherwise provided in the Supplementary Conditions, Owner shall purchase and maintain property insurance upon the Work at the Site in the amount of the full replacement cost thereof (subject to such deductible amounts as may be provided in the Supplementary Conditions or required by Laws and Regulations). This insurance shall:

1. include the interests of Owner, Contractor, Subcontractors, and Engineer, and any other individuals or entities identified in the Supplementary Conditions, and the officers, directors, partners, employees, agents, consultants and subcontractors of each and any of them, each of whom is deemed to have an insurable interest and shall be listed as an insured or additional insured;

2. be written on a Builder's Risk "all-risk" or open peril or special causes of loss policy form that shall at least include insurance for physical loss or damage to the Work, temporary buildings, false work, and materials and equipment in transit, and shall insure against at least the following perils or causes of loss: fire, lightning, extended coverage, theft, vandalism and malicious mischief, earthquake, collapse, debris removal, demolition occasioned by enforcement of Laws and Regulations, water damage, (other than caused by flood) and such other perils or causes of loss as may be specifically required by the Supplementary Conditions;

3. include expenses incurred in the repair or replacement of any insured property (including but not limited to fees and charges of engineers and architects);

4. cover materials and equipment stored at the Site or at another location that was agreed to in writing by Owner prior to being incorporated in the Work, provided

that such materials and equipment have been included in an Application for Payment recommended by Engineer;

5. allow for partial utilization of the Work by Owner;

6. include testing and startup; and

7. be maintained in effect until final payment is made unless otherwise agreed to in writing by Owner, Contractor, and Engineer with 30 days written notice to each other additional insured to whom a certificate of insurance has been issued.

B. Owner shall purchase and maintain such boiler and machinery insurance or additional property insurance as may be required by the Supplementary Conditions or Laws and Regulations which will include the interests of Owner, Contractor, Subcontractors, and Engineer, and any other individuals or entities identified in the Supplementary Conditions, and the officers, directors, partners, employees, agents, consultants and subcontractors of each and any of them, each of whom is deemed to have an insurable interest and shall be listed as an insured or additional insured.

C. All the policies of insurance (and the certificates or other evidence thereof) required to be purchased and maintained in accordance with Paragraph 5.06 will contain a provision or endorsement that the coverage afforded will not be canceled or materially changed or renewal refused until at least 30 days prior written notice has been given to Owner and Contractor and to each other additional insured to whom a certificate of insurance has been issued and will contain waiver provisions in accordance with Paragraph 5.07.

D. Owner shall not be responsible for purchasing and maintaining any property insurance specified in this Paragraph 5.06 to protect the interests of Contractor, Subcontractors, or others in the Work to the extent of any deductible amounts that are identified in the Supplementary Conditions. The risk of loss within such identified deductible amount will be borne by Contractor, Subcontractors, or others suffering any such loss, and if any of them wishes property insurance coverage within the limits of such amounts, each may purchase and maintain it at the purchaser's own expense.

E. If Contractor requests in writing that other special insurance be included in the property insurance policies provided under Paragraph 5.06, Owner shall, if possible, include such insurance, and the cost thereof will be charged to Contractor by appropriate Change Order. Prior to commencement of the Work at the Site, Owner shall in writing advise Contractor whether or not such other insurance has been procured by Owner.

5.07 *Waiver of Rights*

A. Owner and Contractor intend that all policies purchased in accordance with Paragraph 5.06 will protect Owner, Contractor, Subcontractors, and Engineer, and all other individuals or entities identified in the Supplementary Conditions to be listed as insureds or additional insureds (and the officers, directors, partners, employees, agents, consultants and subcontractors of each and any of them) in such policies and will provide primary coverage for all losses and damages caused by the perils or causes of loss covered thereby. All such policies shall contain provisions to the effect that in the event of payment of any loss or damage the insurers will have no rights of recovery against any of the insureds or additional insureds thereunder. Owner and Contractor waive all rights against each other and their respective officers, directors, partners, employees, agents, consultants and subcontractors of each and any of them for all losses and damages caused by, arising out of or resulting from any of the perils or causes of loss covered by such policies and any other property insurance applicable to the Work; and, in addition, waive all such rights against Subcontractors, and Engineer, and all other individuals or entities identified in the Supplementary Conditions to be listed as insured or additional insured (and the officers, directors, partners, employees, agents, consultants and subcontractors of each and any of them) under such policies for losses and damages so caused. None of the above waivers shall extend to the rights that any party making such waiver may have to the proceeds of insurance held by Owner as trustee or otherwise payable under any policy so issued.

B. Owner waives all rights against Contractor, Subcontractors, and Engineer, and the officers, directors, partners, employees, agents, consultants and subcontractors of each and any of them for:

1. loss due to business interruption, loss of use, or other consequential loss extending beyond direct physical loss or damage to Owner's property or the Work caused by, arising out of, or resulting from fire or other perils whether or not insured by Owner; and

2. loss or damage to the completed Project or part thereof caused by, arising out of, or resulting from fire or other insured peril or cause of loss covered by any property insurance maintained on the completed Project or part thereof by Owner during partial utilization pursuant to Paragraph 14.05, after Substantial Completion pursuant to Paragraph 14.04, or after final payment pursuant to Paragraph 14.07.

C. Any insurance policy maintained by Owner covering any loss, damage or consequential loss referred to in Paragraph 5.07.B shall contain provisions to the effect that in the event of payment of any such loss, damage, or consequential loss, the insurers will have no rights of recovery against Contractor, Subcontractors, or Engineer, and the officers, directors, partners, employees,

agents, consultants and subcontractors of each and any of them.

5.08 *Receipt and Application of Insurance Proceeds*

A. Any insured loss under the policies of insurance required by Paragraph 5.06 will be adjusted with Owner and made payable to Owner as fiduciary for the insureds, as their interests may appear, subject to the requirements of any applicable mortgage clause and of Paragraph 5.08.B. Owner shall deposit in a separate account any money so received and shall distribute it in accordance with such agreement as the parties in interest may reach. If no other special agreement is reached, the damaged Work shall be repaired or replaced, the moneys so received applied on account thereof, and the Work and the cost thereof covered by an appropriate Change Order .

B. Owner as fiduciary shall have power to adjust and settle any loss with the insurers unless one of the parties in interest shall object in writing within 15 days after the occurrence of loss to Owner's exercise of this power. If such objection be made, Owner as fiduciary shall make settlement with the insurers in accordance with such agreement as the parties in interest may reach. If no such agreement among the parties in interest is reached, Owner as fiduciary shall adjust and settle the loss with the insurers and, if required in writing by any party in interest, Owner as fiduciary shall give bond for the proper performance of such duties.

5.09 *Acceptance of Bonds and Insurance; Option to Replace*

A. If either Owner or Contractor has any objection to the coverage afforded by or other provisions of the bonds or insurance required to be purchased and maintained by the other party in accordance with Article 5 on the basis of non-conformance with the Contract Documents, the objecting party shall so notify the other party in writing within 10 days after receipt of the certificates (or other evidence requested) required by Paragraph 2.01.B. Owner and Contractor shall each provide to the other such additional information in respect of insurance provided as the other may reasonably request. If either party does not purchase or maintain all of the bonds and insurance required of such party by the Contract Documents, such party shall notify the other party in writing of such failure to purchase prior to the start of the Work, or of such failure to maintain prior to any change in the required coverage. Without prejudice to any other right or remedy, the other party may elect to obtain equivalent bonds or insurance to protect such other party's interests at the expense of the party who was required to provide such coverage, and a Change Order shall be issued to adjust the Contract Price accordingly.

5.10 *Partial Utilization, Acknowledgment of Property Insurer*

A. If Owner finds it necessary to occupy or use a portion or portions of the Work prior to Substantial Completion of all the Work as provided in Paragraph 14.05, no such use or occupancy shall commence before the insurers providing the property insurance pursuant to Paragraph 5.06 have acknowledged notice thereof and in writing effected any changes in coverage necessitated thereby. The insurers providing the property insurance shall consent by endorsement on the policy or policies, but the property insurance shall not be canceled or permitted to lapse on account of any such partial use or occupancy.

ARTICLE 6 - CONTRACTOR'S RESPONSIBILITIES

6.01 *Supervision and Superintendence*

A. Contractor shall supervise, inspect, and direct the Work competently and efficiently, devoting such attention thereto and applying such skills and expertise as may be necessary to perform the Work in accordance with the Contract Documents. Contractor shall be solely responsible for the means, methods, techniques, sequences, and procedures of construction. Contractor shall not be responsible for the negligence of Owner or Engineer in the design or specification of a specific means, method, technique, sequence, or procedure of construction which is shown or indicated in and expressly required by the Contract Documents.

B. At all times during the progress of the Work, Contractor shall assign a competent resident superintendent who shall not be replaced without written notice to Owner and Engineer except under extraordinary circumstances. The superintendent will be Contractor's representative at the Site and shall have authority to act on behalf of Contractor. All communications given to or received from the superintendent shall be binding on Contractor.

6.02 *Labor; Working Hours*

A. Contractor shall provide competent, suitably qualified personnel to survey and lay out the Work and perform construction as required by the Contract Documents. Contractor shall at all times maintain good discipline and order at the Site.

B. Except as otherwise required for the safety or protection of persons or the Work or property at the Site or adjacent thereto, and except as otherwise stated in the Contract Documents, all Work at the Site shall be performed during regular working hours. Contractor will not permit the performance of Work on a Saturday, Sunday, or any legal holiday without Owner's written

consent (which will not be unreasonably withheld) given after prior written notice to Engineer.

6.03 *Services, Materials, and Equipment*

A. Unless otherwise specified in the Contract Documents, Contractor shall provide and assume full responsibility for all services, materials, equipment, labor, transportation, construction equipment and machinery, tools, appliances, fuel, power, light, heat, telephone, water, sanitary facilities, temporary facilities, and all other facilities and incidentals necessary for the performance, testing, start-up, and completion of the Work.

B. All materials and equipment incorporated into the Work shall be as specified or, if not specified, shall be of good quality and new, except as otherwise provided in the Contract Documents. All special warranties and guarantees required by the Specifications shall expressly run to the benefit of Owner. If required by Engineer, Contractor shall furnish satisfactory evidence (including reports of required tests) as to the source, kind, and quality of materials and equipment.

C. All materials and equipment shall be stored, applied, installed, connected, erected, protected, used, cleaned, and conditioned in accordance with instructions of the applicable Supplier, except as otherwise may be provided in the Contract Documents.

6.04 *Progress Schedule*

A. Contractor shall adhere to the Progress Schedule established in accordance with Paragraph 2.07 as it may be adjusted from time to time as provided below.

1. Contractor shall submit to Engineer for acceptance (to the extent indicated in Paragraph 2.07) proposed adjustments in the Progress Schedule that will not result in changing the Contract Times. Such adjustments will comply with any provisions of the General Requirements applicable thereto.

2. Proposed adjustments in the Progress Schedule that will change the Contract Times shall be submitted in accordance with the requirements of Article 12. Adjustments in Contract Times may only be made by a Change Order.

6.05 *Substitutes and "Or-Equals"*

A. Whenever an item of material or equipment is specified or described in the Contract Documents by using the name of a proprietary item or the name of a particular Supplier, the specification or description is intended to establish the type, function, appearance, and quality required. Unless the specification or description contains or is followed by words reading that no like, equivalent, or "or-equal" item or no substitution is permitted, other items of material or equipment or material or equipment of other Suppliers may be submitted to Engineer for review under the circumstances described below.

1. *"Or-Equal" Items:* If in Engineer's sole discretion an item of material or equipment proposed by Contractor is functionally equal to that named and sufficiently similar so that no change in related Work will be required, it may be considered by Engineer as an "or-equal" item, in which case review and approval of the proposed item may, in Engineer's sole discretion, be accomplished without compliance with some or all of the requirements for approval of proposed substitute items. For the purposes of this Paragraph 6.05.A.1, a proposed item of material or equipment will be considered functionally equal to an item so named if:

a. in the exercise of reasonable judgment Engineer determines that:

1) it is at least equal in materials of construction, quality, durability, appearance, strength, and design characteristics;

2) it will reliably perform at least equally well the function and achieve the results imposed by the design concept of the completed Project as a functioning whole,

3) it has a proven record of performance and availability of responsive service; and

b. Contractor certifies that, if approved and incorporated into the Work:

1) there will be no increase in cost to the Owner or increase in Contract Times, and

2) it will conform substantially to the detailed requirements of the item named in the Contract Documents.

2. Substitute Items

a. If in Engineer's sole discretion an item of material or equipment proposed by Contractor does not qualify as an "or-equal" item under Paragraph 6.05.A.1, it will be considered a proposed substitute item.

b. Contractor shall submit sufficient information as provided below to allow Engineer to determine that the item of material or equipment proposed is essentially equivalent to that named and an acceptable substitute therefor. Requests for review of proposed substitute items of material or equipment will not be accepted by Engineer from anyone other than Contractor.

c. The requirements for review by Engineer will be as set forth in Paragraph 6.05.A.2.d, as

supplemented in the General Requirements and as Engineer may decide is appropriate under the circumstances.

d. Contractor shall make written application to Engineer for review of a proposed substitute item of material or equipment that Contractor seeks to furnish or use. The application:

1) shall certify that the proposed substitute item will:

a) perform adequately the functions and achieve the results called for by the general design,

b) be similar in substance to that specified, and

c) be suited to the same use as that specified;

2) will state:

a) the extent, if any, to which the use of the proposed substitute item will prejudice Contractor's achievement of Substantial Completion on time;

b) whether or not use of the proposed substitute item in the Work will require a change in any of the Contract Documents (or in the provisions of any other direct contract with Owner for other work on the Project) to adapt the design to the proposed substitute item; and

c) whether or not incorporation or use of the proposed substitute item in connection with the Work is subject to payment of any license fee or royalty;

3) will identify:

a) all variations of the proposed substitute item from that specified , and

b) available engineering, sales, maintenance, repair, and replacement services;

4) and shall contain an itemized estimate of all costs or credits that will result directly or indirectly from use of such substitute item, including costs of redesign and claims of other contractors affected by any resulting change,

B. *Substitute Construction Methods or Procedures:* If a specific means, method, technique, sequence, or procedure of construction is expressly required by the Contract Documents, Contractor may furnish or utilize a substitute means, method, technique, sequence, or procedure of construction approved by Engineer. Contractor shall submit sufficient information to allow Engineer, in Engineer's sole discretion, to determine that the substitute proposed is equivalent to that expressly called for by the Contract Documents. The requirements for review by Engineer will be similar to those provided in Paragraph 6.05.A.2.

C. *Engineer's Evaluation:* Engineer will be allowed a reasonable time within which to evaluate each proposal or submittal made pursuant to Paragraphs 6.05.A and 6.05.B. Engineer may require Contractor to furnish additional data about the proposed substitute item. Engineer will be the sole judge of acceptability. No "or equal" or substitute will be ordered, installed or utilized until Engineer's review is complete, which will be evidenced by either a Change Order for a substitute or an approved Shop Drawing for an "or equal." Engineer will advise Contractor in writing of any negative determination.

D. *Special Guarantee:* Owner may require Contractor to furnish at Contractor's expense a special performance guarantee or other surety with respect to any substitute.

E. *Engineer's Cost Reimbursement*: Engineer will record Engineer's costs in evaluating a substitute proposed or submitted by Contractor pursuant to Paragraphs 6.05.A.2 and 6.05.B Whether or not Engineer approves a substitute item so proposed or submitted by Contractor, Contractor shall reimburse Owner for the charges of Engineer for evaluating each such proposed substitute. Contractor shall also reimburse Owner for the charges of Engineer for making changes in the Contract Documents (or in the provisions of any other direct contract with Owner) resulting from the acceptance of each proposed substitute.

F. *Contractor's Expense*: Contractor shall provide all data in support of any proposed substitute or "or-equal" at Contractor's expense.

6.06 *Concerning Subcontractors, Suppliers, and Others*

A. Contractor shall not employ any Subcontractor, Supplier, or other individual or entity (including those acceptable to Owner as indicated in Paragraph 6.06.B), whether initially or as a replacement, against whom Owner may have reasonable objection. Contractor shall not be required to employ any Subcontractor, Supplier, or other individual or entity to furnish or perform any of the Work against whom Contractor has reasonable objection.

B. If the Supplementary Conditions require the identity of certain Subcontractors, Suppliers, or other individuals or entities to be submitted to Owner in

advance for acceptance by Owner by a specified date prior to the Effective Date of the Agreement, and if Contractor has submitted a list thereof in accordance with the Supplementary Conditions, Owner's acceptance (either in writing or by failing to make written objection thereto by the date indicated for acceptance or objection in the Bidding Documents or the Contract Documents) of any such Subcontractor, Supplier, or other individual or entity so identified may be revoked on the basis of reasonable objection after due investigation. Contractor shall submit an acceptable replacement for the rejected Subcontractor, Supplier, or other individual or entity, and the Contract Price will be adjusted by the difference in the cost occasioned by such replacement, and an appropriate Change Order will be issued . No acceptance by Owner of any such Subcontractor, Supplier, or other individual or entity, whether initially or as a replacement, shall constitute a waiver of any right of Owner or Engineer to reject defective Work.

C. Contractor shall be fully responsible to Owner and Engineer for all acts and omissions of the Subcontractors, Suppliers, and other individuals or entities performing or furnishing any of the Work just as Contractor is responsible for Contractor's own acts and omissions. Nothing in the Contract Documents:

1. shall create for the benefit of any such Subcontractor, Supplier, or other individual or entity any contractual relationship between Owner or Engineer and any such Subcontractor, Supplier or other individual or entity, nor

2. shall anything in the Contract Documents create any obligation on the part of Owner or Engineer to pay or to see to the payment of any moneys due any such Subcontractor, Supplier, or other individual or entity except as may otherwise be required by Laws and Regulations.

D. Contractor shall be solely responsible for scheduling and coordinating the Work of Subcontractors, Suppliers, and other individuals or entities performing or furnishing any of the Work under a direct or indirect contract with Contractor.

E. Contractor shall require all Subcontractors, Suppliers, and such other individuals or entities performing or furnishing any of the Work to communicate with Engineer through Contractor.

F. The divisions and sections of the Specifications and the identifications of any Drawings shall not control Contractor in dividing the Work among Subcontractors or Suppliers or delineating the Work to be performed by any specific trade.

G. All Work performed for Contractor by a Subcontractor or Supplier will be pursuant to an appropriate agreement between Contractor and the Subcontractor or Supplier which specifically binds the Subcontractor or Supplier to the applicable terms and conditions of the Contract Documents for the benefit of Owner and Engineer. Whenever any such agreement is with a Subcontractor or Supplier who is listed as an additional insured on the property insurance provided in Paragraph 5.06, the agreement between the Contractor and the Subcontractor or Supplier will contain provisions whereby the Subcontractor or Supplier waives all rights against Owner, Contractor, and Engineer,, and all other individuals or entities identified in the Supplementary Conditions to be listed as insureds or additional insureds (and the officers, directors, partners, employees, agents, consultants and subcontractors of each and any of them) for all losses and damages caused by, arising out of, relating to, or resulting from any of the perils or causes of loss covered by such policies and any other property insurance applicable to the Work. If the insurers on any such policies require separate waiver forms to be signed by any Subcontractor or Supplier, Contractor will obtain the same.

6.07 *Patent Fees and Royalties*

A. Contractor shall pay all license fees and royalties and assume all costs incident to the use in the performance of the Work or the incorporation in the Work of any invention, design, process, product, or device which is the subject of patent rights or copyrights held by others. If a particular invention, design, process, product, or device is specified in the Contract Documents for use in the performance of the Work and if to the actual knowledge of Owner or Engineer its use is subject to patent rights or copyrights calling for the payment of any license fee or royalty to others, the existence of such rights shall be disclosed by Owner in the Contract Documents.

B. To the fullest extent permitted by Laws and Regulations, Contractor shall indemnify and hold harmless Owner and Engineer, and the officers, directors, partners, employees, agents, consultants and subcontractors of each and any of them from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to any infringement of patent rights or copyrights incident to the use in the performance of the Work or resulting from the incorporation in the Work of any invention, design, process, product, or device not specified in the Contract Documents.

6.08 *Permits*

A. Unless otherwise provided in the Supplementary Conditions, Contractor shall obtain and pay for all construction permits and licenses. Owner shall assist Contractor, when necessary, in obtaining such permits and licenses. Contractor shall pay all governmental charges and inspection fees necessary for the prosecution of the Work which are applicable at the time of opening

of Bids, or, if there are no Bids, on the Effective Date of the Agreement. Owner shall pay all charges of utility owners for connections for providing permanent service to the Work.

6.09 *Laws and Regulations*

A. Contractor shall give all notices required by and shall comply with all Laws and Regulations applicable to the performance of the Work. Except where otherwise expressly required by applicable Laws and Regulations, neither Owner nor Engineer shall be responsible for monitoring Contractor's compliance with any Laws or Regulations.

B. If Contractor performs any Work knowing or having reason to know that it is contrary to Laws or Regulations, Contractor shall bear all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such Work. However, it shall not be Contractor's primary responsibility to make certain that the Specifications and Drawings are in accordance with Laws and Regulations, but this shall not relieve Contractor of Contractor's obligations under Paragraph 3.03.

C. Changes in Laws or Regulations not known at the time of opening of Bids (or, on the Effective Date of the Agreement if there were no Bids) having an effect on the cost or time of performance of the Work shall be the subject of an adjustment in Contract Price or Contract Times. If Owner and Contractor are unable to agree on entitlement to or on the amount or extent, if any, of any such adjustment, a Claim may be made therefor as provided in Paragraph 10.05.

6.10 *Taxes*

A. Contractor shall pay all sales, consumer, use, and other similar taxes required to be paid by Contractor in accordance with the Laws and Regulations of the place of the Project which are applicable during the performance of the Work.

6.11 *Use of Site and Other Areas*

A. Limitation on Use of Site and Other Areas

1. Contractor shall confine construction equipment, the storage of materials and equipment, and the operations of workers to the Site and other areas permitted by Laws and Regulations, and shall not unreasonably encumber the Site and other areas with construction equipment or other materials or equipment. Contractor shall assume full responsibility for any damage to any such land or area, or to the owner or occupant thereof, or of any adjacent land or areas resulting from the performance of the Work.

2. Should any claim be made by any such owner or occupant because of the performance of the Work, Contractor shall promptly settle with such other party by negotiation or otherwise resolve the claim by arbitration or other dispute resolution proceeding or at law.

3. To the fullest extent permitted by Laws and Regulations, Contractor shall indemnify and hold harmless Owner and Engineer, and the officers, directors, partners, employees, agents, consultants and subcontractors of each and any of them from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to any claim or action, legal or equitable, brought by any such owner or occupant against Owner, Engineer, or any other party indemnified hereunder to the extent caused by or based upon Contractor's performance of the Work.

B. *Removal of Debris During Performance of the Work:* During the progress of the Work Contractor shall keep the Site and other areas free from accumulations of waste materials, rubbish, and other debris. Removal and disposal of such waste materials, rubbish, and other debris shall conform to applicable Laws and Regulations.

C. *Cleaning:* Prior to Substantial Completion of the Work Contractor shall clean the Site and the Work and make it ready for utilization by Owner. At the completion of the Work Contractor shall remove from the Site all tools, appliances, construction equipment and machinery, and surplus materials and shall restore to original condition all property not designated for alteration by the Contract Documents.

D. *Loading Structures:* Contractor shall not load nor permit any part of any structure to be loaded in any manner that will endanger the structure, nor shall Contractor subject any part of the Work or adjacent property to stresses or pressures that will endanger it.

6.12 *Record Documents*

A. Contractor shall maintain in a safe place at the Site one record copy of all Drawings, Specifications, Addenda, Change Orders, Work Change Directives, Field Orders, and written interpretations and clarifications in good order and annotated to show changes made during construction. These record documents together with all approved Samples and a counterpart of all approved Shop Drawings will be available to Engineer for reference. Upon completion of the Work, these record documents, Samples, and Shop Drawings will be delivered to Engineer for Owner.

6.13 *Safety and Protection*

A. Contractor shall be solely responsible for initiating, maintaining and supervising all safety precau-

tions and programs in connection with the Work. Contractor shall take all necessary precautions for the safety of, and shall provide the necessary protection to prevent damage, injury or loss to:

1. all persons on the Site or who may be affected by the Work;

2. all the Work and materials and equipment to be incorporated therein, whether in storage on or off the Site; and

3. other property at the Site or adjacent thereto, including trees, shrubs, lawns, walks, pavements, roadways, structures, utilities, and Underground Facilities not designated for removal, relocation, or replacement in the course of construction.

B. Contractor shall comply with all applicable Laws and Regulations relating to the safety of persons or property, or to the protection of persons or property from damage, injury, or loss; and shall erect and maintain all necessary safeguards for such safety and protection. Contractor shall notify owners of adjacent property and of Underground Facilities and other utility owners when prosecution of the Work may affect them, and shall cooperate with them in the protection, removal, relocation, and replacement of their property.

C. All damage, injury, or loss to any property referred to in Paragraph 6.13.A.2 or 6.13.A.3 caused, directly or indirectly, in whole or in part, by Contractor, any Subcontractor, Supplier, or any other individual or entity directly or indirectly employed by any of them to perform any of the Work, or anyone for whose acts any of them may be liable, shall be remedied by Contractor (except damage or loss attributable to the fault of Drawings or Specifications or to the acts or omissions of Owner or Engineer or , or anyone employed by any of them, or anyone for whose acts any of them may be liable, and not attributable, directly or indirectly, in whole or in part, to the fault or negligence of Contractor or any Subcontractor, Supplier, or other individual or entity directly or indirectly employed by any of them).

D. Contractor's duties and responsibilities for safety and for protection of the Work shall continue until such time as all the Work is completed and Engineer has issued a notice to Owner and Contractor in accordance with Paragraph 14.07.B that the Work is acceptable (except as otherwise expressly provided in connection with Substantial Completion).

6.14 *Safety Representative*

A. Contractor shall designate a qualified and experienced safety representative at the Site whose duties and responsibilities shall be the prevention of accidents and the maintaining and supervising of safety precautions and programs.

6.15 *Hazard Communication Programs*

A. Contractor shall be responsible for coordinating any exchange of material safety data sheets or other hazard communication information required to be made available to or exchanged between or among employers at the Site in accordance with Laws or Regulations.

6.16 *Emergencies*

A. In emergencies affecting the safety or protection of persons or the Work or property at the Site or adjacent thereto, Contractor is obligated to act to prevent threatened damage, injury, or loss. Contractor shall give Engineer prompt written notice if Contractor believes that any significant changes in the Work or variations from the Contract Documents have been caused thereby or are required as a result thereof. If Engineer determines that a change in the Contract Documents is required because of the action taken by Contractor in response to such an emergency, a Work Change Directive or Change Order will be issued.

6.17 *Shop Drawings and Samples*

A. Contractor shall submit Shop Drawings and Samples to Engineer for review and approval in accordance with the acceptable Schedule of Submittals (as required by Paragraph 2.07). Each submittal will be identified as Engineer may require.

1. Shop Drawings

a. Submit number of copies specified in the General Requirements.

b. Data shown on the Shop Drawings will be complete with respect to quantities, dimensions, specified performance and design criteria, materials, and similar data to show Engineer the services, materials, and equipment Contractor proposes to provide and to enable Engineer to review the information for the limited purposes required by Paragraph 6.17.D.

2. *Samples:* Contractor shall also submit Samples to Engineer for review and approval in accordance with the acceptable schedule of Shop Drawings and Sample submittals.

a. Submit number of Samples specified in the Specifications.

b. Clearly identify each Sample as to material, Supplier, pertinent data such as catalog numbers, the use for which intended and other data as Engineer may require to enable Engineer to review the submittal for the limited purposes required by Paragraph 6.17.D.

B. Where a Shop Drawing or Sample is required by the Contract Documents or the Schedule of Submittals , any related Work performed prior to Engineer's review and approval of the pertinent submittal will be at the sole expense and responsibility of Contractor.

C. Submittal Procedures

1. Before submitting each Shop Drawing or Sample, Contractor shall have determined and verified:

a. all field measurements, quantities, dimensions, specified performance and design criteria, installation requirements, materials, catalog numbers, and similar information with respect thereto;

b. the suitability of all materials with respect to intended use, fabrication, shipping, handling, storage, assembly, and installation pertaining to the performance of the Work;

c. all information relative to Contractor's responsibilities for means, methods, techniques, sequences, and procedures of construction, and safety precautions and programs incident thereto; and

d. shall also have reviewed and coordinated each Shop Drawing or Sample with other Shop Drawings and Samples and with the requirements of the Work and the Contract Documents.

2. Each submittal shall bear a stamp or specific written certification that Contractor has satisfied Contractor's obligations under the Contract Documents with respect to Contractor's review and approval of that submittal.

3. With each submittal, Contractor shall give Engineer specific written notice of any variations, that the Shop Drawing or Sample may have from the requirements of the Contract Documents. This notice shall be both a written communication separate from the Shop Drawing's or Sample Submittal; and, in addition, by a specific notation made on each Shop Drawing or Sample submitted to Engineer for review and approval of each such variation.

D. *Engineer's Review*

1. Engineer will provide timely review of Shop Drawings and Samples in accordance with the Schedule of Submittals acceptable to Engineer. Engineer's review and approval will be only to determine if the items covered by the submittals will, after installation or incorporation in the Work, conform to the information given in the Contract Documents and be compatible with the design concept of the completed Project as a functioning whole as indicated by the Contract Documents.

2. Engineer's review and approval will not extend to means, methods, techniques, sequences, or procedures of construction (except where a particular means, method, technique, sequence, or procedure of construction is specifically and expressly called for by the Contract Documents) or to safety precautions or programs incident thereto. The review and approval of a separate item as such will not indicate approval of the assembly in which the item functions.

3. Engineer's review and approval shall not relieve Contractor from responsibility for any variation from the requirements of the Contract Documents unless Contractor has complied with the requirements of Paragraph 6.17.C.3 and Engineer has given written approval of each such variation by specific written notation thereof incorporated in or accompanying the Shop Drawing or Sample. Engineer's review and approval shall not relieve Contractor from responsibility for complying with the requirements of Paragraph 6.17.C.1.

E. *Resubmittal Procedures*

1. Contractor shall make corrections required by Engineer and shall return the required number of corrected copies of Shop Drawings and submit, as required, new Samples for review and approval. Contractor shall direct specific attention in writing to revisions other than the corrections called for by Engineer on previous submittals.

6.18 *Continuing the Work*

A. Contractor shall carry on the Work and adhere to the Progress Schedule during all disputes or disagreements with Owner. No Work shall be delayed or postponed pending resolution of any disputes or disagreements, except as permitted by Paragraph 15.04 or as Owner and Contractor may otherwise agree in writing.

6.19 *Contractor's General Warranty and Guarantee*

A. Contractor warrants and guarantees to Owner that all Work will be in accordance with the Contract Documents and will not be defective. Engineer and its Related Entities shall be entitled to rely on representation of Contractor's warranty and guarantee.

B. Contractor's warranty and guarantee hereunder excludes defects or damage caused by:

1. abuse, modification, or improper maintenance or operation by persons other than Contractor, Subcontractors, Suppliers, or any other individual or entity for whom Contractor is responsible; or

2. normal wear and tear under normal usage.

C. Contractor's obligation to perform and complete the Work in accordance with the Contract Documents shall be absolute. None of the following will constitute an acceptance of Work that is not in accordance with the Contract Documents or a release of Contractor's obligation to perform the Work in accordance with the Contract Documents:

1. observations by Engineer;

2. recommendation by Engineer or payment by Owner of any progress or final payment;

3. the issuance of a certificate of Substantial Completion by Engineer or any payment related thereto by Owner;

4. use or occupancy of the Work or any part thereof by Owner;

5. any review and approval of a Shop Drawing or Sample submittal or the issuance of a notice of acceptability by Engineer;

6. any inspection, test, or approval by others; or

7. any correction of defective Work by Owner.

6.20 *Indemnification*

A. To the fullest extent permitted by Laws and Regulations, Contractor shall indemnify and hold harmless Owner and Engineer, and the officers, directors, partners, employees, agents, consultants and subcontractors of each and any of them from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to the performance of the Work, provided that any such claim, cost, loss, or damage is attributable to bodily injury, sickness, disease, or death, or to injury to or destruction of tangible property (other than the Work itself), including the loss of use resulting therefrom but only to the extent caused by any negligent act or omission of Contractor, any Subcontractor, any Supplier, or any individual or entity directly or indirectly employed by any of them to perform any of the Work or anyone for whose acts any of them may be liable .

B. In any and all claims against Owner or Engineer or any of their respective consultants, agents, officers, directors, partners, or employees by any employee (or the survivor or personal representative of such employee) of Contractor, any Subcontractor, any Supplier, or any individual or entity directly or indirectly employed by any of them to perform any of the Work, or anyone for whose acts any of them may be liable, the indemnification obligation under Paragraph 6.20.A shall not be limited in any way by any limitation on the amount or type of damages, compensation, or benefits payable by or for Contractor or any such Subcontractor, Supplier, or other individual or entity under workers' compensation acts, disability benefit acts, or other employee benefit acts.

C. The indemnification obligations of Contractor under Paragraph 6.20.A shall not extend to the liability of Engineer and Engineer's officers, directors, partners, employees, agents, consultants and subcontractors arising out of:

1. the preparation or approval of, or the failure to prepare or approve, maps, Drawings, opinions, reports, surveys, Change Orders, designs, or Specifications; or

2. giving directions or instructions, or failing to give them, if that is the primary cause of the injury or damage.

6.21 *Delegation of Professional Design Services*

A. Contractor will not be required to provide professional design services unless such services are specifically required by the Contract Documents for a portion of the Work or unless such services are required to carry out Contractor's responsibilities for construction means, methods, techniques, sequences and procedures. Contractor shall not be required to provide professional services in violation of applicable law.

B. If professional design services or certifications by a design professional related to systems, materials or equipment are specifically required of Contractor by the Contract Documents, Owner and Engineer will specify all performance and design criteria that such services must satisfy. Contractor shall cause such services or certifications to be provided by a properly licensed professional, whose signature and seal shall appear on all drawings, calculations, specifications, certifications, Shop Drawings and other submittals prepared by such professional. Shop Drawings and other submittals related to the Work designed or certified by such professional, if prepared by others, shall bear such professional's written approval when submitted to Engineer.

C. Owner and Engineer shall be entitled to rely upon the adequacy, accuracy and completeness of the services, certifications or approvals performed by such design professionals, provided Owner and Engineer have specified to Contractor all performance and design criteria that such services must satisfy.

D. Pursuant to this Paragraph 6.21, Engineer's review and approval of design calculations and design drawings will be only for the limited purpose of checking for conformance with performance and design criteria given and the design concept expressed in the Contract Documents. Engineer's review and approval of Shop Drawings and other submittals (except design calculations

and design drawings) will be only for the purpose stated in Paragraph 6.17.D.1.

E. Contractor shall not be responsible for the adequacy of the performance or design criteria required by the Contract Documents.

ARTICLE 7 - OTHER WORK AT THE SITE

7.01 *Related Work at Site*

A. Owner may perform other work related to the Project at the Site with Owner's employees, or via other direct contracts therefor, or have other work performed by utility owners. If such other work is not noted in the Contract Documents, then:

1. written notice thereof will be given to Contractor prior to starting any such other work; and

2. if Owner and Contractor are unable to agree on entitlement to or on the amount or extent, if any, of any adjustment in the Contract Price or Contract Times that should be allowed as a result of such other work, a Claim may be made therefor as provided in Paragraph 10.05.

B. Contractor shall afford each other contractor who is a party to such a direct contract, each utility owner and Owner, if Owner is performing other work with Owner's employees, proper and safe access to the Site, a reasonable opportunity for the introduction and storage of materials and equipment and the execution of such other work, and shall properly coordinate the Work with theirs. Contractor shall do all cutting, fitting, and patching of the Work that may be required to properly connect or otherwise make its several parts come together and properly integrate with such other work. Contractor shall not endanger any work of others by cutting, excavating, or otherwise altering their work and will only cut or alter their work with the written consent of Engineer and the others whose work will be affected. The duties and responsibilities of Contractor under this Paragraph are for the benefit of such utility owners and other contractors to the extent that there are comparable provisions for the benefit of Contractor in said direct contracts between Owner and such utility owners and other contractors.

C. If the proper execution or results of any part of Contractor's Work depends upon work performed by others under this Article 7, Contractor shall inspect such other work and promptly report to Engineer in writing any delays, defects, or deficiencies in such other work that render it unavailable or unsuitable for the proper execution and results of Contractor's Work. Contractor's failure to so report will constitute an acceptance of such other work as fit and proper for integration with Contractor's Work except for latent defects and deficiencies in such other work.

7.02 *Coordination*

A. If Owner intends to contract with others for the performance of other work on the Project at the Site, the following will be set forth in Supplementary Conditions:

1. the individual or entity who will have authority and responsibility for coordination of the activities among the various contractors will be identified;

2. the specific matters to be covered by such authority and responsibility will be itemized; and

3. the extent of such authority and responsibilities will be provided.

B. Unless otherwise provided in the Supplementary Conditions, Owner shall have sole authority and responsibility for such coordination.

7.03 *Legal Relationships*

A. Paragraphs 7.01.A and 7.02 are not applicable for utilities not under the control of Owner.

B. Each other direct contract of Owner under Paragraph 7.01.A shall provide that the other contractor is liable to Owner and Contractor for the reasonable direct delay and disruption costs incurred by Contractor as a result of the other contractor's actions or inactions.

C. Contractor shall be liable to Owner and any other contractor for the reasonable direct delay and disruption costs incurred by such other contractor as a result of Contractor's action or inactions.

ARTICLE 8 - OWNER'S RESPONSIBILITIES

8.01 *Communications to Contractor*

A. Except as otherwise provided in these General Conditions, Owner shall issue all communications to Contractor through Engineer.

8.02 *Replacement of Engineer*

A. In case of termination of the employment of Engineer, Owner shall appoint an engineer to whom Contractor makes no reasonable objection, whose status under the Contract Documents shall be that of the former Engineer.

8.03 *Furnish Data*

A. Owner shall promptly furnish the data required of Owner under the Contract Documents.

8.04 *Pay When Due*

A. Owner shall make payments to Contractor when they are due as provided in Paragraphs 14.02.C and 14.07.C.

8.05 *Lands and Easements; Reports and Tests*

A. Owner's duties in respect of providing lands and easements and providing engineering surveys to establish reference points are set forth in Paragraphs 4.01 and 4.05. Paragraph 4.02 refers to Owner's identifying and making available to Contractor copies of reports of explorations and tests of subsurface conditions and drawings of physical conditions in or relating to existing surface or subsurface structures at or contiguous to the Site that have been utilized by Engineer in preparing the Contract Documents.

8.06 *Insurance*

A. Owner's responsibilities, if any, in respect to purchasing and maintaining liability and property insurance are set forth in Article 5.

8.07 *Change Orders*

A. Owner is obligated to execute Change Orders as indicated in Paragraph 10.03.

8.08 *Inspections, Tests, and Approvals*

A. Owner's responsibility in respect to certain inspections, tests, and approvals is set forth in Paragraph 13.03.B.

8.09 *Limitations on Owner's Responsibilities*

A. The Owner shall not supervise, direct, or have control or authority over, nor be responsible for, Contractor's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of Contractor to comply with Laws and Regulations applicable to the performance of the Work. Owner will not be responsible for Contractor's failure to perform the Work in accordance with the Contract Documents.

8.10 *Undisclosed Hazardous Environmental Condition*

A. Owner's responsibility in respect to an undisclosed Hazardous Environmental Condition is set forth in Paragraph 4.06.

8.11 *Evidence of Financial Arrangements*

A. If and to the extent Owner has agreed to furnish Contractor reasonable evidence that financial arrangements have been made to satisfy Owner's obligations under the Contract Documents, Owner's responsibility in respect thereof will be as set forth in the Supplementary Conditions.

ARTICLE 9 - ENGINEER'S STATUS DURING CONSTRUCTION

9.01 *Owner's Representative*

A. Engineer will be Owner's representative during the construction period. The duties and responsibilities and the limitations of authority of Engineer as Owner's representative during construction are set forth in the Contract Documents and will not be changed without written consent of Owner and Engineer.

9.02 *Visits to Site*

A. Engineer will make visits to the Site at intervals appropriate to the various stages of construction as Engineer deems necessary in order to observe as an experienced and qualified design professional the progress that has been made and the quality of the various aspects of Contractor's executed Work. Based on information obtained during such visits and observations, Engineer, for the benefit of Owner, will determine, in general, if the Work is proceeding in accordance with the Contract Documents. Engineer will not be required to make exhaustive or continuous inspections on the Site to check the quality or quantity of the Work. Engineer's efforts will be directed toward providing for Owner a greater degree of confidence that the completed Work will conform generally to the Contract Documents. On the basis of such visits and observations, Engineer will keep Owner informed of the progress of the Work and will endeavor to guard Owner against defective Work.

B. Engineer's visits and observations are subject to all the limitations on Engineer's authority and responsibility set forth in Paragraph 9.09. Particularly, but without limitation, during or as a result of Engineer's visits or observations of Contractor's Work Engineer will not supervise, direct, control, or have authority over or be responsible for Contractor's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of Contractor to comply with Laws and Regulations applicable to the performance of the Work.

9.03 *Project Representative*

A. If Owner and Engineer agree, Engineer will furnish a Resident Project Representative to assist Engineer in providing more extensive observation of the Work. The authority and responsibilities of any such Resident Project Representative and assistants will be as provided in the Supplementary Conditions, and limitations on the responsibilities thereof will be as provided in Paragraph 9.09. If Owner designates another representative or agent to represent Owner at the Site who

is not Engineer's consultant, agent or employee, the responsibilities and authority and limitations thereon of such other individual or entity will be as provided in the Supplementary Conditions.

9.04 *Authorized Variations in Work*

A. Engineer may authorize minor variations in the Work from the requirements of the Contract Documents which do not involve an adjustment in the Contract Price or the Contract Times and are compatible with the design concept of the completed Project as a functioning whole as indicated by the Contract Documents. These may be accomplished by a Field Order and will be binding on Owner and also on Contractor, who shall perform the Work involved promptly. If Owner or Contractor believes that a Field Order justifies an adjustment in the Contract Price or Contract Times, or both, and the parties are unable to agree on entitlement to or on the amount or extent, if any, of any such adjustment , a Claim may be made therefor as provided in Paragraph 10.05.

9.05 *Rejecting Defective Work*

A. Engineer will have authority to reject Work which Engineer believes to be defective, or that Engineer believes will not produce a completed Project that conforms to the Contract Documents or that will prejudice the integrity of the design concept of the completed Project as a functioning whole as indicated by the Contract Documents. Engineer will also have authority to require special inspection or testing of the Work as provided in Paragraph 13.04, whether or not the Work is fabricated, installed, or completed.

9.06 *Shop Drawings, Change Orders and Payments*

A. In connection with Engineer's authority, and limitations thereof, as to Shop Drawings and Samples, see Paragraph 6.17.

B. In connection with Engineer's authority, and limitations thereof, as to design calculations and design drawings submitted in response to a delegation of professional design services, if any, see Paragraph 6.21.

C. In connection with Engineer's authority as to Change Orders, see Articles 10, 11, and 12.

D. In connection with Engineer's authority as to Applications for Payment, see Article 14.

9.07 *Determinations for Unit Price Work*

A. Engineer will determine the actual quantities and classifications of Unit Price Work performed by Contractor. Engineer will review with Contractor the Engineer's preliminary determinations on such matters before rendering a written decision thereon (by recommendation of an Application for Payment or otherwise). Engineer's written decision thereon will be final and binding (except as modified by Engineer to reflect changed factual conditions or more accurate data) upon Owner and Contractor, subject to the provisions of Paragraph 10.05.

9.08 *Decisions on Requirements of Contract Documents and Acceptability of Work*

A. Engineer will be the initial interpreter of the requirements of the Contract Documents and judge of the acceptability of the Work thereunder. All matters in question and other matters between Owner and Contractor arising prior to the date final payment is due relating to the acceptability of the Work, and the interpretation of the requirements of the Contract Documents pertaining to the performance of the Work, will be referred initially to Engineer in writing within 30 days of the event giving rise to the question

B. Engineer will, with reasonable promptness, render a written decision on the issue referred. If Owner or Contractor believe that any such decision entitles them to an adjustment in the Contract Price or Contract Times or both, a Claim may be made under Paragraph 10.05. The date of Engineer's decision shall be the date of the event giving rise to the issues referenced for the purposes of Paragraph 10.05.B.

C. Engineer's written decision on the issue referred will be final and binding on Owner and Contractor, subject to the provisions of Paragraph 10.05.

D. When functioning as interpreter and judge under this Paragraph 9.08, Engineer will not show partiality to Owner or Contractor and will not be liable in connection with any interpretation or decision rendered in good faith in such capacity.

9.09 *Limitations on Engineer's Authority and Responsibilities*

A. Neither Engineer's authority or responsibility under this Article 9 or under any other provision of the Contract Documents nor any decision made by Engineer in good faith either to exercise or not exercise such authority or responsibility or the undertaking, exercise, or performance of any authority or responsibility by Engineer shall create, impose, or give rise to any duty in contract, tort, or otherwise owed by Engineer to Contractor, any Subcontractor, any Supplier, any other individual or entity, or to any surety for or employee or agent of any of them.

B. Engineer will not supervise, direct, control, or have authority over or be responsible for Contractor's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of Contractor to comply with Laws and Regulations applicable to the performance of the Work. Engineer will not be respon-

sible for Contractor's failure to perform the Work in accordance with the Contract Documents.

C. Engineer will not be responsible for the acts or omissions of Contractor or of any Subcontractor, any Supplier, or of any other individual or entity performing any of the Work.

D. Engineer's review of the final Application for Payment and accompanying documentation and all maintenance and operating instructions, schedules, guarantees, bonds, certificates of inspection, tests and approvals, and other documentation required to be delivered by Paragraph 14.07.A will only be to determine generally that their content complies with the requirements of, and in the case of certificates of inspections, tests, and approvals that the results certified indicate compliance with the Contract Documents.

E. The limitations upon authority and responsibility set forth in this Paragraph 9.09 shall also apply to, the Resident Project Representative, if any, and assistants, if any.

ARTICLE 10 - CHANGES IN THE WORK; CLAIMS

10.01 *Authorized Changes in the Work*

A. Without invalidating the Contract and without notice to any surety, Owner may, at any time or from time to time, order additions, deletions, or revisions in the Work by a Change Order, or a Work Change Directive. Upon receipt of any such document, Contractor shall promptly proceed with the Work involved which will be performed under the applicable conditions of the Contract Documents (except as otherwise specifically provided).

B. If Owner and Contractor are unable to agree on entitlement to, or on the amount or extent, if any, of an adjustment in the Contract Price or Contract Times, or both, that should be allowed as a result of a Work Change Directive, a Claim may be made therefor as provided in Paragraph 10.05.

10.02 *Unauthorized Changes in the Work*

A.Contractor shall not be entitled to an increase in the Contract Price or an extension of the Contract Times with respect to any work performed that is not required by the Contract Documents as amended, modified, or supplemented as provided in Paragraph 3.04, except in the case of an emergency as provided in Paragraph 6.16 or in the case of uncovering Work as provided in Paragraph 13.04.B.

10.03 *Execution of Change Orders*

A. Owner and Contractor shall execute appropriate Change Orders recommended by Engineer covering:

1. changes in the Work which are: (i) ordered by Owner pursuant to Paragraph 10.01.A, (ii) required because of acceptance of defective Work under Paragraph 13.08.A or Owner's correction of defective Work under Paragraph 13.09, or (iii) agreed to by the parties;

2. changes in the Contract Price or Contract Times which are agreed to by the parties, including any undisputed sum or amount of time for Work actually performed in accordance with a Work Change Directive; and

3. changes in the Contract Price or Contract Times which embody the substance of any written decision rendered by Engineer pursuant to Paragraph 10.05; provided that, in lieu of executing any such Change Order, an appeal may be taken from any such decision in accordance with the provisions of the Contract Documents and applicable Laws and Regulations, but during any such appeal, Contractor shall carry on the Work and adhere to the Progress Schedule as provided in Paragraph 6.18.A.

10.04 *Notification to Surety*

A. If notice of any change affecting the general scope of the Work or the provisions of the Contract Documents (including, but not limited to, Contract Price or Contract Times) is required by the provisions of any bond to be given to a surety, the giving of any such notice will be Contractor's responsibility. The amount of each applicable bond will be adjusted to reflect the effect of any such change.

10.05 *Claims*

A. *Engineer's Decision Required*: All Claims, except those waived pursuant to Paragraph 14.09, shall be referred to the Engineer for decision. A decision by Engineer shall be required as a condition precedent to any exercise by Owner or Contractor of any rights or remedies either may otherwise have under the Contract Documents or by Laws and Regulations in respect of such Claims.

B. *Notice:* Written notice stating the general nature of each Claim, shall be delivered by the claimant to Engineer and the other party to the Contract promptly (but in no event later than 30 days) after the start of the event giving rise thereto. The responsibility to substantiate a Claim shall rest with the party making the Claim. Notice of the amount or extent of the Claim, with supporting data shall be delivered to the Engineer and the other party to the Contract within 60 days after the start of such event (unless Engineer allows additional time for claimant to submit additional or more accurate data in support of such Claim). A Claim for an adjustment in Contract Price shall be prepared in accordance with the provisions of Paragraph 12.01.B. A Claim for an adjustment in Contract Time shall be prepared in accordance with the provisions of Paragraph 12.02.B. Each Claim shall be accompanied

by claimant's written statement that the adjustment claimed is the entire adjustment to which the claimant believes it is entitled as a result of said event. The opposing party shall submit any response to Engineer and the claimant within 30 days after receipt of the claimant's last submittal (unless Engineer allows additional time).

C. *Engineer's Action*: Engineer will review each Claim and, within 30 days after receipt of the last submittal of the claimant or the last submittal of the opposing party, if any, take one of the following actions in writing:

1. deny the Claim in whole or in part,

2. approve the Claim, or

3. notify the parties that the Engineer is unable to resolve the Claim if, in the Engineer's sole discretion, it would be inappropriate for the Engineer to do so. For purposes of further resolution of the Claim, such notice shall be deemed a denial.

D. In the event that Engineer does not take action on a Claim within said 30 days, the Claim shall be deemed denied.

E. Engineer's written action under Paragraph 10.05.C or denial pursuant to Paragraphs 10.05.C.3 or 10.05.D will be final and binding upon Owner and Contractor, unless Owner or Contractor invoke the dispute resolution procedure set forth in Article 16 within 30 days of such action or denial.

F. No Claim for an adjustment in Contract Price or Contract Times will be valid if not submitted in accordance with this Paragraph 10.05.

ARTICLE 11 - COST OF THE WORK; ALLOWANCES; UNIT PRICE WORK

11.01 *Cost of the Work*

A. *Costs Included:* The term Cost of the Work means the sum of all costs, except those excluded in Paragraph 11.01.B, necessarily incurred and paid by Contractor in the proper performance of the Work. When the value of any Work covered by a Change Order or when a Claim for an adjustment in Contract Price is determined on the basis of Cost of the Work, the costs to be reimbursed to Contractor will be only those additional or incremental costs required because of the change in the Work or because of the event giving rise to the Claim. Except as otherwise may be agreed to in writing by Owner, such costs shall be in amounts no higher than those prevailing in the locality of the Project, shall include only the following items, and shall not include any of the costs itemized in Paragraph 11.01.B.

1. Payroll costs for employees in the direct employ of Contractor in the performance of the Work under schedules of job classifications agreed upon by Owner and Contractor. Such employees shall include, without limitation, superintendents, foremen, and other personnel employed full time at the Site. Payroll costs for employees not employed full time on the Work shall be apportioned on the basis of their time spent on the Work. Payroll costs shall include, but not be limited to, salaries and wages plus the cost of fringe benefits, which shall include social security contributions, unemployment, excise, and payroll taxes, workers' compensation, health and retirement benefits, bonuses, sick leave, vacation and holiday pay applicable thereto. The expenses of performing Work outside of regular working hours, on Saturday, Sunday, or legal holidays, shall be included in the above to the extent authorized by Owner.

2. Cost of all materials and equipment furnished and incorporated in the Work, including costs of transportation and storage thereof, and Suppliers' field services required in connection therewith. All cash discounts shall accrue to Contractor unless Owner deposits funds with Contractor with which to make payments, in which case the cash discounts shall accrue to Owner. All trade discounts, rebates and refunds and returns from sale of surplus materials and equipment shall accrue to Owner, and Contractor shall make provisions so that they may be obtained.

3. Payments made by Contractor to Subcontractors for Work performed by Subcontractors. If required by Owner, Contractor shall obtain competitive bids from subcontractors acceptable to Owner and Contractor and shall deliver such bids to Owner, who will then determine, with the advice of Engineer, which bids, if any, will be acceptable. If any subcontract provides that the Subcontractor is to be paid on the basis of Cost of the Work plus a fee, the Subcontractor's Cost of the Work and fee shall be determined in the same manner as Contractor's Cost of the Work and fee as provided in this Paragraph 11.01.

4. Costs of special consultants (including but not limited to Engineers, architects, testing laboratories, surveyors, attorneys, and accountants) employed for services specifically related to the Work.

5. Supplemental costs including the following:

a. The proportion of necessary transportation, travel, and subsistence expenses of Contractor's employees incurred in discharge of duties connected with the Work.

b. Cost, including transportation and maintenance, of all materials, supplies, equipment, machinery, appliances, office, and temporary facilities at the Site, and hand tools not owned by the workers, which are consumed in the performance of the Work, and cost, less market value,

of such items used but not consumed which remain the property of Contractor.

c. Rentals of all construction equipment and machinery, and the parts thereof whether rented from Contractor or others in accordance with rental agreements approved by Owner with the advice of Engineer, and the costs of transportation, loading, unloading, assembly, dismantling, and removal thereof. All such costs shall be in accordance with the terms of said rental agreements. The rental of any such equipment, machinery, or parts shall cease when the use thereof is no longer necessary for the Work.

d. Sales, consumer, use, and other similar taxes related to the Work, and for which Contractor is liable, imposed by Laws and Regulations.

e. Deposits lost for causes other than negligence of Contractor, any Subcontractor, or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable, and royalty payments and fees for permits and licenses.

f. Losses and damages (and related expenses) caused by damage to the Work, not compensated by insurance or otherwise, sustained by Contractor in connection with the performance of the Work (except losses and damages within the deductible amounts of property insurance established in accordance with Paragraph 5.06.D), provided such losses and damages have resulted from causes other than the negligence of Contractor, any Subcontractor, or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable. Such losses shall include settlements made with the written consent and approval of Owner. No such losses, damages, and expenses shall be included in the Cost of the Work for the purpose of determining Contractor's fee.

g. The cost of utilities, fuel, and sanitary facilities at the Site.

h. Minor expenses such as telegrams, long distance telephone calls, telephone service at the Site, expresses, and similar petty cash items in connection with the Work.

i. The costs of premiums for all bonds and insurance Contractor is required by the Contract Documents to purchase and maintain.

B. *Costs Excluded:* The term Cost of the Work shall not include any of the following items:

1. Payroll costs and other compensation of Contractor's officers, executives, principals (of partnerships and sole proprietorships), general managers, safety managers, engineers, architects, estimators, attorneys, auditors, accountants, purchasing and contracting agents, expediters, timekeepers, clerks, and other personnel employed by Contractor, whether at the Site or in Contractor's principal or branch office for general administration of the Work and not specifically included in the agreed upon schedule of job classifications referred to in Paragraph 11.01.A.1 or specifically covered by Paragraph 11.01.A.4, all of which are to be considered administrative costs covered by the Contractor's fee.

2. Expenses of Contractor's principal and branch offices other than Contractor's office at the Site.

3. Any part of Contractor's capital expenses, including interest on Contractor's capital employed for the Work and charges against Contractor for delinquent payments.

4. Costs due to the negligence of Contractor, any Subcontractor, or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable, including but not limited to, the correction of defective Work, disposal of materials or equipment wrongly supplied, and making good any damage to property.

5. Other overhead or general expense costs of any kind and the costs of any item not specifically and expressly included in Paragraphs 11.01.A and 11.01.B.

C. *Contractor's Fee:* When all the Work is performed on the basis of cost-plus, Contractor's fee shall be determined as set forth in the Agreement. When the value of any Work covered by a Change Order or when a Claim for an adjustment in Contract Price is determined on the basis of Cost of the Work, Contractor's fee shall be determined as set forth in Paragraph 12.01.C.

D. *Documentation:* Whenever the Cost of the Work for any purpose is to be determined pursuant to Paragraphs 11.01.A and 11.01.B, Contractor will establish and maintain records thereof in accordance with generally accepted accounting practices and submit in a form acceptable to Engineer an itemized cost breakdown together with supporting data.

11.02 *Allowances*

A. It is understood that Contractor has included in the Contract Price all allowances so named in the Contract Documents and shall cause the Work so covered to be performed for such sums and by such persons or entities as may be acceptable to Owner and Engineer.

B. *Cash Allowances*

1. Contractor agrees that:

a. the cash allowances include the cost to Contractor (less any applicable trade discounts) of materials and equipment required by the allowances to be delivered at the Site, and all applicable taxes; and

b. Contractor's costs for unloading and handling on the Site, labor, installation , overhead, profit, and other expenses contemplated for the cash allowances have been included in the Contract Price and not in the allowances, and no demand for additional payment on account of any of the foregoing will be valid.

C. Contingency Allowance

1. Contractor agrees that a contingency allowance, if any, is for the sole use of Owner to cover unanticipated costs.

D. Prior to final payment, an appropriate Change Order will be issued as recommended by Engineer to reflect actual amounts due Contractor on account of Work covered by allowances, and the Contract Price shall be correspondingly adjusted.

11.03 *Unit Price Work*

A. Where the Contract Documents provide that all or part of the Work is to be Unit Price Work, initially the Contract Price will be deemed to include for all Unit Price Work an amount equal to the sum of the unit price for each separately identified item of Unit Price Work times the estimated quantity of each item as indicated in the Agreement.

B. The estimated quantities of items of Unit Price Work are not guaranteed and are solely for the purpose of comparison of Bids and determining an initial Contract Price. Determinations of the actual quantities and classifications of Unit Price Work performed by Contractor will be made by Engineer subject to the provisions of Paragraph 9.07.

C. Each unit price will be deemed to include an amount considered by Contractor to be adequate to cover Contractor's overhead and profit for each separately identified item.

D. Owner or Contractor may make a Claim for an adjustment in the Contract Price in accordance with Paragraph 10.05 if:

1. the quantity of any item of Unit Price Work performed by Contractor differs materially and significantly from the estimated quantity of such item indicated in the Agreement; and

2. there is no corresponding adjustment with respect any other item of Work; and

3. Contractor believes that Contractor is entitled to an increase in Contract Price as a result of having incurred additional expense or Owner believes that Owner is entitled to a decrease in Contract Price and the parties are unable to agree as to the amount of any such increase or decrease.

ARTICLE 12 - CHANGE OF CONTRACT PRICE; CHANGE OF CONTRACT TIMES

12.01 *Change of Contract Price*

A. The Contract Price may only be changed by a Change Order. Any Claim for an adjustment in the Contract Price shall be based on written notice submitted by the party making the Claim to the Engineer and the other party to the Contract in accordance with the provisions of Paragraph 10.05.

B. The value of any Work covered by a Change Order or of any Claim for an adjustment in the Contract Price will be determined as follows:

1. where the Work involved is covered by unit prices contained in the Contract Documents, by application of such unit prices to the quantities of the items involved (subject to the provisions of Paragraph 11.03); or

2. where the Work involved is not covered by unit prices contained in the Contract Documents, by a mutually agreed lump sum (which may include an allowance for overhead and profit not necessarily in accordance with Paragraph 12.01.C.2); or

3. where the Work involved is not covered by unit prices contained in the Contract Documents and agreement to a lump sum is not reached under Paragraph 12.01.B.2, on the basis of the Cost of the Work (determined as provided in Paragraph 11.01) plus a Contractor's fee for overhead and profit (determined as provided in Paragraph 12.01.C).

C. *Contractor's Fee:* The Contractor's fee for overhead and profit shall be determined as follows:

1. a mutually acceptable fixed fee; or

2. if a fixed fee is not agreed upon, then a fee based on the following percentages of the various portions of the Cost of the Work:

a. for costs incurred under Paragraphs 11.01.A.1 and 11.01.A.2, the Contractor's fee shall be 15 percent;

b. for costs incurred under Paragraph 11.01.A.3, the Contractor's fee shall be five percent;

c. where one or more tiers of subcontracts are on the basis of Cost of the Work plus a fee and no fixed fee is agreed upon, the intent of Paragraph 12.01.C.2.a is that the Subcontractor who actually performs the Work, at whatever tier, will be paid a fee of 15 percent of the costs incurred by such Subcontractor under Paragraphs 11.01.A.1 and 11.01.A.2 and that any higher tier Subcontractor and Contractor will each be paid a fee of five percent of the amount paid to the next lower tier Subcontractor;

d. no fee shall be payable on the basis of costs itemized under Paragraphs 11.01.A.4, 11.01.A.5, and 11.01.B;

e. the amount of credit to be allowed by Contractor to Owner for any change which results in a net decrease in cost will be the amount of the actual net decrease in cost plus a deduction in Contractor's fee by an amount equal to five percent of such net decrease; and

f. when both additions and credits are involved in any one change, the adjustment in Contractor's fee shall be computed on the basis of the net change in accordance with Paragraphs 12.01.C.2.a through 12.01.C.2.e, inclusive.

12.02 *Change of Contract Times*

A. The Contract Times may only be changed by a Change Order. Any Claim for an adjustment in the Contract Times shall be based on written notice submitted by the party making the Claim to the Engineer and the other party to the Contract in accordance with the provisions of Paragraph 10.05.

B. Any adjustment of the Contract Times covered by a Change Order or any Claim for an adjustment in the Contract Times will be determined in accordance with the provisions of this Article 12.

12.03 *Delays*

A. Where Contractor is prevented from completing any part of the Work within the Contract Times due to delay beyond the control of Contractor, the Contract Times will be extended in an amount equal to the time lost due to such delay if a Claim is made therefor as provided in Paragraph 12.02.A. Delays beyond the control of Contractor shall include, but not be limited to, acts or neglect by Owner, acts or neglect of utility owners or other contractors performing other work as contemplated by Article 7, fires, floods, epidemics, abnormal weather conditions, or acts of God.

B. If Owner, Engineer, or other contractors or utility owners performing other work for Owner as contemplated by Article 7, or anyone for whom Owner is responsible, delays, disrupts, or interferes with the performance or progress of the Work, then Contractor shall be entitled to an equitable adjustment in the Contract Price or the Contract Times , or both. Contractor's entitlement to an adjustment of the Contract Times is conditioned on such adjustment being essential to Contractor's ability to complete the Work within the Contract Times.

C If Contractor is delayed in the performance or progress of the Work by fire, flood, epidemic, abnormal weather conditions, acts of God, acts or failures to act of utility owners not under the control of Owner, or other causes not the fault of and beyond control of Owner and Contractor, then Contractor shall be entitled to an equitable adjustment in Contract Times, if such adjustment is essential to Contractor's ability to complete the Work within the Contract Times. Such an adjustment shall be Contractor's sole and exclusive remedy for the delays described in this Paragraph 12.03.C.

D. Owner, Engineer and the Related Entities of each of them shall not be liable to Contractor for any claims, costs, losses, or damages (including but not limited to all fees and charges of Engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) sustained by Contractor on or in connection with any other project or anticipated project.

E. Contractor shall not be entitled to an adjustment in Contract Price or Contract Times for delays within the control of Contractor. Delays attributable to and within the control of a Subcontractor or Supplier shall be deemed to be delays within the control of Contractor.

ARTICLE 13 - TESTS AND INSPECTIONS; CORRECTION, REMOVAL OR ACCEPTANCE OF DEFECTIVE WORK

13.01 *Notice of Defects*

A. Prompt notice of all defective Work of which Owner or Engineer has actual knowledge will be given to Contractor. All defective Work may be rejected, corrected, or accepted as provided in this Article 13.

13.02 *Access to Work*

A. Owner, Engineer, their consultants and other representatives and personnel of Owner, independent testing laboratories, and governmental agencies with jurisdictional interests will have access to the Site and the Work at reasonable times for their observation, inspecting, and testing. Contractor shall provide them proper and safe conditions for such access and advise them of Contractor's Site safety procedures and programs so that they may comply therewith as applicable.

13.03 *Tests and Inspections*

A. Contractor shall give Engineer timely notice of readiness of the Work for all required inspections, tests, or approvals and shall cooperate with inspection and testing personnel to facilitate required inspections or tests.

B. Owner shall employ and pay for the services of an independent testing laboratory to perform all inspections, tests, or approvals required by the Contract Documents except:

1. for inspections, tests, or approvals covered by Paragraphs 13.03.C and 13.03.D below;

2. that costs incurred in connection with tests or inspections conducted pursuant to Paragraph 13.04.B shall be paid as provided in said Paragraph 13.04.C; and

3. as otherwise specifically provided in the Contract Documents.

C. If Laws or Regulations of any public body having jurisdiction require any Work (or part thereof) specifically to be inspected, tested, or approved by an employee or other representative of such public body, Contractor shall assume full responsibility for arranging and obtaining such inspections, tests, or approvals, pay all costs in connection therewith, and furnish Engineer the required certificates of inspection or approval.

D. Contractor shall be responsible for arranging and obtaining and shall pay all costs in connection with any inspections, tests, or approvals required for Owner's and Engineer's acceptance of materials or equipment to be incorporated in the Work; or acceptance of materials, mix designs, or equipment submitted for approval prior to Contractor's purchase thereof for incorporation in the Work. Such inspections, tests, or approvals shall be performed by organizations acceptable to Owner and Engineer.

E. If any Work (or the work of others) that is to be inspected, tested, or approved is covered by Contractor without written concurrence of Engineer, it must, if requested by Engineer, be uncovered for observation.

F. Uncovering Work as provided in Paragraph 13.03.E shall be at Contractor's expense unless Contractor has given Engineer timely notice of Contractor's intention to cover the same and Engineer has not acted with reasonable promptness in response to such notice.

13.04 *Uncovering Work*

A. If any Work is covered contrary to the written request of Engineer, it must, if requested by Engineer, be uncovered for Engineer's observation and replaced at Contractor's expense.

B. If Engineer considers it necessary or advisable that covered Work be observed by Engineer or inspected or tested by others, Contractor, at Engineer's request, shall uncover, expose, or otherwise make available for observation, inspection, or testing as Engineer may require, that portion of the Work in question, furnishing all necessary labor, material, and equipment.

C. If it is found that the uncovered Work is defective, Contractor shall pay all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such uncovering, exposure, observation, inspection, and testing, and of satisfactory replacement or reconstruction (including but not limited to all costs of repair or replacement of work of others); and Owner shall be entitled to an appropriate decrease in the Contract Price. If the parties are unable to agree as to the amount thereof, Owner may make a Claim therefor as provided in Paragraph 10.05.

D. If, the uncovered Work is not found to be defective, Contractor shall be allowed an increase in the Contract Price or an extension of the Contract Times, or both, directly attributable to such uncovering, exposure, observation, inspection, testing, replacement, and reconstruction. If the parties are unable to agree as to the amount or extent thereof, Contractor may make a Claim therefor as provided in Paragraph 10.05.

13.05 *Owner May Stop the Work*

A. If the Work is defective, or Contractor fails to supply sufficient skilled workers or suitable materials or equipment, or fails to perform the Work in such a way that the completed Work will conform to the Contract Documents, Owner may order Contractor to stop the Work, or any portion thereof, until the cause for such order has been eliminated; however, this right of Owner to stop the Work shall not give rise to any duty on the part of Owner to exercise this right for the benefit of Contractor, any Subcontractor, any Supplier, any other individual or entity, or any surety for, or employee or agent of any of them.

13.06 *Correction or Removal of Defective Work*

A. Promptly after receipt of notice, Contractor shall correct all defective Work, whether or not fabricated, installed, or completed, or, if the Work has been rejected by Engineer, remove it from the Project and replace it with Work that is not defective. Contractor shall pay all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such correction or removal (including but not limited to all costs of repair or replacement of work of others).

B. When correcting defective Work under the terms of this Paragraph 13.06 or Paragraph 13.07, Contractor shall take no action that would void or otherwise impair Owner's special warranty and guarantee, if any, on said Work.

13.07 *Correction Period*

A. If within one year after the date of Substantial Completion (or such longer period of time as may be prescribed by the terms of any applicable special guarantee required by the Contract Documents) or by any specific provision of the Contract Documents, any Work is found to be defective, or if the repair of any damages to the land or areas made available for Contractor's use by Owner or permitted by Laws and Regulations as contemplated in Paragraph 6.11.A is found to be defective, Contractor shall promptly, without cost to Owner and in accordance with Owner's written instructions:

1. repair such defective land or areas; or

2. correct such defective Work; or

3. if the defective Work has been rejected by Owner, remove it from the Project and replace it with Work that is not defective, and

4. satisfactorily correct or repair or remove and replace any damage to other Work, to the work of others or other land or areas resulting therefrom.

B. If Contractor does not promptly comply with the terms of Owner's written instructions, or in an emergency where delay would cause serious risk of loss or damage, Owner may have the defective Work corrected or repaired or may have the rejected Work removed and replaced. All claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such correction or repair or such removal and replacement (including but not limited to all costs of repair or replacement of work of others) will be paid by Contractor.

C. In special circumstances where a particular item of equipment is placed in continuous service before Substantial Completion of all the Work, the correction period for that item may start to run from an earlier date if so provided in the Specifications .

D. Where defective Work (and damage to other Work resulting therefrom) has been corrected or removed and replaced under this Paragraph 13.07, the correction period hereunder with respect to such Work will be extended for an additional period of one year after such correction or removal and replacement has been satisfactorily completed.

E. Contractor's obligations under this Paragraph 13.07 are in addition to any other obligation or warranty. The provisions of this Paragraph 13.07 shall not be construed as a substitute for or a waiver of the provisions of any applicable statute of limitation or repose.

13.08 *Acceptance of Defective Work*

A. If, instead of requiring correction or removal and replacement of defective Work, Owner (and, prior to Engineer's recommendation of final payment, Engineer) prefers to accept it, Owner may do so. Contractor shall pay all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) attributable to Owner's evaluation of and determination to accept such defective Work (such costs to be approved by Engineer as to reasonableness) and the diminished value of the Work to the extent not otherwise paid by Contractor pursuant to this sentence. If any such acceptance occurs prior to Engineer's recommendation of final payment, a Change Order will be issued incorporating the necessary revisions in the Contract Documents with respect to the Work, and Owner shall be entitled to an appropriate decrease in the Contract Price, reflecting the diminished value of Work so accepted. If the parties are unable to agree as to the amount thereof, Owner may make a Claim therefor as provided in Paragraph 10.05. If the acceptance occurs after such recommendation, an appropriate amount will be paid by Contractor to Owner.

13.09 *Owner May Correct Defective Work*

A. If Contractor fails within a reasonable time after written notice from Engineer to correct defective Work or to remove and replace rejected Work as required by Engineer in accordance with Paragraph 13.06.A, or if Contractor fails to perform the Work in accordance with the Contract Documents, or if Contractor fails to comply with any other provision of the Contract Documents, Owner may, after seven days written notice to Contractor, correct or remedy any such deficiency.

B. In exercising the rights and remedies under this Paragraph 13.09, Owner shall proceed expeditiously. In connection with such corrective or remedial action, Owner may exclude Contractor from all or part of the Site, take possession of all or part of the Work and suspend Contractor's services related thereto, take possession of Contractor's tools, appliances, construction equipment and machinery at the Site, and incorporate in the Work all materials and equipment stored at the Site or for which Owner has paid Contractor but which are stored elsewhere. Contractor shall allow Owner, Owner's representatives, agents and employees, Owner's other contractors, and Engineer and Engineer's consultants access to the Site to enable Owner to exercise the rights and remedies under this Paragraph.

C. All claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) incurred or sustained by Owner in exercising the rights and remedies under this Paragraph 13.09 will be charged against Contractor, and a Change Order will be issued incorporating the necessary revisions in the Contract Documents with respect to the Work; and Owner shall be entitled to an appropriate decrease in the Contract Price. If the parties are unable to agree as to the amount of the adjustment, Owner may make a Claim therefor as provided in Paragraph 10.05. Such claims, costs, losses and damages will include but not be limited to all costs of repair, or replacement of work of others destroyed or damaged by correction, removal, or replacement of Contractor's defective Work.

D. Contractor shall not be allowed an extension of the Contract Times because of any delay in the performance of the Work attributable to the exercise by Owner of Owner's rights and remedies under this Paragraph 13.09.

ARTICLE 14 - PAYMENTS TO CONTRACTOR AND COMPLETION

14.01 *Schedule of Values*

A. The Schedule of Values established as provided in Paragraph 2.07.A will serve as the basis for progress payments and will be incorporated into a form of Application for Payment acceptable to Engineer. Progress payments on account of Unit Price Work will be based on the number of units completed.

14.02 *Progress Payments*

A. Applications for Payments

1. At least 20 days before the date established in the Agreement for each progress payment (but not more often than once a month), Contractor shall submit to Engineer for review an Application for Payment filled out and signed by Contractor covering the Work completed as of the date of the Application and accompanied by such supporting documentation as is required by the Contract Documents. If payment is requested on the basis of materials and equipment not incorporated in the Work but delivered and suitably stored at the Site or at another location agreed to in writing, the Application for Payment shall also be accompanied by a bill of sale, invoice, or other documentation warranting that Owner has received the materials and equipment free and clear of all Liens and evidence that the materials and equipment are covered by appropriate property insurance or other arrangements to protect Owner's interest therein, all of which must be satisfactory to Owner.

2. Beginning with the second Application for Payment, each Application shall include an affidavit of Contractor stating that all previous progress payments received on account of the Work have been applied on account to discharge Contractor's legitimate obligations associated with prior Applications for Payment.

3. The amount of retainage with respect to progress payments will be as stipulated in the Agreement.

B. *Review of Applications*

1. Engineer will, within 10 days after receipt of each Application for Payment, either indicate in writing a recommendation of payment and present the Application to Owner or return the Application to Contractor indicating in writing Engineer's reasons for refusing to recommend payment. In the latter case, Contractor may make the necessary corrections and resubmit the Application.

2. Engineer's recommendation of any payment requested in an Application for Payment will constitute a representation by Engineer to Owner, based on Engineer's observations on the Site of the executed Work as an experienced and qualified design professional and on Engineer's review of the Application for Payment and the accompanying data and schedules, that to the best of Engineer's knowledge, information and belief:

a. the Work has progressed to the point indicated;

b. the quality of the Work is generally in accordance with the Contract Documents (subject to an evaluation of the Work as a functioning whole prior to or upon Substantial Completion, to the results of any subsequent tests called for in the Contract Documents, to a final determination of quantities and classifications for Unit Price Work under Paragraph 9.07, and to any other qualifications stated in the recommendation); and

c. the conditions precedent to Contractor's being entitled to such payment appear to have been fulfilled in so far as it is Engineer's responsibility to observe the Work.

3. By recommending any such payment Engineer will not thereby be deemed to have represented that:

a. inspections made to check the quality or the quantity of the Work as it has been performed have been exhaustive, extended to every aspect of the Work in progress, or involved detailed inspections of the Work beyond the responsibilities specifically assigned to Engineer in the Contract Documents; or

b. that there may not be other matters or issues between the parties that might entitle Contractor

to be paid additionally by Owner or entitle Owner to withhold payment to Contractor.

4. Neither Engineer's review of Contractor's Work for the purposes of recommending payments nor Engineer's recommendation of any payment, including final payment, will impose responsibility on Engineer:

a. to supervise, direct, or control the Work, or

b. for the means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or

c. for Contractor's failure to comply with Laws and Regulations applicable to Contractor's performance of the Work, or

d. to make any examination to ascertain how or for what purposes Contractor has used the moneys paid on account of the Contract Price, or

e. to determine that title to any of the Work, materials, or equipment has passed to Owner free and clear of any Liens.

5. Engineer may refuse to recommend the whole or any part of any payment if, in Engineer's opinion, it would be incorrect to make the representations to Owner stated in Paragraph 14.02.B.2. Engineer may also refuse to recommend any such payment or, because of subsequently discovered evidence or the results of subsequent inspections or tests, revise or revoke any such payment recommendation previously made, to such extent as may be necessary in Engineer's opinion to protect Owner from loss because:

a. the Work is defective, or completed Work has been damaged, requiring correction or replacement;

b. the Contract Price has been reduced by Change Orders;

c. Owner has been required to correct defective Work or complete Work in accordance with Paragraph 13.09; or

d. Engineer has actual knowledge of the occurrence of any of the events enumerated in Paragraph 15.02.A.

C. *Payment Becomes Due*

1. Ten days after presentation of the Application for Payment to Owner with Engineer's recommendation, the amount recommended will (subject to the provisions of Paragraph 14.02.D) become due, and when due will be paid by Owner to Contractor.

D. *Reduction in Payment*

1. Owner may refuse to make payment of the full amount recommended by Engineer because:

a. claims have been made against Owner on account of Contractor's performance or furnishing of the Work;

b. Liens have been filed in connection with the Work, except where Contractor has delivered a specific bond satisfactory to Owner to secure the satisfaction and discharge of such Liens;

c. there are other items entitling Owner to a set-off against the amount recommended; or

d. Owner has actual knowledge of the occurrence of any of the events enumerated in Paragraphs 14.02.B.5.a through 14.02.B.5.c or Paragraph 15.02.A.

2. If Owner refuses to make payment of the full amount recommended by Engineer, Owner will give Contractor immediate written notice (with a copy to Engineer) stating the reasons for such action and promptly pay Contractor any amount remaining after deduction of the amount so withheld. Owner shall promptly pay Contractor the amount so withheld, or any adjustment thereto agreed to by Owner and Contractor, when Contractor corrects to Owner's satisfaction the reasons for such action.

3. If it is subsequently determined that Owner's refusal of payment was not justified, the amount wrongfully withheld shall be treated as an amount due as determined by Paragraph 14.02.C.1.

14.03 *Contractor's Warranty of Title*

A. Contractor warrants and guarantees that title to all Work, materials, and equipment covered by any Application for Payment, whether incorporated in the Project or not, will pass to Owner no later than the time of payment free and clear of all Liens.

14.04 *Substantial Completion*

A. When Contractor considers the entire Work ready for its intended use Contractor shall notify Owner and Engineer in writing that the entire Work is substantially complete (except for items specifically listed by Contractor as incomplete) and request that Engineer issue a certificate of Substantial Completion.

B. Promptly after Contractor's notification, , Owner, Contractor, and Engineer shall make an inspection of the Work to determine the status of completion. If Engineer does not consider the Work substantially complete, Engineer will notify Contractor in writing giving the reasons therefor.

C. If Engineer considers the Work substantially complete, Engineer will deliver to Owner a tentative certificate of Substantial Completion which shall fix the date of Substantial Completion. There shall be attached to the certificate a tentative list of items to be completed or corrected before final payment. Owner shall have seven days after receipt of the tentative certificate during which to make written objection to Engineer as to any provisions of the certificate or attached list. If, after considering such objections, Engineer concludes that the Work is not substantially complete, Engineer will within 14 days after submission of the tentative certificate to Owner notify Contractor in writing, stating the reasons therefor. If, after consideration of Owner's objections, Engineer considers the Work substantially complete, Engineer will within said 14 days execute and deliver to Owner and Contractor a definitive certificate of Substantial Completion (with a revised tentative list of items to be completed or corrected) reflecting such changes from the tentative certificate as Engineer believes justified after consideration of any objections from Owner.

D. At the time of delivery of the tentative certificate of Substantial Completion, Engineer will deliver to Owner and Contractor a written recommendation as to division of responsibilities pending final payment between Owner and Contractor with respect to security, operation, safety, and protection of the Work, maintenance, heat, utilities, insurance, and warranties and guarantees. Unless Owner and Contractor agree otherwise in writing and so inform Engineer in writing prior to Engineer's issuing the definitive certificate of Substantial Completion, Engineer's aforesaid recommendation will be binding on Owner and Contractor until final payment.

E. Owner shall have the right to exclude Contractor from the Site after the date of Substantial Completion subject to allowing Contractor reasonable access to complete or correct items on the tentative list.

14.05 *Partial Utilization*

A. Prior to Substantial Completion of all the Work, Owner may use or occupy any substantially completed part of the Work which has specifically been identified in the Contract Documents, or which Owner, Engineer, and Contractor agree constitutes a separately functioning and usable part of the Work that can be used by Owner for its intended purpose without significant interference with Contractor's performance of the remainder of the Work, subject to the following conditions.

1. Owner at any time may request Contractor in writing to permit Owner to use or occupy any such part of the Work which Owner believes to be ready for its intended use and substantially complete. If and when Contractor agrees that such part of the Work is substantially complete, Contractor will certify to Owner and Engineer that such part of the Work is substantially complete and request Engineer to issue a certificate of Substantial Completion for that part of the Work.

2. Contractor at any time may notify Owner and Engineer in writing that Contractor considers any such part of the Work ready for its intended use and substantially complete and request Engineer to issue a certificate of Substantial Completion for that part of the Work.

3. Within a reasonable time after either such request, Owner, Contractor, and Engineer shall make an inspection of that part of the Work to determine its status of completion. If Engineer does not consider that part of the Work to be substantially complete, Engineer will notify Owner and Contractor in writing giving the reasons therefor. If Engineer considers that part of the Work to be substantially complete, the provisions of Paragraph 14.04 will apply with respect to certification of Substantial Completion of that part of the Work and the division of responsibility in respect thereof and access thereto.

4. No use or occupancy or separate operation of part of the Work may occur prior to compliance with the requirements of Paragraph 5.10 regarding property insurance.

14.06 *Final Inspection*

A. Upon written notice from Contractor that the entire Work or an agreed portion thereof is complete, Engineer will promptly make a final inspection with Owner and Contractor and will notify Contractor in writing of all particulars in which this inspection reveals that the Work is incomplete or defective. Contractor shall immediately take such measures as are necessary to complete such Work or remedy such deficiencies.

14.07 *Final Payment*

A. Application for Payment

1. After Contractor has, in the opinion of Engineer, satisfactorily completed all corrections identified during the final inspection and has delivered, in accordance with the Contract Documents, all maintenance and operating instructions, schedules, guarantees, bonds, certificates or other evidence of insurance certificates of inspection, marked-up record documents (as provided in Paragraph 6.12), and other documents, Contractor may make application for final payment following the procedure for progress payments.

2. The final Application for Payment shall be accompanied (except as previously delivered) by:

a. all documentation called for in the Contract Documents, including but not limited to the evidence of insurance required by Paragraph 5.04.B.7;

b. consent of the surety, if any, to final payment;

c. a list of all Claims against Owner that Contractor believes are unsettled; and

d. complete and legally effective releases or waivers (satisfactory to Owner) of all Lien rights arising out of or Liens filed in connection with the Work.

3. In lieu of the releases or waivers of Liens specified in Paragraph 14.07.A.2 and as approved by Owner, Contractor may furnish receipts or releases in full and an affidavit of Contractor that: (i) the releases and receipts include all labor, services, material, and equipment for which a Lien could be filed; and (ii) all payrolls, material and equipment bills, and other indebtedness connected with the Work for which Owner or Owner's property might in any way be responsible have been paid or otherwise satisfied. If any Subcontractor or Supplier fails to furnish such a release or receipt in full, Contractor may furnish a bond or other collateral satisfactory to Owner to indemnify Owner against any Lien.

B. *Engineer's Review of Application and Acceptance*

1. If, on the basis of Engineer's observation of the Work during construction and final inspection, and Engineer's review of the final Application for Payment and accompanying documentation as required by the Contract Documents, Engineer is satisfied that the Work has been completed and Contractor's other obligations under the Contract Documents have been fulfilled, Engineer will, within ten days after receipt of the final Application for Payment, indicate in writing Engineer's recommendation of payment and present the Application for Payment to Owner for payment. At the same time Engineer will also give written notice to Owner and Contractor that the Work is acceptable subject to the provisions of Paragraph 14.09. Otherwise, Engineer will return the Application for Payment to Contractor, indicating in writing the reasons for refusing to recommend final payment, in which case Contractor shall make the necessary corrections and resubmit the Application for Payment.

C. Payment Becomes Due

1. Thirty days after the presentation to Owner of the Application for Payment and accompanying documentation, the amount recommended by Engineer, less any sum Owner is entitled to set off against Engineer's recommendation, including but not limited to liquidated damages, will become due and , will be paid by Owner to Contractor.

14.08 *Final Completion Delayed*

A. If, through no fault of Contractor, final completion of the Work is significantly delayed, and if Engineer so confirms, Owner shall, upon receipt of Contractor's final Application for Payment (for Work fully completed and accepted) and recommendation of Engineer, and without terminating the Contract, make payment of the balance due for that portion of the Work fully completed and accepted. If the remaining balance to be held by Owner for Work not fully completed or corrected is less than the retainage stipulated in the Agreement, and if bonds have been furnished as required in Paragraph 5.01, the written consent of the surety to the payment of the balance due for that portion of the Work fully completed and accepted shall be submitted by Contractor to Engineer with the Application for such payment. Such payment shall be made under the terms and conditions governing final payment, except that it shall not constitute a waiver of Claims.

14.09 *Waiver of Claims*

A. The making and acceptance of final payment will constitute:

1. a waiver of all Claims by Owner against Contractor, except Claims arising from unsettled Liens, from defective Work appearing after final inspection pursuant to Paragraph 14.06, from failure to comply with the Contract Documents or the terms of any special guarantees specified therein, or from Contractor's continuing obligations under the Contract Documents; and

2. a waiver of all Claims by Contractor against Owner other than those previously made in accordance with the requirements herein and expressly acknowledged by Owner in writing as still unsettled.

ARTICLE 15 - SUSPENSION OF WORK AND TERMINATION

15.01 *Owner May Suspend Work*

A. At any time and without cause, Owner may suspend the Work or any portion thereof for a period of not more than 90 consecutive days by notice in writing to Contractor and Engineer which will fix the date on which Work will be resumed. Contractor shall resume the Work on the date so fixed. Contractor shall be granted an adjustment in the Contract Price or an extension of the Contract Times, or both, directly attributable to any such suspension if Contractor makes a Claim therefor as provided in Paragraph 10.05.

15.02 *Owner May Terminate for Cause*

A. The occurrence of any one or more of the following events will justify termination for cause:

1. Contractor's persistent failure to perform the Work in accordance with the Contract Documents

(including, but not limited to, failure to supply sufficient skilled workers or suitable materials or equipment or failure to adhere to the Progress Schedule established under Paragraph 2.07 as adjusted from time to time pursuant to Paragraph 6.04);

2. Contractor's disregard of Laws or Regulations of any public body having jurisdiction;

3. Contractor's disregard of the authority of Engineer; or

4. Contractor's violation in any substantial way of any provisions of the Contract Documents.

B. If one or more of the events identified in Paragraph 15.02.A occur, Owner may, after giving Contractor (and surety) seven days written notice of its intent to terminate the services of Contractor:

1. exclude Contractor from the Site, and take possession of the Work and of all Contractor's tools, appliances, construction equipment, and machinery at the Site, and use the same to the full extent they could be used by Contractor (without liability to Contractor for trespass or conversion),

2. incorporate in the Work all materials and equipment stored at the Site or for which Owner has paid Contractor but which are stored elsewhere, and

3. complete the Work as Owner may deem expedient.

C. If Owner proceeds as provided in Paragraph 15.02.B, Contractor shall not be entitled to receive any further payment until the Work is completed. If the unpaid balance of the Contract Price exceeds all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) sustained by Owner arising out of or relating to completing the Work, such excess will be paid to Contractor. If such claims, costs, losses, and damages exceed such unpaid balance, Contractor shall pay the difference to Owner. Such claims, costs, losses, and damages incurred by Owner will be reviewed by Engineer as to their reasonableness and, when so approved by Engineer, incorporated in a Change Order. When exercising any rights or remedies under this Paragraph Owner shall not be required to obtain the lowest price for the Work performed.

D. Notwithstanding Paragraphs 15.02.B and 15.02.C, Contractor's services will not be terminated if Contractor begins within seven days of receipt of notice of intent to terminate to correct its failure to perform and proceeds diligently to cure such failure within no more than 30 days of receipt of said notice.

E. Where Contractor's services have been so terminated by Owner, the termination will not affect any rights or remedies of Owner against Contractor then existing or which may thereafter accrue. Any retention or payment of moneys due Contractor by Owner will not release Contractor from liability.

F. If and to the extent that Contractor has provided a performance bond under the provisions of Paragraph 5.01.A, the termination procedures of that bond shall supersede the provisions of Paragraphs 15.02.B, and 15.02.C.

15.03 *Owner May Terminate For Convenience*

A. Upon seven days written notice to Contractor and Engineer, Owner may, without cause and without prejudice to any other right or remedy of Owner, terminate the Contract. In such case, Contractor shall be paid for (without duplication of any items):

1. completed and acceptable Work executed in accordance with the Contract Documents prior to the effective date of termination, including fair and reasonable sums for overhead and profit on such Work;

2. expenses sustained prior to the effective date of termination in performing services and furnishing labor, materials, or equipment as required by the Contract Documents in connection with uncompleted Work, plus fair and reasonable sums for overhead and profit on such expenses;

3. all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) incurred in settlement of terminated contracts with Subcontractors, Suppliers, and others; and

4. reasonable expenses directly attributable to termination.

B. Contractor shall not be paid on account of loss of anticipated profits or revenue or other economic loss arising out of or resulting from such termination.

15.04 *Contractor May Stop Work or Terminate*

A. If, through no act or fault of Contractor, (i) the Work is suspended for more than 90 consecutive days by Owner or under an order of court or other public authority, or (ii) Engineer fails to act on any Application for Payment within 30 days after it is submitted, or (iii) Owner fails for 30 days to pay Contractor any sum finally determined to be due, then Contractor may, upon seven days written notice to Owner and Engineer, and provided Owner or Engineer do not remedy such suspension or failure within that time, terminate the Contract and recover from Owner payment on the same terms as provided in Paragraph 15.03.

B. In lieu of terminating the Contract and without prejudice to any other right or remedy, if Engineer has failed to act on an Application for Payment within 30 days after it is submitted, or Owner has failed for 30 days to pay Contractor any sum finally determined to be due, Contractor may, seven days after written notice to Owner and Engineer, stop the Work until payment is made of all such amounts due Contractor, including interest thereon. The provisions of this Paragraph 15.04 are not intended to preclude Contractor from making a Claim under Paragraph 10.05 for an adjustment in Contract Price or Contract Times or otherwise for expenses or damage directly attributable to Contractor's stopping the Work as permitted by this Paragraph.

ARTICLE 16 - DISPUTE RESOLUTION

16.01 *Methods and Procedures*

A. Either Owner or Contractor may request mediation of any Claim submitted to Engineer for a decision under Paragraph 10.05 before such decision becomes final and binding. The mediation will be governed by the Construction Industry Mediation Rules of the American Arbitration Association in effect as of the Effective Date of the Agreement. The request for mediation shall be submitted in writing to the American Arbitration Association and the other party to the Contract. Timely submission of the request shall stay the effect of Paragraph 10.05.E.

B. Owner and Contractor shall participate in the mediation process in good faith. The process shall be concluded within 60 days of filing of the request. The date of termination of the mediation shall be determined by application of the mediation rules referenced above.

C. If the Claim is not resolved by mediation, Engineer's action under Paragraph 10.05.C or a denial pursuant to Paragraphs 10.05.C.3 or 10.05.D shall become final and binding 30 days after termination of the mediation unless, within that time period, Owner or Contractor:

1. elects in writing to invoke any dispute resolution process provided for in the Supplementary Conditions, or

2. agrees with the other party to submit the Claim to another dispute resolution process, or

3. gives written notice to the other party of their intent to submit the Claim to a court of competent jurisdiction.

ARTICLE 17 - MISCELLANEOUS

17.01 *Giving Notice*

A. Whenever any provision of the Contract Documents requires the giving of written notice, it will be deemed to have been validly given if:

1. delivered in person to the individual or to a member of the firm or to an officer of the corporation for whom it is intended, or

2. delivered at or sent by registered or certified mail, postage prepaid, to the last business address known to the giver of the notice.

17.02 *Computation of Times*

A. When any period of time is referred to in the Contract Documents by days, it will be computed to exclude the first and include the last day of such period. If the last day of any such period falls on a Saturday or Sunday or on a day made a legal holiday by the law of the applicable jurisdiction, such day will be omitted from the computation.

17.03 *Cumulative Remedies*

A. The duties and obligations imposed by these General Conditions and the rights and remedies available hereunder to the parties hereto are in addition to, and are not to be construed in any way as a limitation of, any rights and remedies available to any or all of them which are otherwise imposed or available by Laws or Regulations, by special warranty or guarantee, or by other provisions of the Contract Documents. The provisions of this Paragraph will be as effective as if repeated specifically in the Contract Documents in connection with each particular duty, obligation, right, and remedy to which they apply.

17.04 *Survival of Obligations*

A. All representations, indemnifications, warranties, and guarantees made in, required by, or given in accordance with the Contract Documents, as well as all continuing obligations indicated in the Contract Documents, will survive final payment, completion, and acceptance of the Work or termination or completion of the Contract or termination of the services of Contractor.

17.05 *Controlling Law*

A. This Contract is to be governed by the law of the state in which the Project is located.

17.06 *Headings*

A. Article and paragraph headings are inserted for convenience only and do not constitute parts of these General Conditions.

SECTION 01 1100
SUMMARY OF WORK

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Scope of work

B. Contractor use of site and premises

C. Work sequence

D. Owner occupancy and utilization

1.2 CONTRACTOR USE OF SITE AND PREMISES

A. Limit use of site and premises to allow:

1. Owner occupancy.

2. Use of premises by Owner to conduct normal activities.

B. Tie-ins to existing systems must be done in a manner so as to minimize interference with Owner's operations (i.e., during premium time).

1. Use of site and premises by public.

1.3 WORK SEQUENCE

A. Install work in phases to accommodate Owner’s occupancy requirements during the construction period. Coordinate mechanical or electrical schedule and operations with Owner/Engineer:

1. Phase 1: First AHU Replacement

2. Phase 2: Second AHU Replacement

1.4 OWNER OCCUPANCY AND UTILIZATION

A. Owner will occupy the premises during entire period of construction.

B. Cooperate with Owner to minimize conflict and to facilitate Owner’s operations.

C. Schedule the work to accommodate this requirement.

PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

Not Applicable

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 01\01 1100-Summary of Work.docx

SECTION 01 3101
MECHANICAL AND ELECTRICAL COORDINATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Mechanical and electrical coordination

B. Submittals

C. Coordination required

D. Coordination documents

E. Coordination of submittals

F. Coordination of substitutions and modifications

G. Observation of work

H. Documentation

I. Equipment start up

J. Inspection and acceptance of equipment

1.2 MECHANICAL AND ELECTRICAL WORK COORDINATION

A. Provide coordination for the type of mechanical and electrical work required for this Project for the duration of the Work.

1.3 SUBMITTALS

A. Submit any coordination documents prior to submitting shop drawings, product data and samples.

1.4 COORDINATION REQUIRED

A. Coordinate mechanical and electrical work of Divisions 20, 21, 22, 23, 26, 27, and 28 with work of each other and of other Divisions.

B. Coordinate progress schedules, including dates for submittals and for delivery of products.

C. Conduct conferences among Subcontractors and others concerned with the Work to establish and maintain coordination and schedules and to resolve coordination matters in dispute.

D. Confer with other Contractors regarding location and size of pipes, equipment, fixtures, conduit, ducts, openings, switches, outlets, fire sprinkler heads, fire hose cabinets, etc., in progress of the work of any Contractor project. Architectural drawings shall take precedence over mechanical and electrical drawings.

E. Where work connects to that of another trade or to piping or equipment in place, make measurements in field to make connection work come true and line up with item being connected.

F. Where work specified under other Divisions of Specifications connects to equipment which is part of Divisions 20, 21, 22, 23, 26, 27, or 28, provide proper connection(s) to such equipment.

G. Participate in progress meetings. Report on progress of Work to be adjusted under coordination requirements and any required changes in schedules. Transmit minutes of meetings and reports to concerned parties.

1.5 COORDINATION DOCUMENTS

A. Prepare coordination drawings to organize installation of Products for efficient use of available space, for proper sequence of installation and to identify potential conflicts.

B. Prepare a master schedule to identify responsibilities under each section of Divisions 20, 21, 22, 23, 26, 27, and 28 of the Specifications for activities which directly relate to this work, including submittals and temporary services. Identify electrical power characteristics and control wiring required for each item of equipment.

C. Maintain documents for the duration of the Work, recording changes due to site instructions, modifications or adjustments.

D. After Engineer review original and revised documents, reproduce and distribute copies to concerned parties.

1.6 COORDINATION OF SUBMITTALS

A. Review shop drawings, product data and samples for compliance with Contract Documents and for coordination among work of all sections of the Project Manual. Transmit to Contractor for review, then transmit to Engineer.

B. Check field dimensions and clearances and relationship to available space and anchors.

C. Check compatibility with equipment and Work of other sections, electrical characteristics and operational control requirements.

D. Check motor voltages and control characteristics.

E. Coordinate controls, interlocks, wiring of pneumatic switches and relays.

F. Coordinate wiring and control diagrams.

G. Review the effect of any changes on work of other sections.

H. Verify and coordinate maintenance of Record Documents.

1.7 COORDINATION OF SUBSTITUTIONS AND MODIFICATIONS

A. Review proposals and requests from subcontractors.

B. Verify compliance with Contract Documents and for compatibility with Work and Products of other sections.

C. Submit to Engineer with recommendation for action.

1.8 OBSERVATION OF WORK

A. Observe work for compliance with Contract Documents.

B. Maintain a list of observed deficiencies and defects; promptly submit to Engineer.

1.9 DOCUMENTATION

A. Observe and maintain a record of tests. Record:

1. Specification section number, product and name of Subcontractor.
2. Name of testing agency and name of inspector.
3. Name of manufacturer's representative present.

4. Date, time and duration of tests.
5. Type of test and results.
6. Retesting required.

B. Assemble background documentation for dispute and claim settlement by Engineer.

C. Submit copies of documentation to Engineer upon request.

1.10 EQUIPMENT START UP

A. Verify utilities, connections and controls are complete and equipment is in operable condition as required by Division 01 Section 01 3103, “Starting of Systems.”

B. Observe start-up and adjustments; record time and date of start up and results.

C. Observe equipment demonstrations to Owner; record times and additional information required for Operation and Maintenance Manuals.

1.11 INSPECTION AND ACCEPTANCE OF EQUIPMENT

A. Prior to inspection, verify that equipment is tested and operational and clean.

B. Assist Engineer with inspection. Prepare list of items to be completed and corrected.

PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

Not Applicable

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 01\01 3101-Mechanical & Electrical Coordination.docx

SECTION 01 3102
ALTERATION PROJECT PROCEDURES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Demolition, alterations, cutting and protection

B. Products and installation for patching and extending Work

C. Transition and adjustments

D. Repair of damaged surfaces, finishes and cleaning

1.2 SEQUENCE AND SCHEDULES

A. Schedule work in sequences and within times specified in Division 01 Section 01 0000, “Summary of Work.”

B. Submit separate detailed sub-schedule for alterations work, coordinated with Master Construction Schedule. Show:

1. Each stage of work; occupancy dates of areas
2. Date of Substantial Completion for each area of alteration work
3. Crafts and subcontractors employed in each stage

C. Schedule noisy or hazardous work to avoid problems with Owner’s operations.

1.3 DEMOLITION, ALTERATIONS, CUTTING AND PROTECTION

A. Assign demolition, moving, removal, cutting and patching work to crafts qualified to perform work in manner to cause least damage to each type of work and provide means of restoring surfaces to appearance of new work.

B. Perform cutting and removal work to remove minimum necessary and in manner to avoid damage to adjacent work.

1. Cut finish surfaces such as masonry, tile, plaster or metals by methods to terminate surfaces in straight line at natural point of division.

C. Perform cutting and patching as specified in Division 01 Section 01 7329, “Cutting and Patching.”

D. Protect existing finishes, equipment and adjacent work which are scheduled to remain from damage.

1. Protect existing and new work from weather and temperature extremes.
    a. Maintain existing interior work above 60°F.
    b. Provide weather protection, waterproofing, heat and humidity control to prevent damage to remaining existing work and to new work.

E. Provide temporary enclosures to separate work areas from existing building and from areas occupied by Owner and to provide weather protection.

PART 2 - PRODUCTS

2.1 SALVAGED MATERIALS

A. Salvage sufficient quantities of cut or removed materials to replace damaged work of existing construction, when material is not readily obtainable on current market.

B. Store salvaged items in a dry, secure place on site.

C. Items not specified for use in repair work remain property of Owner.

D. Do not use salvaged or used material in new construction except with prior written authorization from Engineer.

2.2 PRODUCTS FOR PATCHING AND EXTENDING WORK

A. Ensure that work is complete.

B. Provide same materials or types of construction as that in existing structure, to patch, extend or match existing work.

1. Contract Documents may not define products or standards of workmanship present in existing construction.

2. Determine products by inspection and testing.

3. Determine workmanship by use of existing as sample of comparison.

C. Presence of a product, finish or type of construction requires that patching, extending or matching be performed to make work complete and consistent to identical quality standards.

PART 3 - EXECUTION

3.1 EXAMINATION (PRE-DEMOLITION)

A. Verify if all hazardous waste materials (asbestos, PCB/transformers, etc.) have been removed from work area. If this is not verified, notify Owner/Engineer in writing.

B. Demolition drawings are based on casual field observation and existing record documents. Review site conditions and report discrepancies to Owner/Engineer before disturbing existing installation.

C. Beginning of demolition work means acceptance of existing conditions.

3.2 PERFORMANCE

A. Patch and extend existing work using skilled craftsmen capable of matching existing quality of workmanship. For patched or extended work, provide quality equal to that specified for new work.

3.3 PREPARATION

A. Cut, move, or remove items as necessary for access to alterations and renovation Work. Replace and restore at completion.

B. Remove unsuitable material not marked for salvage, such as rotted wood, corroded metals and deteriorated masonry and concrete. Replace materials as specified for finished Work.

C. If, during course of project, hazardous materials are in any way suspected, including but not limited to asbestos, pollutants, or PCB, inform Owner immediately and suspend action on that portion of work.

D. Remove or repair dangerous or unsanitary conditions.

E. Remove debris and abandoned items from area and from concealed spaces.

F. Remove abandoned piping, conduit and wiring.

G. Prepare surface and remove surface finishes to provide for proper installation of new work and finishes.

H. Close openings in exterior surfaces to protect existing work and salvage items from weather and extremes of temperature and humidity. Insulate ductwork and piping to prevent condensation in exposed areas.

3.4 EXAMINATION (PRE-INSTALLATION)

A. Verify that demolition is complete and areas are ready for installation of new Work.

B. Beginning of restoration Work means acceptance of existing conditions.

3.5 INSTALLATION

A. Coordinate work of alterations and renovations to expedite completion sequentially and to accommodate Owner occupancy.

B. Project: Complete in all respects including operational mechanical and electrical work.

C. Remove, cut and patch work in a manner to minimize damage and to provide a means of restoring Products and finishes to original condition.

D. Refinish visible existing surfaces to remain in renovated rooms and spaces, to specified condition for each material, with a neat transition to adjacent finishes.

E. In addition to specified replacement of equipment restore existing heating, ventilation, air conditioning, and electrical systems to full operational condition.

F. Install products as specified in individual Sections of Divisions 20, 21, 22, 23, 26, 27, and 28.

3.6 TRANSITIONS

A. Where new work abuts or aligns with existing, perform a smooth and even transition. Patched Work to match existing adjacent work in texture and appearance.

B. When finished surfaces are cut so that a smooth transition with new work is not possible, terminate existing surface along a straight line at a natural line of division and make recommendation to Engineer.

3.7 ADJUSTMENTS

A. Where removal of partitions or walls results in adjacent spaces becoming one, rework floors, walls and ceilings to a smooth plane without breaks, steps, or bulkheads.

B. Where a change of plane of ¼”or more occurs, submit recommendation for providing a smooth transition for Engineer review.

C. Fit work at penetrations of surfaces as specified in Division 01 Section 01 7329, “Cutting and Patching.”

3.8 REPAIR OF DAMAGED SURFACES

A. Patch or replace portions of existing surfaces which are damaged, lifted, discolored, or showing other imperfections. This includes pipe covering, equipment and duct insulation.

B. Repair substrate prior to patching finish.

3.9 FINISHES

A. Finish patches to product uniform finish and texture over entire area. When finish cannot be matched, refinish entire surface to nearest intersections.

3.10 CLEANING

A. Perform construction cleaning as specified in Division 01 Section 01 7700, “Project Closeout.”

1. Clean Owner-occupied areas daily.

2. Clean all spillage, overspray and heavy dust collections in Owner-occupied areas immediately.

B. At completion of work of each craft, clean area and make surfaces ready for work of successive crafts.

C. At completion of alterations work in each area, provide final cleaning in accord with Section 01700 and return space to a condition suitable for use of Owner.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 01\01 3102-Alteration Project Procedures.docx

SECTION 01 3103
STARTING OF SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Starting systems

B. Demonstration and instructions

C. Testing, adjusting, and balancing

1.2 STARTING SYSTEMS

A. Coordinate schedule for start up of various equipment and systems.

B. Notify Engineer/Owner seven calendar days prior to start up of each item.

C. Verify that each piece of equipment or system has been checked for proper lubrication, drive rotation, belt tension, control sequence, or other conditions which may cause damage.

D. Verify that tests, meter readings and specified electrical characteristics agree with those required by the equipment or system manufacturer.

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

F. Verify utilities, connections and controls are complete and equipment is in operable condition.

G. Observe start-up and adjustments: Record time and date of start-up and results.

H. Observe equipment demonstrations to Owner: Record times and additional information required for Operation and Maintenance Manuals.

I. Execute start up under supervision of responsible manufacturer's representative in accordance with manufacturers' instructions.

J. 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.

K. Submit a written report in accordance with Division 01 Section 01 4000, “Quality Control Services,” that equipment or system has been properly installed and is functioning correctly.

1.3 DEMONSTRATION AND INSTRUCTIONS

A. Demonstrate operation and maintenance of Products to Owner's personnel two weeks prior to date of final inspection.

B. Demonstration and instructions shall be provided by a qualified manufacturers' representative who is knowledgeable about the Project.

C. For equipment or systems requiring seasonal operation, perform demonstration for other season within six months.

D. Utilize operation and maintenance manuals as basis for instruction. Review contents of manual with Owners’ personnel in detail to explain all aspects of operation and maintenance.

E. Demonstrate start up, operation, control, adjustment, trouble shooting, servicing, maintenance and shutdown of each item of equipment at scheduled times, at equipment location.

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

1.4 INSPECTION AND ACCEPTANCE OF EQUIPMENT

A. Prior to inspection, verify that equipment is tested, operational and clean.

B. Assist Engineer with inspection. Prepare list of items to be completed and corrected.

1.5 TESTING, ADJUSTING AND BALANCING

A. Owner will appoint, employ and pay for services of an independent firm to perform testing, adjusting and balancing.

B. The independent firm will perform services specified in Division 23 Section 23 0593, “Testing, Adjusting, and Balancing for HVAC,” except for factory tests.

C. Reports will be submitted by the independent firm to the Engineer indicating observations and results of tests and indicating compliance or non compliance with specified requirements and with the requirements of the Contract Documents.

1.6 ADJUSTING

A. Adjust operating products and equipment to ensure smooth and unhindered operation.

PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

Not Applicable

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 01\01 3103-Starting of Systems.docx

SECTION 01 3300
SUBMITTALS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Submittal procedures

B. Proposed products list

C. Contractor-prepared shop drawings

D. Preventive maintenance (PM) tasks/schedule

E. Product data

F. Samples

G. Manufacturers' instructions

H. Manufacturers' certificates

1.2 SUBMITTAL PROCEDURES

A. Refer also to provisions of the General Conditions.

B. Identify Project, Contractor, Subcontractor or supplier; pertinent Drawing sheet, equipment tag, system designation number(s) and specification Section number, as appropriate.

C. Where possible, submit shop drawings and product data grouped to include complete submittals of related systems, products and accessories in a single submittal so long as this does not delay individual items whose review is time-critical.

D. If only part of required drawings in one group are submitted, action will be withheld on them until remaining drawings are submitted.

E. Catalog cuts showing more than one model of a product shall be clearly marked indicating which model is being proposed.

F. Capacity and performance data shall be given in same form, units and completeness presented in Contract Documents.

G. Identifying symbols and tags used on drawings shall be clearly cross-referenced on shop drawings.

H. Identify room names and numbers in which various products will be used.

I. Schedule submittals to expedite the Project and deliver to Engineer at business address.

J. Mark in units to match those specified.

K. Provide space for Contractor and Engineer review stamps.

L. Apply Contractor's stamp, signed or initialed, certifying that review, verification of Products required, field dimensions, adjacent construction Work and coordination of information is in accordance with the requirements of the Work and Contract Documents.

M. Identify variations from Contract Documents and product or system limitations which may be detrimental to successful performance of the completed Work.

N. Revise and resubmit submittals as required, identifying all changes made since previous submittal.

O. Distribute copies of reviewed submittals to concerned parties. Instruct parties to promptly report any inability to comply with provisions.

1.3 CONSTRUCTION PROGRESS SCHEDULES

A. Refer to General Conditions.

1.4 PROPOSED PRODUCTS LIST

A. Within 15 business days after date of Owner's Contract Agreement, submit complete list of major products proposed for use, with name of manufacturer, trade name and model number of each product.

B. Include products specified in the following Sections:

1. Section 237313.

C. For products specified only by reference standards, give manufacturer, trade name, model or catalog designation and reference standards.

D. Mark dimensions and values in units to match those specified.

1.5 CONTRACTOR-PREPARED SHOP DRAWINGS

A. Submit the number of hard copies as established at the preconstruction conference. Alternatively, shop drawings may be submitted electronically in .pdf format.

B. Submit ¼" scale floor plans indicating proposed routing of new piping, electrical and duct systems, new and relocated equipment locations and connection points to existing services including sections through equipment and piping diagrams of all connections.

C. Identify equipment, pipe risers, duct risers, column lines, etc., with designations shown on Contract Documents.

D. After review, distribute in accordance with Article on Procedures above and provide copies for Record Documents described in Division 01 Section 01 7700, "Project Closeout."

1.6 PREVENTIVE MAINTENANCE (PM) TASKS/SCHEDULE

A. Submit complete listing of PM tasks within 10 business days after date of Notice to Proceed.

1.7 PRODUCT DATA

A. Submit the number of hard copies as established at the preconstruction conference. Alternatively, shop drawings may be submitted electronically in .pdf format.

B. Mark each copy to identify applicable products, models, systems, equipment tags and other data. Supplement manufacturers' standard data to provide information unique to this Project.

C. After review, distribute in accordance with Article on Procedures above and provide copies for Record Documents described in Division 01 Section 01 7700, "Project Closeout."

1.8 SAMPLES

A. Submit samples to illustrate functional and/or aesthetic characteristics of the Product, with integral parts and attachment devices.

B. Submit the number of samples specified in individual specification Sections, one of which will be retained by Engineer.

C. Include identification on each sample, with full Project information.

1.9 MANUFACTURER'S INSTRUCTIONS

A. When specified in individual specification Sections, submit manufacturers' printed instructions for delivery, assembly, installation, start up, adjusting, testing, in quantities specified for Product Data.

B. Identify conflicts between manufacturers' instructions and Contract Documents.

1.10 MANUFACTURER'S CERTIFICATES

A. When specified in individual specification Sections, submit manufacturer's certificate to Engineer for review in quantities specified for Product Data.

B. Indicate that material or product conforms to or exceeds specified requirements. Submit supporting reference data, affidavits and certifications as appropriate.

C. Certificates may be recent or previous test results on material or Product but must be acceptable to Engineer.

PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

Not Applicable

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 01\01 3300-Submittals.docx

SECTION 01 4000
QUALITY CONTROL SERVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Quality assurance and control of installation

B. References

C. Manufacturers' field services and reports

1.2 QUALITY ASSURANCE/CONTROL OF INSTALLATION

A. Monitor quality control over suppliers, manufacturers, Products, services, site conditions and workmanship to produce Work of specified quality.

B. Comply fully with manufacturers' instructions, including each step in sequence.

C. Should manufacturers' instructions conflict with Contract Documents, request clarification from Engineer before proceeding.

D. Comply with specified standards as a minimum quality for the Work except when more stringent tolerances, codes or specified requirements indicate higher standards or more precise workmanship.

E. Work to be performed by persons qualified to produce workmanship of specified quality.

F. Secure products in place with positive anchorage devices designed and sized to withstand stresses, vibration, physical distortion or disfigurement.

1.3 REFERENCES

A. Conform to reference standard by date of Contract Documents when there are no Bids date specified in product Sections.

B. Should specified reference standards conflict with Contract Documents, request clarification from Engineer before proceeding.

C. The contractual relationship of the parties to the Contract shall not be altered from the Contract Documents by mention or inference otherwise in any reference document.

1.4 MANUFACTURERS' FIELD SERVICES, FIELD TESTS AND REPORTS

A. When specified in individual specification Sections, Contractor shall require material or Product suppliers, Subcontractors, or manufacturers to provide qualified staff personnel to observe site conditions; testing; conditions of installation; quality of workmanship; start-up of equipment; testing, adjusting and balancing of equipment and materials; and troubleshooting as applicable B and to initiate instructions when necessary. Submit report per paragraph C below, this section.

B. Report observations and site decisions or instructions given to Owner, applicators or installers that are supplemental or contrary to manufacturers' written instructions.

C. Submit written report in duplicate within 10 days of observation, start-up, testing, etc. to Engineer for review.

PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

Not Applicable

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 01\01 4000-Quality Control Services.docx

SECTION 01 4200
REFERENCE ORGANIZATIONS FOR QUALITY ASSURANCE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Quality assurance

B. Schedule of references

1.2 QUALITY ASSURANCE

A. For products or workmanship specified by association, trade, or Federal standards, comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes.

B. Conform to reference standard by date of issue current on date of Contract Documents date for receiving bids date of Owner Contractor Agreement when there are no Bids date specified in Product Sections.

1. Maintain copy at jobsite during submittals, planning and progress of the specific work, until Substantial Completion.

C. Should specified reference standards conflict with Contract Documents, request clarification from Engineer before proceeding.

D. The contractual relationship of the parties to the Contract shall not be altered from the Contract Documents by mention or inference otherwise in any reference document.

1.3 SCHEDULE OF REFERENCES

AA Aluminum Association
818 Connecticut Avenue, N.W.
Washington, DC 20006

AABC Associated Air Balance Council
1000 Vermont Avenue, N.W.
Washington, DC 20005

AASHTO American Association of State Highway and Transportation Officials
444 North Capitol Street, N.W.
Washington, DC 20001

ACI American Concrete Institute
Box 19150
Reford Station
Detroit, MI 48219

ADC Air Diffusion Council
230 North Michigan Avenue
Chicago, IL 60601

AGC	Associated General Contractors of America 1957 E Street, N.W. Washington, DC 20006
AHRI	Air Conditioning, Heating, and Refrigeration Institute 2311 Wilson Boulevard, Suite 400 Arlington, VA 22201
AIA	American Institute of Architects 1735 New York Avenue, N.W. Washington, DC 20006
AISC	American Institute of Steel Construction 400 North Michigan Avenue, Eighth Floor Chicago, IL 60611
AMCA	Air Movement and Control Association 30 West University Drive Arlington Heights, IL 60004
ANSI	American National Standards Institute 1430 Broadway New York, NY 10018
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers 1791 Tullie Circle, N.E. Atlanta, GA 30329
ASME	American Society of Mechanical Engineers 345 East 47th Street New York, NY 10017
ASPE	American Society of Plumbing Engineers 8614 Catalpa Avenue Suite 1007 Chicago, IL 60656
ASSE	American Society of Sanitary Engineers P. O. Box 40362 Bay Village, OH 44140
ASTM	American Society for Testing and Materials 1916 Race Street Philadelphia, PA 19103
AWS	American Welding Society 550 LeJeune Road, N.W. Miami, FL 33135

AWWA	American Water Works Association 6666 West Quincy Avenue Denver, CO 80235
CDA	Copper Development Association 57th Floor, Chrysler Building 405 Lexington Avenue New York, NY 10174
CRSI	Concrete Reinforcing Steel Institute 933 Plum Grove Road Schaumburg, IL 60195
DHI	Door and Hardware Institute 7711 Old Springhouse Road McLean, VA 22102
EJCDC	Engineers' Joint Contract Documents Committee American Consulting Engineers Council 1015 15th Street, N.W. Washington, DC 20005
FM	Factory Mutual System 1151 Boston Providence Turnpike P.O. Box 688 Norwood, MA 02062
FS	Federal Specification General Services Administration Specifications and Consumer Information Distribution Section (WFSIS) Washington Navy Yard, Bldg. 197 Washington, DC 20407
HI	The Hydronics Institute 35 Russo Place P. O. Box 218 Berkeley Heights, NJ 07922
ICBO	International Conference of Building Officials 5360 South Workman Mill Road Whittier, CA 90601
IEEE	Institute of Electrical and Electronics Engineers 345 East 47th Street New York, NY 10017

MSS	Manufacturers Standardization Society of the Valve and Fitting Industry 127 Park Street, N.E. Vienna, VA 22180
NEBB	National Environmental Balancing Bureau 8224 Old Courthouse Road Vienna, VA 22180
NEMA	National Electrical Manufacturers' Association 2101 'L' Street, N.W. Washington, DC 20037
NFPA	National Fire Protection Association Battery March Park Quincy, MA 02269
PCA	Portland Cement Association 5420 Old Orchard Road Skokie, IL 60077
PCI	Prestressed Concrete Institute 201 North Wells Street Chicago, IL 60606
PS	Product Standard U. S. Department of Commerce Washington, DC 20203
SMACNA	Sheet Metal and Air Conditioning Contractors' National Association 8224 Old Court House Road Vienna, VA 22180
UL	Underwriters Laboratories, Inc. 333 Pfingsten Road Northbrook, IL 60062.2096

PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

Not Applicable

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 01\01 4200-Reference Orgs for Quality Assurance.docx

SECTION 01 6000
MATERIAL AND EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Products

B. Transportation and handling

C. Storage and protection

D. Product options

E. Substitutions

1.2 PRODUCTS

A. Products: Means new material, machinery, components, equipment, fixtures and systems forming the work. Does not include machinery and equipment used for preparation, fabrication, conveying and erection of the Work. Products may also include existing materials or components required for reuse.

B. Do not use materials and equipment removed from existing premises, except as specifically permitted by the Contract Documents.

C. Provide interchangeable components of the same manufacturer for similar components.

1.3 TRANSPORTATION AND HANDLING

A. Transport and handle products in accordance with manufacturer's instructions.

B. Promptly inspect shipments to assure that products comply with requirements, quantities are correct and products are undamaged.

C. Provide equipment and personnel to handle products by methods to prevent soiling, disfigurement or damage.

1.4 STORAGE AND PROTECTION

A. Store and protect products in accordance with manufacturer's instructions, with seals and labels intact and legible. Store sensitive products in weather tight, climate-controlled enclosures.

B. For exterior storage of fabricated products, place on sloped supports above ground.

C. Provide off site storage and protection when site does not permit on site storage or protection.

D. Cover products subject to deterioration with impervious sheet covering. Provide ventilation to avoid condensation.

E. Store loose granular materials on solid flat surfaces in a well-drained area. Prevent mixing with foreign matter.

F. Provide equipment and personnel to store products by methods to prevent soiling, disfigurement or damage.

G. Arrange storage of products to permit access for inspection. Periodically inspect to assure products are undamaged and are maintained under specified conditions.

1.5 PRODUCT OPTIONS

A. Products specified by Reference Standards or by description only: Any product meeting those standards or description.

B. Products specified by naming one or more manufacturers: Products of manufacturers named and meeting specifications; no options or substitutions allowed.

C. Product specified by naming one manufacturer as a base and naming others as acceptable: Obligations listed in the following “Substitutions” paragraph apply when an “Acceptable Other” is used. Manufacturer named on the drawings and in equipment scheduling are to be considered as a Base; with respect to the particular product described, other manufacturers named in those documents are acceptable others.

D. When an “Acceptable Other” manufacturer is used in lieu of Specified, Contractor shall coordinate mechanical, plumbing and electrical requirements and will bear any additional costs required by other subcontractors as a result of the proposed product.

1.6 SUBSTITUTIONS

A. Instructions to Bidders specify time restrictions for submitting requests for Substitutions during the bidding period to requirements specified in this Section.

B. Substitutions will not be considered when a product becomes unavailable through no fault of the Contractor.

C. Document each request with complete data substantiating compliance of proposed substitution with Contract Documents.

D. A request constitutes a representation that the Bidder:

1. Has investigated proposed product and determined that it meets or exceeds the quality level of the specified product.
2. Will provide the same warranty for the substitution as for the specified product.
3. Will coordinate installation and make changes to other Work which may be required for the Work to be complete with no additional cost to Owner.
4. Has investigated that the proposed product can be installed in the space available with access for servicing and maintenance.
5. Has coordinated mechanical, plumbing and electrical requirements and will bear any additional costs required by other subcontractors as a result of the proposed product.
6. Waives claims for additional costs or time extension which may subsequently become apparent.
7. Will reimburse Owner for review or redesign services associated with re approval by authorities.

E. Substitutions will not be considered when they are indicated or implied on shop drawing or product data submittals, or when acceptance will require revision to the Contract Documents.

PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

Not Applicable

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 01\01 6000-Material and Equipment.docx

SECTION 01 7329
CUTTING AND PATCHING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements and limitations for cutting and patching of work.

1.2 SUBMITTALS

A. Submit written request in advance of cutting or alteration which affects:

1. Structural integrity of any element of project
2. Integrity of weather exposed or moisture resistant element
3. Efficiency, maintenance, or safety of any operational element
4. Visual qualities of sight exposed elements
5. Work of Owner or separate contractor

B. Include in request:

1. Effect on work of Owner or separate contractor
2. Written permission of affected separate contractor
3. Identification of project
4. Location and description of affected work
5. Necessity for cutting or alteration
6. Description of proposed work and products to be used
7. Alternatives to cutting and patching
8. Effect on work of Owner or separate contractor
9. Written permission of affected separate contractor
10. Date and time work will be executed

PART 2 - PRODUCTS

2.1 MATERIALS

A. Primary products: Those required for original installation.

B. Product substitution: For any proposed change in materials, submit request for substitution under provisions of Division 01 Section 01 6000, “Material and Equipment.”

PART 3 - EXECUTION

3.1 EXAMINATION

A. Inspect existing conditions prior to commencing Work, including elements subject to damage or movement during cutting and patching.

B. After uncovering existing work, inspect conditions affecting performance of work.

C. Beginning of cutting or patching means acceptance of existing conditions.

3.2 PREPARATION

A. Provide temporary supports to ensure structural integrity of the work. Provide devices and methods to protect other portions of project from damage.

B. Provide protection from elements for areas which may be exposed by uncovering work.

C. Maintain excavations free of water.

3.3 CUTTING AND PATCHING

A. Execute cutting, fitting and patching to complete work.

B. Fit products together, to integrate with other work.

C. Uncover work to install ill-timed work.

D. Remove and replace defective or non-conforming work.

E. Remove samples of installed work for testing.

F. Provide openings in the work for penetration of mechanical and electrical work.

3.4 PERFORMANCE

A. Execute work by methods to avoid damage to other work and which will provide appropriate surfaces to receive patching and finishing.

B. Employ original installer to perform cutting and patching for weather exposed and moisture resistant elements and sight exposed surfaces.

C. Cut rigid materials using masonry saw or core drill. Pneumatic tools not allowed without prior approval.

D. Restore work with new products in accordance with requirements of Contract Documents.

E. Fit work air tight to pipes, sleeves, ducts, conduit and other penetrations through surfaces.

F. At penetrations of fire rated walls, partitions, ceiling, or floor construction, completely seal voids with fire rated material in accordance with [Division 20 Section 20 0517, “Penetrations for Mechanical, Plumbing, and Fire Suppression,” to full thickness of the penetrated element.

G. Refinish surfaces to match adjacent finish. For continuous surfaces, refinish to nearest intersection or natural break. For an assembly, refinish entire unit.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 01\01 7329-Cutting and Patching.docx

SECTION 01 7700
PROJECT CLOSEOUT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Closeout procedures

B. Final cleaning

C. Adjusting

D. Project record documents

E. Operation and maintenance data

F. Warranties

G. Spare parts and maintenance materials

1.2 CLOSEOUT PROCEDURES

A. Submit written certification that Contract Documents have been reviewed, Work has been inspected and that Work is complete in accordance with Contract Documents and ready for inspection by Engineer.

B. Provide submittals to Engineer that are required by governing or other authorities.

C. Submit final Application for Payment identifying total adjusted Contract Sum, previous payments, and sum remaining due.

D. Owner will occupy all the building as specified in Division 01 Section 01 1100, “Summary of Work.”

1.3 FINAL CLEANING

A. Execute final cleaning prior to final inspection.

B. Clean interior and exterior glass and surfaces exposed to view; remove temporary labels, stains, and foreign substances; polish transparent and glossy surfaces; vacuum carpeted and soft surfaces.

C. Clean equipment and fixtures to a sanitary condition.

D. Clean strainers and replace filters of operating equipment affected by new installation.

E. Remove waste and surplus materials, rubbish and any construction facilities and equipment from the site.

1.4 ADJUSTING

A. Adjust operating products and equipment to ensure smooth and unhindered operation.

1.5 PROJECT RECORD DOCUMENTS

A. Maintain on site, one set of the following record documents; record actual revisions to the Work:

1. Contract drawings
2. Specifications
3. Addenda

4. Change Orders and other modifications to the Contract
5. Reviewed shop drawings, product data, and samples

B. Store Record Documents separate from documents used for construction.

C. Record information concurrent with construction progress.

D. Specifications: Legibly mark and record at each product section description of actual products installed, including the following:

1. Manufacturer's name and product model and number
2. Product substitutions or alternates utilized
3. Changes made by Addenda and Modifications

E. Record documents and shop drawings: Legibly mark each item to record actual construction including:

1. Measured depths of foundations in relation to finish main floor datum
2. Measured horizontal and vertical locations of underground utilities and appurtenances, referenced to permanent surface improvements
3. Measured locations of internal utilities and appurtenances concealed in construction, referenced to visible and accessible features of the Work
4. Field changes of dimension and detail
5. Details not on original Contract drawings

F. Submit changes to Record Documents in AutoCAD format.

G. Delete Engineer title block and seal from all documents.

H. Submit documents to Engineer with claim for final Application for Payment.

1.6 OPERATION AND MAINTENANCE DATA

A. Quality assurance

1. Instructions and data are to be prepared by personnel experienced in maintenance and operation of described products.

B. Binders: Commercial quality, 8½" x 11" binders with hardback, cleanable, plastic covers; 1" maximum ring size. When multiple binders are used, correlate data into related consistent groupings.

C. Prepare binder covers with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS" and title of project. Include subject matter of binder when multiple binders are required.

D. Internally subdivide the binder contents with permanent page dividers, logically organized as described below with tab titling clearly printed under reinforced laminated plastic tabs.

E. Contents: Prepare a Table of Contents for each volume, with each Product or System description.

F. Part 1: Directory listing names, addresses, and telephone numbers of Engineer, Contractor, Subcontractors and major equipment suppliers.

G. Part 2: Operation and maintenance instructions, arranged by system and subdivided by component. For each category, identify names, addresses, and telephone numbers of Subcontractors and suppliers. Identify the following:

1. Significant design criteria.
2. List of equipment.
3. Parts list for each component.
4. Operating instructions.
5. Maintenance instructions for equipment and systems.
6. Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.

H. Part 3: Project documents and certificates, including the following:

1. Shop drawings and product data.
2. Air and water balance reports.
3. Certificates.
4. Photocopies of warranties.

I. Submit one copy of completed volumes in final form 15 days prior to final inspection. This copy will be returned after final inspection with Engineer comments. Revise content of documents as required prior to final submittal.

J. Submit final volumes revised within 10 days after final inspection.

1.7 WARRANTIES

A. Provide notarized copies.

B. Execute and assemble documents from Subcontractors, suppliers and manufacturers.

C. Provide Table of Contents and assemble in 3-D side ring binder with durable cover.

D. Submit prior to final Application for Payment.

E. For items of Work delayed beyond date of Substantial Completion, provide updated submittal within 10 days after acceptance, listing date of acceptance as start of warranty period.

1.8 SPARE PARTS AND MAINTENANCE MATERIALS

A. Provide products, spare parts, maintenance and extra materials in quantities specified in individual specification Sections.

B. Deliver to Project site; obtain receipt from Owner prior to final payment.

PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

Not Applicable

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 01\01 7700-Project Closeout.docx

SECTION 01 7823
OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Format and content of manuals

B. Instruction of Owner's personnel

C. Schedule of submittals

1.2 QUALITY ASSURANCE

A. Prepare instructions and data by personnel experienced in maintenance and operation of described products.

1.3 FORMAT

A. Prepare data in the form of an instructional manual.

B. Binders: Commercial quality, 8½" x 11" binders with hardback, cleanable, plastic covers; 1" maximum ring size. When multiple binders are used, correlate data into related consistent groupings.

C. Cover: Identify each binder with typed or printed title "OPERATION AND MAINTENANCE INSTRUCTIONS;" list title of Project; identify subject matter of contents.

D. Arrange content by systems under section numbers and sequence of Table of Contents of this Project Manual.

E. Provide tabbed fly leaf for each separate product and system with typed description of product and major component parts of equipment.

F. Text: Manufacturer's printed data or typewritten data on 20 -pound paper.

G. Drawings: Provide with reinforced punched binder tab. Bind in with text; fold larger drawings to size of text pages.

1.4 CONTENTS, EACH VOLUME

A. Table of Contents: Provide title of Project; names, addresses and telephone numbers of Engineer, subconsultants and Contractor with name of responsible parties; schedule of products and systems indexed to content of the volume.

B. For each product or system: List names, addresses and telephone numbers of Subcontractors and suppliers, including local source of supplies and replacement parts.

C. Product data: Mark each sheet to clearly identify specific products and component parts and data applicable to installation. Delete inapplicable information.

D. Drawings: Supplement product data to illustrate relations of component parts of equipment and systems to show control and flow diagrams.

E. Type text: As required to supplement product data. Provide logical sequence of instructions for each procedure, incorporating manufacturer's instructions specified in Division 01 Section 01 4000, "Quality Control Services."

F. Warranties and bonds: Bind in copy of each.

1.5 MANUAL FOR MATERIALS AND FINISHES

A. Building products, applied materials and finishes: Include product data, with catalog number, size, composition and color and texture designations.

B. Instructions for care and maintenance: Include manufacturer's recommendations for cleaning agents and methods, precautions against detrimental agents and methods and recommended schedule for cleaning and maintenance.

C. Moisture protection and weather-exposed products: Include product data listing applicable reference standards, chemical composition and details of installation. Provide recommendations for inspections, maintenance and repair.

D. Additional requirements: As specified in individual product specification Sections.

1.6 MANUAL FOR EQUIPMENT AND SYSTEMS

A. Each item of equipment and each system: Include description of unit or system and component parts. Identify function, normal operating characteristics and limiting conditions. Include performance curves, with engineering data and tests and complete nomenclature and commercial number of replaceable parts.

B. Panelboard circuit directories: Provide electrical service characteristics, controls and communications.

C. Include color-coded wiring diagrams as installed.

D. Operating procedures: Include start up, break in and routine normal operating instructions and sequences. Include regulation, control, stopping, shut down and emergency instructions. Include summer, winter and any special operating instructions.

E. Maintenance requirements: Include routine procedures and guide for trouble shooting; disassembly, repair and reassembly instructions; and alignment, adjusting, balancing and checking instructions.

F. Provide servicing and lubrication schedule and list of lubricants required.

G. Include manufacturer's printed operation and maintenance instructions.

H. Include sequence of operation by controls manufacturer.

I. Provide original manufacturer's parts list, illustrations, assembly drawings and diagrams required for maintenance.

J. Provide control diagrams by controls manufacturer as installed.

K. Provide Contractor's coordination drawings with color-coded piping diagrams as installed.

L. Provide charts of valve tag numbers, with location and function of each valve keyed to flow and control diagrams.

M. Provide list of original manufacturer's spare parts and recommended quantities to be maintained in storage.

N. Include test and balancing reports as specified in Division 01 Section 01 4000, "Quality Control Services" and Division 23 Section 23 0593, "Testing, Adjusting, and Balancing for HVAC."

O. Additional requirements: As specified in individual product specification Sections.

1.7 DEMONSTRATIONS AND INSTRUCTIONS OF OWNER PERSONNEL

A. Before final observation, instruct Owner's designated personnel in operation, adjustment and maintenance of products, equipment and systems at agreed upon times.

B. Project equipment demonstrations are to be by qualified manufacturers' representatives who are knowledgeable about the Project.

C. For equipment requiring seasonal operation, perform instructions for other seasons within six months.

D. Use operation and maintenance manuals as basis for instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.

E. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance and shutdown of each item of equipment at agreed-upon times at equipment location.

F. Prepare and insert additional data in Operation and Maintenance Manual when need for such data becomes apparent during instruction.

1.8 SUBMITTALS

A. Submit two copies of preliminary draft or proposed formats and outlines of contents before start of Work. Engineer will review draft and return one copy with comments.

B. For equipment or component parts of equipment put into service during construction and operated by Owner, submit documents within 10 days after acceptance.

C. Submit one copy of completed volumes in final form 15 days prior to final observation. Copy will be returned after final observation, with Engineer comments. Revise content of documents as required prior to final submittal.

D. Submit two copies of revised volumes of data in final form within 10 days after final observation.

PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

Not Applicable

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 01\01 7823-Operation and Maintenance Data.docx

SECTION 01 9113
GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Commissioning is a requirement of this project and required as per the 2015 IECC code, Chapter 4 Commercial Energy Efficiency, Section C408 System Commissioning.

B. The General Contractor shall retain an independent Commissioning Provider (CxP) to coordinate commissioning activities for this project. The objective of the commissioning process is to verify and document that the performance of facilities, systems, and assemblies installed as part of this project meet defined objectives and criteria.

C. The Commissioning Provider (CxP) shall be independent from the General Contractor and all sub-contractors.

D. The Commissioning Provider must hold a current commissioning certification from the Building Commissioning Association (BCxA), University of Wisconsin, AABC Commissioning Group (ACG).

E. The Commissioning Provider must hold current membership, AND be able to demonstrate continuous membership in either BCxA or ACG for the past five years.

F. The Commissioning Provider must have completed and provide examples of at a minimum 3 projects of similar size and scope to be qualified for this project. The General Contractor shall provide to the registered design professional (design engineer) the qualifications and certifications for all commissioning firms proposing on the project for review and approval. As per the IECC commissioning code, the final approval of all commissioning work is the registered design professional (design engineer), therefore, the engineer and General Contractor will jointly make the final selection of the CxP.

G. This section outlines the general roles and responsibilities of the CxP, Owner, Design Team, and General Contractor. Division 23 section defines roles and responsibilities which are applicable to Division 23 work.

H. The CxP will be an independent consulting specialist retained directly by the General Contractor and not associated with any of the other project contractors.

I. Commissioning requires support from the General Contractor and sub-contractors.

J. The General Contractor is responsible for coordinating all commissioning activities. In the absence of a General Contractor, the Prime Contractor shall take on this role.

1.2 RELATED SECTIONS

A. Division 23 Section 23 0800 - Commissioning of HVAC Systems

B. Division 26 Section 26 0800 - Commissioning of Electrical Systems

1.3 DEFINITIONS

A. *Checklists*: Project and element-specific checklists that are developed and used during all phases of the Commissioning Process to verify that the owner's project requirements and design intent are being achieved. Checklists are used for general evaluation, testing, training, and other design and construction requirements.

B. *Commissioning Process or Commissioning (Cx)*: A quality focused process for enhancing the delivery of a project. The process focuses on verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the project design intent.

C. *Commissioning Provider (CxP)*: An entity approved by the registered design professional and hired by the General Contractor who plans, schedules, and coordinates the commissioning team to implement the Commissioning Process.

D. *Commissioning Field Report*: A written document that identifies the commissioning activities completed during a visit to the project site. The report identifies significant findings, results, comments and questions that resulted from the visit. This is typically produced by the CxP per site visit.

E. *Commissioning Plan*: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the Commissioning Process.

F. *Commissioning Team (Cx Team)*: The individuals and agencies who, through coordinated actions, are responsible for implementing the Commissioning Process.

G. *Construction Team*: The General Contractor, related sub-contractors, and other contractors working for the Owner during the Construction Phase.

H. *Final Commissioning Report (Final Cx Report)*: A document that records the activities and results of the Commissioning Process and is developed from the final Commissioning Plan with all of its attached appendices. The final report shall at a minimum meet all requirements as outlined in IECC 2015, Section C408.2.5.4.

I. *Functional Performance Test (FPT)*: A written protocol that defines methods, personnel, and expectations, for tests conducted on components, equipment, assembles, systems, and interfaces among systems.

J. *Issues Log*: A formal document and ongoing record of problems or concerns identified through the construction phase which deviate from the project's construction documents, applicable codes and/or normal construction industry practices and their resolution. Items on this issues log should be reviewed by the GC and corrected in a timely manner by the applicable trades and contractors.

K. *Preliminary Commissioning Report (Preliminary Cx Report)*: A preliminary report of commissioning test procedures and results that is made available to the Owner, registered design professional (design engineer), General Contractor and authority having jurisdiction (code official) PRIOR to the final mechanical inspection. The preliminary commissioning report shall at a minimum meet all requirements as outlined in IECC 2015, Section C408.2.4.

L. *Training Plan*: A written document that details the expectations, schedule, duration and deliverables of Commissioning Process Activities related to training of project operating and maintenance personnel, users, and occupants.

1.4 ROLES AND RESPONSIBILITIES

A. Commissioning Provider (CxP)

1. The primary role of the CxP is to oversee the commissioning process. This includes: site observations of installation of commissioned systems and equipment; coordination of the execution of equipment startups, and testing/adjusting and balancing; development of FPT procedures; observation and documentation of the FPTs and performance that systems are

functioning in accordance with the design intent and in accordance with the Contract Documents.

2. Develop a Commissioning Plan.
3. Coordinate and direct the commissioning activities in a logical, sequential and efficient manner using consistent protocols and forms, centralized documentation, clear and regular communications with the Cx team, and frequently update timelines and schedules for Cx activities.
4. The CxP may assist with problem solving, non-conformance or deficiencies, but ultimately that responsibility resides with the General Contractor (GC) and the Architect/Engineer (A/E).
5. Coordinate the commissioning schedule and work with the GC to incorporate commissioning activities into the master project schedule maintained by the GC.
6. Update and revise the Commissioning Plan as required.
7. Plan and conduct a commissioning kickoff meeting and other commissioning meetings with the Cx team. The CxP will record meeting minutes for Cx meetings facilitated by the CxP.
8. Request and review additional information required to perform commissioning tasks, including: equipment submittals, installation, operations and maintenance (IOM) manuals and materials, contractor start-up and checkout procedures.
9. Conduct periodic construction observations to verify that systems and equipment are installed consistently with the contract documents. Document deficiencies in the issues logs and distribute it to the Commissioning Team (Note: the Commissioning Provider is responsible for identifying deficiencies but is not responsible for ensuring that deficiencies are corrected).
10. Attend selected job-site meetings to obtain information on construction progress.
11. Collect and review contractor installation tests, such as duct leakage and hydronic system pressure tests, for inclusion in the commissioning report.
12. Collect and selectively witness contractor and/or manufacturer startup procedures and testing of the equipment to be commissioned. Include copies of these reports in the commissioning report.
13. Write and distribute, for the design team and contractor review, the functional performance test procedures
14. Review start-up and TAB reports to confirm included systems are ready for functional performance testing.
15. Coordinate, witness and document functional performance testing by installing contractors. Coordinate retesting as necessary until satisfactory performance is achieved per design specifications. See section 3, "Cost of Re-Evaluation" within this specification, for extent of retesting included in the commissioning scope.
16. Provide a preliminary commissioning report.
17. Coordinate, witness and document required seasonal or deferred functional performance testing and any deficiency corrections required.
18. Oversee and review the training of the Owner’s operating personnel.
19. Review O&M manuals submitted by the GC for completeness and conformance to contract documents.

20. Provide a final commissioning report for review and acceptance by the registered design professional.

B. General Contractor (GC) and Sub-Contractors

1. Include the cost to support the commissioning process and activities in the contract price.
2. The GC is responsible for coordinating all commissioning activities of the sub-contractors. Commissioning activities may be completed by the Mechanical Contractor (MC), Electrical Contractor (EC), Controls Contractor (CC), or Test and Balance (TAB) contractor, but the GC is ultimately responsible for completion of all of these tasks.
3. Facilitate the coordination of the commissioning work by the CxP and incorporate commissioning activities into the master schedule.
4. Furnish a copy of all construction documents, addenda, change orders, Requests for Information (RFIs), approved submittals, shop drawings, and IOMs, related to commissioned systems and equipment to the CxP.
5. In each purchase order or subcontract written, include requirements for commissioning.
6. Ensure that all sub-contractor's execute their commissioning responsibilities according to the Contract Documents and schedule.
7. The GC shall designate a staff member who will be knowledgeable and responsible for the construction of the commissioned systems (typically the MEP superintendent) to be their active representative on the commissioning team. This person shall attend the commissioning kickoff meeting and other necessary meetings scheduled by the CxP to facilitate the commissioning process.
8. The sub-contractors shall designate a staff member who will be knowledgeable and responsible for the construction of the commissioned systems (typically the trade superintendent) to be their active representative on the commissioning team. This person shall attend the commissioning kickoff meeting and other necessary meetings scheduled by the CxP to facilitate the commissioning process.
9. Coordinate and share the issues identified on the Issues Log with the appropriate trade sub-contractors. Respond in writing to the CxP with the contractor’s response, appropriate trade responsible for the corrective action and anticipated completion date for the corrective action.
10. Follow up with the subcontractors as to the status of the corrective actions to the items on the Issues Log, and update the CxP.
11. The GC's designated Cx team staff member shall personally examine, witness, and verify that all issues are corrected and complete when the sub-contractor states they have "corrected" an item on the Issues Log.
12. After the GC has verified issues are resolved, they shall notify the CxP accordingly.
13. Notify the CxP one week in advance of all equipment start-ups and tests required by the Contract Documents.
14. Submit test results for tests required by the Contract Documents, including (but not limited to) duct leakage tests, hydronic system pressure tests, plumbing system disinfection certification, generator tests, smoke evacuation system tests, fire pump tests, fire alarm tests, etc. as applicable to the commissioning scope.

15. Notify the CxP when contractor testing, startups and TAB activities will be taking place and have been completed.
16. Provide CxP copies of all submitted reports.
17. Coordinate with subcontractors to review that all pre-functional activities including contractor testing, equipment startups and TAB work have been completed for systems to be functionally tested.
18. Coordinate with subcontractors to ensure qualified technicians are available for the functional performance test procedures as directed by the CxP.
19. Coordinate the training of Owner personnel.
20. Verify that subcontractors prepare and submit O&M manuals, according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
21. Ensure that subcontractors execute seasonal or deferred functional performance testing, witnessed by the CxP, according to the specifications.
22. Ensure that subcontractors correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.
23. Gather and submit all project closeout documentation, including submittals, O&M manuals, as-built drawings, warranties, etc. to CxP for approval.

C. Owner

1. Arrange for facility operating and maintenance personnel to attend various field commissioning activities and field training sessions according to the Commissioning (Cx) Plan.
2. Provide input and direction on commissioning-related recommendations that arise from the commissioning process which may enhance the operation of the building but are not included in the project documents and may be an additional project cost. If the Owner is in agreement with commissioning recommendations, they are to direct the Design Team to review and issue the appropriate directive to add that scope and maintain the Design Team's responsibility for all construction documents.

D. Design Team (Architect/Engineer)

1. As per IECC 2015, Section C408, the registered design professional (design engineer) shall review and approve the following:
    a. Selection of the CxP with the GC.
    b. Cx Plan
    c. Test procedures including the functional performance test procedures
    d. Air and Hydronic balancing
    e. Preliminary Cx report
    f. Final Cx report
2. If submittal comments are provided by the CxP, incorporate into submittal response back to contractors.
3. Assist (along with the contractors) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.

4. Participate in the resolution of deficiencies identified during commissioning.
5. Notify the CxP of substantive changes to the Contract Documents.
6. Provide clarifications to Contract Documents as required.

1.5 SCOPE OF WORK

A. Refer to specification sections 21-0800, 22-0800, 23-0800 and 26-0800 for listing of systems and equipment to be commissioned and requirements.

1.6 COMMISSIONING DOCUMENTATION

A. General

1. CxP shall prepare and submit a commissioning plan.
2. CxP shall prepare and distribute Cx meeting minutes.
3. CxP shall prepare and distribute field observation reports after each site visits.
4. CxP shall distribute a issues log after each site visit.
5. GC and contractors to respond to the issues log.
6. CxP shall prepare and distribute for review the functional performance test procedures.
7. GC and contractors shall provide copies of all contractor testing, startup reports and TAB reports.
8. The functional performance test documents will be filled in by the CxP as they witness the test conducted by the contractors.
9. GC and contractors shall provide copies of training attendance sign in sheets.
10. CxP shall provide a seasonal or deferred testing plan to test systems under appropriate climatic conditions.
11. CxP shall submit a final report.

1.7 SCHEDULE

A. Commissioning of systems shall proceed per the criteria established in the specific sections that follow, with activities to be performed on a timely basis. The CxP shall be available to respond promptly to avoid construction delays.

B. Contractor field testing, manufacturer startup, TAB and other checkout activities that are the primary responsibility of the contractor / vendor must be in advance of functional performance testing.

C. Problems observed shall be addressed immediately, responsible parties notified, and actions to correct deficiencies coordinated in a timely manner.

D. Contractor schedules and scheduling is the responsibility of the GC. The CxP shall provide commissioning scheduling information to the GC for review and planning activities.

1.8 REFERENCE STANDARDS

A. Industry standards and guidelines are a guide to the commissioning process and are hereby incorporated and will be applied as appropriate. The most current editions of all referenced standards and guidelines shall be used. These include, but are not limited to, the following:

B. References:

1. ASHRAE Standard 202: The Commissioning Process Requirements for New Buildings and New Systems
2. ASHRAE Guideline 0: The Commissioning Process
3. ASHRAE Guideline 1.1: Application of the Commissioning Process to New HVAC&R Systems
4. ASHRAE Guideline 1.4: Preparing Systems Manuals for Facilities

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. All industry standard test equipment required for performing the specified tests shall be provided by the applicable contractor (as specified) and shall be approved by the CxP. Any proprietary vendor specific test equipment shall be provided by that vendor or manufacturer.

B. Any portable or hand-held setup / calibration devices required to initialize the control system shall be made available by the control vendor (at no cost) to the CxP.

C. The instrumentation used in the commissioning process shall meet the following standards:

1. Be of sufficient quality and accuracy to test and/or measure system performance within the tolerances required.
2. Be calibrated at the manufacturer's recommended intervals with calibration tags permanently affixed to the instrument
3. Be maintained in good repair and operating condition throughout the duration of use on this project.
4. Be immediately re-calibrated or repaired if dropped and/or damaged in any way during use on this project.

2.2 BAS HARDWARE AND SOFTWARE

A. BAS access

1. The BAS Contractor shall provide the CxP with access to connect to, communicate with and command the BAS at no additional charge to the CxP.
2. Access level shall allow the CxP to fully execute all commissioning procedures and will include the ability to:
    a. View system operation
    b. Override setpoints
    c. Command digital and analog output points
    d. View BAS programming source code (read-only)
    e. View and print graphics
    f. Create, view, modify, print and download trend logs, histories and reports

B. Technical support

1. The BAS Contractor shall also provide technical support to the CxP as reasonably requested by the CxP regarding setting up and operating BAS hardware and software to support successful execution of the Cx Process.

PART 3 - EXECUTION

3.1 COMMISSIONING PLAN AND SCHEDULE

A. The CxP shall generate a commissioning plan which shows the relative scheduling and extent of resources required from the Commissioning Team and, especially, the General Contractor and Sub-Contractors for construction and post-construction commissioning activities. Per 2015 IECC, Section C408.2.1 the Commissioning Plan shall include at a minimum:

1. A narrative description of the activities that will be accomplished during each phase of commissioning, including personnel intended to accomplish each of the activities.
2. A listing of the specific equipment, appliances or systems to be tested and a description of the tests to be performed.
3. Functions to be tested, including, but not limited to calibration and economizer controls.
4. Conditions under which the test will be performed. At a minimum, testing shall include winter and summer modes of operation and full outside air conditions.

B. The CxP will submit a Cx schedule for the commissioning process which shall be integrated into the construction schedule by the GC.

3.2 PROJECT INFORMATION: SUBMITTALS, RFIS, IOMS, SHOP DRAWINGS, COORDINATION DRAWINGS, BIM MODEL

A. The General Contractor shall provide to the CxP access and copies of all project information requested.

B. The CxP shall review all project information as it pertains to the systems and equipment to be commissioned.

C. The CxP shall develop project specific FPTs based on the project information provided and submitted by sub-contractors.

3.3 MEETINGS AND CONSTRUCTION OBSERVATIONS

A. The CxP shall plan and conduct an initial commissioning kickoff meeting with the Owner, design team, General Contractor and sub-contractors to review the Cx plan and discuss the commissioning requirements for the project.

B. The CxP shall coordinate a special controls integration meeting after submission of the controls submittal. The CxP shall coordinate the meeting which is usually held on the job-site with the design team, GC, mechanical contractor, BAS contractor, TAB contractor and other contractors/vendors that will interface with the BAS such as boilers, chillers, fire, electrical, etc. to review the following:

1. Interoperability and communication needed for the BAS to communicate with other systems that the BAS is connected to.
2. Review of all system controlling devices and sensors and setpoint that are needed by the controls contractor and TAB contractor.
3. Review of special controls or safeties that are specific to manufacturer's equipment such as boilers or chillers.

C. The CxP shall make site visits to attend construction meetings, participate and conduct Cx meetings and observations of work-in-progress to verify conformance with design documents. The CxP shall at

a minimum include one site visit to attending meetings and conducting site observations, these are above and beyond the kick off meeting and controls integration meetings listed above.

D. Each site visits shall be documented with the following:

1. Field Inspection Report
2. Issues Log
3. Photos and other supporting information

E. The CxP shall conduct additional construction observations to witness contractor pre-start testing, manufacturer startups and TAB work in progress as specified in the specific disciple specific commissioning specifications.

F. Document deficiencies via Issues Logs and Commissioning Reports and distribute to the design and construction team (NOTE: The construction team is responsible for ensuring that identified items are completed).

3.4 COMMISSIONING ISSUES LOGS

A. As part of the commissioning process the Issues Log shall be maintained by the CxP as follows.

1. Issues Log
   a. This log is a formal and ongoing record of problems or concerns pertaining to the installation of the commissioned systems and equipment which identifies where the contractors have deviated from the design intent, contract documents, applicable codes or normal industry construction practices. It is the GC's responsibility to receive this log from the CxP, follow up and review each item on the list with the appropriate trades, and respond to the CxP with feedback within 5 business days from the issuance of the log from the CxP.
   b. There is a contractor section identified on log which is where the GC should provide feedback which includes the following sections:
      (1) Response/Action: This is the contractor’s response to the issue identified by the CxP.
      (2) Trade: This identifies the specific contractor responsible for the correction of the issue.
      (3) Expected Completion Date: This is the date which the GC and subcontractor agree the issue will be resolved by. This provides information back to the CxP as to when items should be corrected by for spot checking the correction of issues.
   c. The GC shall provide feedback and updates to the issues log to the CxP within 5 business days from its issuance from the CxP.
   d. The CxP will maintain them master issues log.
   e. A sample of the issues log is included in Appendix B.

3.5 CONTRACTOR INSTALLATION TESTS AND MANUFACTURER STARTUP TESTING

A. The CxP shall include 2 additional site visits to collect documentation and witness contractor installation tests, such as duct leakage and hydronic system pressure tests, for inclusion in the commissioning report.

B. The CxP shall include 2 additional site visits to collect and selectively witness contractor and/or manufacturer startup procedures and testing of the equipment to be commissioned. Include copies of these reports in the commissioning report.

C. The contractors shall conduct all startup testing as required by the specifications, equipment manufacturer, the manufacturer's installation, operations and maintenance manual or as necessary to verify all equipment is properly installed.

D. Startup testing shall be documented. Appropriate documentation shall be by the contractor and/or the manufacturer's representative or entity specified in the construction documents.

E. The startup testing shall be documented using the manufacturer's standard forms or contractor generated forms if no manufacturer forms are available.

F. The GC and/or contractors shall submit a copy of test forms to the CxP.

G. The CxP shall include copies of all contractor testing within the preliminary and final Cx reports.

3.6 TESTING AND BALANCING

A. Testing, Adjusting, and Balance Contractor (TAB) requirements

1. Prior to the start of TAB activities, the TAB contractor shall submit a proposed TAB plan, procedures and documentation to the CxP and A/E for review. TAB procedures shall be submitted to allow sufficient time for CxP review and approval prior to the start of TAB activities.

2. After this review, and prior to start of field work, the TAB contractor will attend one or more planning meetings as required with the Commissioning Team to review and discuss outstanding issues relating to TAB procedures and forms, discuss resolution of issues identified during the TAB contractor’s plan review and field inspections, and to coordinate field work.

3. The TAB contractor shall coordinate with the controls contractor to ensure that all system setpoints and changes made to the control system during TAB (flow coefficients, duct areas, etc.) are archived and become the default or initial values for these parameters.

4. The TAB contractor shall provide daily lists of issues and/or problems identified during TAB work to the GC, CxP and A/E for follow-up & resolution with the appropriate contractors.

5. Participate in verification of the TAB report, which will consist of repeating any selected measurement contained in the TAB report where required by the CxP for verification or diagnostic purposes.

6. Test and balance contractor to provide a copy of the final balancing report to CxP.

7. The CxP shall include 1 additional site visits to participate in a TAB planning meeting and to witness and verify TAB

8. The CxP shall include a copy of the final balancing report within the preliminary and final Cx reports.

3.7 BAS CONTROLS & INSTRUMENTATION TESTING

A. Prior to start of control system Functional Performance Procedures, the Building Automation System (BAS) Contractor shall verify and document that all control systems are installed and operating properly including the following:

1. **Control panels and hardware installation** shall be fully verified and the BAS contractors internal checklists completed prior to proceeding to subsequent installation/checkout steps.

   a. The BAS contractor shall provide a copy of the control panel and hardware installation checklists and documentation to the CxP and design engineer.

2. **Point-to-point checkout** shall be completed and documented per the requirements of Integrated Automation and Controls section of Division 23 and item 3 below; OR; per BAS contractors internal point to point checklists that have been approved by the design engineer.
    a. The BAS contractor shall provide a copy of all point to point checkout documentation to the CxP and design engineer.
3. **Control sequence checkout**. Contractor shall verify that operation of control system programming matches the specified sequences of operation. For these checkouts, the Contractor shall, as much as possible, simulate actual operating conditions for the various operating modes being tested (heating, cooling, etc.) by false-loading systems, adjusting setpoints and similar techniques. The CxP will make the control sequence functional performance test procedures available to the BAS Contractor for use in these checkouts.
    a. The BAS contractor shall provide a copy of the control sequence checkout documentation to the CxP and design engineer
4. **Tune all control loops** to obtain timely and stable response, per the controls specifications, without unreasonable hunting, offset or overshoot. Record tuning parameters and response test results for each control loop and provide trend reports to document results. Trend logs shall show both steady-state operation and response to setpoint changes.
5. **Test all alarms and safeties.** Record all alarm parameters and alarm messages. Document all alarms and safeties have been tested and are functioning properly.

B. The BAS Contractor shall work with the TAB Contractor(s) to make sure that all systems are balanced and system setpoints determined and programmed into the BAS.

C. The CxP shall include a copy of all controls checkout forms and test documents within the preliminary and final Cx reports.

3.8 FUNCTIONAL PERFORMANCE TEST PROCEDURES

A. Scope

1. Functional Performance Test (FPT) procedures are executed after commissioned equipment and systems have been installed, started-up and balanced. The goal of these procedures is to conclusively verify that commissioned equipment, sub-systems and major systems operate and perform per the design intent, the project specifications.
2. Equipment-level FPTs will be used to verify operation and capacity of selected equipment such as boilers, chillers cooling towers, pumps, exhaust fans, air handling units, etc.
3. System-level FPTs will verify the following aspects of system operation
    a. System operation under both normal and alternate operating conditions and modes
    b. Interactions between equipment and sub-systems
    c. Operation of safeties and interlocks
    d. Control system operation, response time, stability and tuning
    e. System response to abnormal and/or emergency conditions such as fire, equipment failure and power outages
    f. All control sequence of operation strategies, alarm generation and reporting shall also be reviewed and proper operation verified by the CxP.
    g. The central work station graphics, point assignments, alarm messages, and logging functions shall be verified.

B. Functional Performance Test forms

1. The CxP shall develop FPT procedures and forms.

C. Contractor requirements

1. The Cx team will, in a joint effort, coordinate and schedule FPT activities.
2. Scheduling of FPTs shall be contingent on notification from the affected contractor(s) to the GC and CxP that equipment and systems are ready for checkout.
3. Other prerequisites for execution of FPTs shall include the following:
    a. All pre-functional activities and contractor startup procedures have been completed and documented.
    b. TAB has been completed.
    c. All Cx issues identified affecting equipment or system performance or operations have been resolved.
4. Prior to claiming readiness for FPT, the controls contractor shall ensure that the following items are completed and documented:
    a. Point-to-point checkouts
    b. Verify that network communication between all devices and systems is established
    c. Sequence of operation checkouts
    d. Printed and annotated trend logs and alarm histories establishing acceptable operation including
        (1) Stable control
        (2) Recovery from upset/changes (e.g., from setback)
        (3) Special and/or seasonal modes
        (4) Emergency and alarm modes including loss/restoration of power
5. Execution of the FPTs will be conducted by the contractors providing and installing the equipment and systems being commissioned and the BAS contractors and witnessed by the CxP.
6. Typical activities during FPT execution will include the following:
    a. Starting/stopping equipment
    b. Energizing/de-energizing electrical distribution gear
    c. Opening/closing valves and dampers
    d. Manipulating BAS inputs, outputs and setpoints
    e. Setup, collection, and downloading of BAS trend data
    f. Test all modes of operation (normal, failure, backup, emergency, etc.)
    g. Confirmation of required alarms sent to BAS
7. The Contractor(s) shall maintain full responsibility for the facility, equipment and systems operated during the FPTs, maintain all guarantees and warranties, and shall repair any damage to the facility caused during the FPTs.
8. Contractors shall conduct seasonal FPTs as necessary. This includes performing FPTs on equipment during the season it is intended to operate (i.e. test cooling equipment during the peak cooling season and test heating equipment during the peak heating season, etc.).

9. The CxP shall assist and witness all seasonal FPT's.

10. Tools, test equipment, and instrumentation required for completion of the FPTs shall be provided by the CxP except for special-purpose or proprietary tools, test equipment and instrumentation which will be provided by the contractors. All instruments shall meet the requirements of Part 2 of this specification.

11. FPT acceptance shall confirm the performance of systems to the extent of the design intent. When a system is accepted, the Owner, design team and General Contractor shall be assured that the system is complete, works as intended, is correctly documented, and operator training has been performed.

3.9 COST OF RE-EVALUATION

A. The cost for Contractors to re-evaluate any Commissioning Procedure due to open issues shall be borne by the contractors.

B. The CxP shall include and be available for two attempts of the Functional Performance Tests (one initial and one re-try) with minimal follow-up where necessary (due to deficiencies, systems not ready, incomplete work, etc.) to try to accomplish each test as part of the contract. When additional work is required because systems are not ready or because they do not successfully pass the FPT after they have been indicated as ready, the contractor will be charged for the CxP's additional retesting costs. Additional fees will be paid to the CxP by the General Contractor. The General Contractor has the authority to back change or request a credit by the sub-contractor that causes multiple re-tests.

C. Any required re-testing by any contractor shall not be allowed as a justified reason for a claim of delay or for a time extension by the contractor.

3.10 PRELIMINARY CX REPORT

A. The CxP shall prepare and submit a preliminary commissioning report upon completion of FPTs and prior to the final mechanical inspection. Per 2015 IECC, Section C408.2.4 the Preliminary commissioning report shall will include **at a minimum**:

1. Itemization of deficiencies found during testing that have not been corrected at the time of report preparation.

2. Deferred tests that cannot be performed at the time of report preparation because of climatic conditions.

3. Climatic conditions required for performance of the deferred tests.

3.11 OPERATING AND MAINTENANCE (O&M) MANUALS

A. The CxP shall review and comment on the contractor submitted O&M manuals for equipment and systems commissioned.

B. The CxP shall review that the contractor submitted operating and maintenance manuals comply with the project's technical specific specifications and at a minimum the IECC code requirements as per, Section C408.2.5.5 Manuals, which states O&M's shall include all of the following:

1. Submittal data stating equipment size and selected options for each piece of equipment requiring maintenance.

2. Manufacturer's operation manuals and maintenance manuals for each piece of equipment requiring maintenance, except equipment not furnished as part of the project. Required routine maintenance actions shall be clearly identified.
3. Name and address of at least one service agency.
4. HVAC controls system maintenance and calibration information, including wiring diagrams, schematics, and control sequence descriptions. Desired or field-determined setpoints shall be permanently recorded on control drawings at control devices or, for digital control systems, in system programming instructions.
5. A narrative of how each system is intended to operate, including recommended setpoints.

C. The CxP shall prepare and provide a supplement to the O&M that documents the system setpoints for each system and piece of equipment commissioned upon completion of the functional performance testing and any seasonal or deferred testing.

3.12 TRAINING

A. General

1. The Contractor shall train the Owner's personnel in the operation and maintenance of systems and equipment listed in this Section and as mentioned in other sections.
2. The CxP review and comment on the training plans submitted by the contractors.
3. The CxP shall participate in, witness and verify training by the contractors.
4. The CxP shall verify training is conducted by obtaining sign in attendance sheets.
5. The required training and demonstration specified within this section is supplemental to the requirements of the training and demonstration as outlined in the discipline specific technical sections of the specifications. See the technical specification sections for the systems and equipment that require training and the quantity of hours to be provided.
6. The CxP shall include one additional site visits to participate in training.

B. Scope of training

1. Training must conducted in two parts and include both classroom and on-the-job (hands-on) instruction by qualified manufacturer's representatives, vendors, installation/service technicians and operation personnel having the necessary knowledge, experience, and teaching skills.
2. The training shall provide comprehensive instruction on the operation and maintenance of building components, equipment, controls, and systems including procedures for startup, shutdown, normal operation, abnormal operation, preventive maintenance, troubleshooting, and corrective maintenance.
3. The classroom portion of each training session, shall be based on the information contained in the approved O&M Manuals and will use copies of these manuals for reference. This shall include the following items as applicable:
    a. Content and organization of appropriate O&M Manual materials
    b. Overall equipment / system layout and configuration
    c. Locations and tag numbers of major components
    d. Theory of operation / design Intent
        (1) Startup and shutdown procedures

(2) Normal operating procedures

(3) Non-normal operating procedures (unoccupied, seasonal operation, etc.)

(4) Emergency procedures

e. Health and safety issues (both to O&M personnel and building occupants)

f. Energy Efficiency issues

g. Occupant comfort and IAQ issues

h. Control system sequence of operation

i. Preventive maintenance procedures

j. Diagnostic and troubleshooting procedures

k. Corrective maintenance and repair procedures

l. Review of the BAS front-end operator's workstation. A temporary workstation and/or laptop shall be set up to review and train O&M staff on the actual BAS controls for this project.

4. The field portion of each training session shall at a minimum cover the following items as applicable:

a. Walk-down of covered equipment and systems

b. Demonstration of startup, shutdown and operating procedures

c. Demonstration of diagnostic, service, maintenance and repair procedures

d. Emergency shutdown procedures

e. Locations of critical isolation valves

5. Follow-up or post-occupancy training, where specified, shall be planned, scheduled and conducted per the requirements of this specification. This training will focus on seasonal issues that could not be addressed during the initial training and on addressing operational and maintenance issues identified by the Owner since turnover.

C. Coordination and scheduling

1. Training shall not begin until the following items have been completed:

a. Building systems and equipment are complete and operational.

b. Functional Performance Testing for the equipment and systems being trained on have been successfully completed.

c. The design team, General Contractor and CxP have received and approved the final submittal copies of the Operation and Maintenance Manuals

d. The contractor's proposed training plan and schedule have been approved by the owner.

e. The building automation system (BAS) has been completed and tested.

2. The contractor shall work closely with the Owner's personnel and the CxP in the development and implementation of the training program. This may include preliminary meetings to map out the direction the training will take and development, with Owner approval, of the written training materials.

3. The minimum specific hours of training time provided for equipment and systems shall be in accordance with the requirements in the individual equipment spec sections.

4. All training shall include two identical training sessions. The first training session shall occur in the morning and shall cover the early morning and day shift staff and the second session shall

occur in the late afternoon and cover the evening and night shift staff. Exact training plan and schedule shall be submitted to General Contractor and owner for approval prior to any training session.

5. The General Contractor and owner retains the option of redistributing training time, subject to the total time specified. This may include repetition of selected training sessions or provision for follow-up training sessions after occupancy.

6. Specific schedules for all training sessions must be coordinated in advance with Owner.

D. Training program and materials

1. The contractor will submit a written training program outlining the proposed scope of training, training materials and instruction schedule for review and approval by the General Contractor, design engineer and CxP approximately 30 days before the scheduled completion of the work for which training is to occur.

2. Copies of training materials furnished by the Contractor as part of their training program shall become the property of the Owner. This includes but is not limited to:

   a. All lesson plans, teachers' guides or training aids used to instruct the students. One complete set shall be given to the Owner.

   b. All written materials. e.g. workbooks, manufacturers' instructions, brochures, student tests, charts or other printed or photographed visual aids. Three sets with one complete reproducible master shall be given to the Owner.

   c. All audio-visual materials e.g. DVD's, CD's, video tapes, film and audio cassettes, overhead projector transparencies, software files of presentations, or other audio visual medium. Three sets shall be given to the Owner.

3. The Contractor shall provide all equipment related to the conveyance of the training program e.g. DVD's, CD,s projectors, TV monitors, overhead projector, or other related equipment. Non-permanent mounted white boards, cork board and projector screens. Equipment of this nature provided by the contractors for use during training sessions does NOT become the property of the Owner. Contractors shall promptly remove said equipment at the end of the training session(s).

E. Instructor qualifications

1. Credentials of training instructors are subject to review and approval by the design engineer, General Contractor and CxP.

2. Instructors must have knowledge and experience with the equipment on which they are providing training

3. Instructors must be familiar with the organization and content of Operation and Maintenance Manuals for the equipment on which they are providing training.

4. Instructors for controls must be knowledgeable and familiar with the specific controls equipment, project applications, and specific sequences of operation for this project.

F. Classroom training facilities

1. Locations for classroom training sessions shall be coordinated with the Owner. All training shall be conducted on-site except by prior arrangement and approval by the General Contractor and Owner.

3.13 CX FINAL REPORT

A. The CxP shall prepare and submit a final commissioning report within 90 days of the date of receipt of the certificate of occupancy to the contractor and building contractor, which will include an executive summary, list of participants and roles, brief building description, the commissioning plan, a list of all open and closed deficiencies found, copies of all commissioning site observation field reports, copied of all completed and/or uncompleted FPTs. Per 2015 IECC, Section C408.2.5.4 the Final commissioning report shall will include at a minimum:

1. Results of functional performance tests.
2. Disposition of deficiencies found during testing, including details of corrective measures used or proposed.
3. Functional performance test procedures used during the commissioning process including measurable criteria for test acceptance, provided herein for repeatability.
4. (Exception: Deferred tests which cannot be performed at the time of report preparation due to climatic conditions.)

3.14 SEASONAL / DEFERRED TESTING

A. Seasonal and deferred testing is required by these specifications and IECC code whenever full-load or part-load performance testing cannot be done at the time of initial functional performance testing because of inappropriate climatic conditions.

B. The CxP and contractors shall assume seasonal testing will be required based on the preliminary project schedule available at the time these specifications were prepared.

3.15 RECORD DRAWINGS

A. The CxP shall review the as-built contract documents to verify incorporation of both design changes and as-built construction details. Discrepancies noted shall be corrected by the appropriate party.

3.16 EXCLUSIONS

A. Responsibility for construction means and methods: The CxP is not responsible for construction means, methods, job safety, or any construction management or general contractor functions on the job site.

B. Hands-on work by the CxP: The contractors shall provide all services requiring tools or the use of tools to start-up, test, adjust, or otherwise bring equipment and systems into a fully operational state. The CxP shall coordinate and observe these procedures (and may make minor adjustments), but shall not perform construction or technician services other than verification of testing, adjusting, balancing, and control functions.

END OF SECTION

SECTION 20 0500
BASIC REQUIREMENTS FOR MECHANICAL, PLUMBING, AND FIRE SUPPRESSION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Basic mechanical requirements specifically applicable to Divisions 20, 21, 22, and 23.

1.2 DEFINITIONS

A. The following words or phrases have special meaning when used in the article (of the division and in any other requirement) applicable to this discussion:

1. "Exposed to View" or "Exposed" — shall have reference to and mean that the pipes, ducts, etc., insulated or otherwise, in the completed structure are visible within any normally occupied space, room or area.
2. "In Concealed Spaces", "Concealed or "Not Exposed to View" — shall have reference to and mean that the pipes, duct, etc., insulated or otherwise are concealed and not exposed to view within furred spaces, above suspended ceilings, pipe chases, etc.
3. "Unfinished Spaces" or "Unfinished Rooms" — shall have reference to areas such as Machine Rooms, Equipment Rooms, or similar areas. Where the words "In Finished Areas" or "Finished Rooms" are used, it shall have reference to rooms or spaces, such as, Reading rooms, Offices, Public Corridors, etc.
4. "Finished Rooms or Spaces" shall refer to areas similar to offices, public corridors, and public toilet rooms.
5. "Provide" — shall be taken to mean "furnish and install" meaning to purchase and deliver to the job site and the installation thereof.
6. "Piping" — shall include, in addition to pipe all fittings, valves, hangers, and other supports, expansion compensators, anchors, and accessories related to such piping including associated insulation.
7. "Ductwork" — shall include, in addition to ducts, all fittings, transitions, dampers, hangers and other supports, fire dampers, access panels, associated insulation and accessories related to such ductwork.
8. "Contractor" in Specifications and Drawing refers to respective Contractor performing that portion of work.
9. "Invert Elevation" (I.E.) means elevation of inside bottom of pipe or duct.
10. "Mechanical Work" is work in Divisions 20, 21, 22, and 23.
    a. NOTE: The words "Contractor shall" are implied and shall be so understood wherever the directions "furnish," "install" or "provide" are used.

1.3 SPECIAL CONDITIONS

A. Minor items and accessories or devices reasonably inferable as necessary to the complete and proper operation of any system shall be provided by the Contractor for such system whether or not they are specifically called for by the specifications or drawings.

B. Where work specified in other sections of the specifications connects to equipment specified in Divisions 20, 21, 22, and 23 Sections, check the required connection to such equipment.

1.4 PROJECT/SITE CONDITIONS

A. Install work in locations shown on drawings, unless prevented by project conditions.

B. Prepare drawings showing proposed rearrangement of work to meet project conditions, including changes to Work specified in other Sections. Obtain permission of Owner before proceeding.

1.5 CONTRACTORS' USE OF PREMISES

A. Refer to General Conditions and Division 01.

B. The Owner will be responsible for the identification and abatement of all hazardous materials and asbestos associated with the project. Although great care will be taken to eliminate any risks, the Contractor must be aware that hazardous materials may exist on site. Therefore, the Contractor shall immediately suspend work and notify the Owner if asbestos or other hazardous material is suspected in the work area of the project.

1.6 WORK SEQUENCE

A. Refer to General Conditions and Division 01.

1.7 SUMMARY OF PROJECT

A. Refer to General Conditions and Division 01.

1.8 ALLOWANCES

A. Refer to General Conditions and Division 01.

1.9 UNIT PRICES

A. Refer to General Conditions and Division 01.

1.10 ALTERNATES

A. Refer to General Conditions and Division 01.

1.11 REFERENCE STANDARDS

A. Refer to General Conditions and Division 01.

1.12 SUBMITTALS

A. Refer to General Conditions and Division 01.

1.13 PROPOSED PRODUCTS LIST

A. Refer to General Conditions and Division 01.

1.14 CONTRACTOR-PREPARED SHOP DRAWINGS

A. Refer to General Conditions and Division 01.

1.15 PRODUCT DATA

A. Refer to General Conditions and Division 01.

1.16 SAMPLES

A. Refer to General Conditions and Division 01.

1.17 MANUFACTURER'S INSTRUCTIONS

A. Refer to General Conditions and Division 01.

1.18 MANUFACTURER'S CERTIFICATES

A. Refer to General Conditions and Division 01.

1.19 QUALITY CONTROL SERVICES

A. Refer to General Conditions and Division 01.

1.20 MANUFACTURER'S FIELD SERVICES AND REPORTS

A. Refer to General Conditions and Division 01.

1.21 CONTRACT CLOSEOUT

A. Closeout procedures

1. Refer to General Conditions and Division 01.

B. Final cleaning

1. Refer to General Conditions and Division 01.

C. Adjusting

1. Refer to General Conditions and Division 01.

D. Project Record Documents

1. Refer to General Conditions and Division 01.

1.22 O&M DATA

A. Quality assurance

1. Refer to General Conditions and Division 01.

B. Format

1. Refer to General Conditions and Division 01.

C. Contents, each volume

1. Refer to General Conditions and Division 01.

D. Manual for materials and finishes

1. Refer to General Conditions and Division 01.

E. Manual for equipment and systems

1. Refer to General Conditions and Division 01.

F. Instruction of Owner personnel

1. Refer to General Conditions and Division 01.

G. Submittals

1. Refer to General Conditions and Division 01.

H. Warranties

1. Refer to General Conditions and Division 01.

PART 2 - PRODUCTS

2.1 MATERIAL AND EQUIPMENT

A. Refer to General Conditions and Division 01.

2.2 STORAGE AND PROTECTION

A. Refer to General Conditions and Division 01.

2.3 PRODUCT OPTIONS

A. Refer to General Conditions and Division 01.

2.4 SUBSTITUTIONS

A. Refer to General Conditions and Division 01.

PART 3 - EXECUTION

3.1 SCOPE

A. Work included under Divisions 20, 21, 22, and 23 shall include all labor, services, materials and equipment and performance of all work required for installation of mechanical, plumbing, and fire suppression systems as shown on drawings and as herein specified in following sections.

3.2 INTERPRETATION OF CONSTRUCTION DOCUMENTS

A. Should there be discrepancy or a question of intent, refer matter to Engineer for decision before ordering any equipment or materials or before starting any related work.

B. Drawings and specifications are to be taken together. Work specified and not shown or work shown and not specified shall be performed or furnished as though mentioned in both specifications and drawings. If there is discrepancy between drawings and specifications as to quantity or quality to be provided, the greater quantity or better quality shall be provided.

C. Minor items and accessories or devices reasonably inferable as necessary to complete and proper installation and operation of any system shall be provided by Contractor for such system whether or not specifically called for by specifications or drawings.

D. Engineer may change location of any equipment 5’ and any piping, ductwork, conduit, etc. 10’ in any direction without extra charge, provided such changes are made before installation.

E. Locations of items not definitely fixed by dimensions are approximate only and exact locations necessary to secure the best conditions and results shall be determined at the site and shall be subject to review and approval by Architect.

F. Follow drawings in laying out work, check drawings of other trades to verify spaces in which work will be installed, and maintain maximum headroom and space conditions at all points.

1. Where headroom or space conditions appear inadequate, notify Architect or Owner's field representative before proceeding with installation.

2. Duct and pipe rerouting and duct size changes shall be made at no additional cost to the Owner.

G. Furnish advance information on locations and sizes of frames, boxes, sleeves and openings needed for the work, and also furnish information and shop drawings necessary to permit installation of other work without delay.

H. Where there is evidence that parts of the Work specified in Divisions 20, 21, 22, and 23 will interfere with other work, assist in working out space conditions to make satisfactory adjustments, revise and submit coordinated shop drawings.

I. After review and without additional cost to the Owner, make minor modifications in the work as required by structural interferences, by interferences with work of other sections or for proper execution of the work.

J. Work installed before coordinating with other work so as to cause interference with other work shall be changed and corrected without additional cost to the Owner.

K. Drawings are diagrammatic in nature and are a graphic representation of requirements and shall be followed as closely as actual building construction will permit. All changes from the plans necessary to make the work conform to the building as constructed and to fit the work of other trades or to conform to rules of the Governmental Authorities having jurisdiction, NFPA, OSHA and the Owner's Insurance Underwriters, shall be made by the Contractor without extra cost to the Owner.

L. The layout of the piping, ductwork, equipment, etc., as shown on the drawings shall be checked and exact locations shall be determined by the dimensions of the equipment approved and the Contractor shall obtain approval for the revised layout before the apparatus is installed. The Contractor shall field measure or consult existing record architectural and structural drawings if available for all dimensions, locations of partitions, locations and sizes of structural supports, foundations, etc.

M. Omission in the drawings and/or specifications of any items necessary for the proper completion or operation of the work outlined in this specification shall not relieve the Contractor from furnishing same without additional cost to the Owner.

N. The equipment shop drawings will be furnished to the Contractor before roughing in. Contractor shall not install any piping or ductwork for said equipment until he has received approved shop drawings for same.

3.3 PROJECT/SITE CONDITIONS

A. Each Contractor shall visit the site prior to bid submission to determine all existing conditions that may affect his work and shall make appropriate allowances for such conditions in his bid. Failure to visit the site shall not be cause for a request for additional compensation later in the project during construction.

B. Install work in locations shown on drawings, unless prevented by project conditions.

C. Prepare drawings showing proposed rearrangement of Work to meet Project conditions, including changes to work specified in other Sections. Obtain permission of Engineer before proceeding.

3.4 ALTERATIONS IN PRESENT BUILDING AND SYSTEMS

A. Contractor shall take particular note of the revisions and alterations to the existing systems, facilities and equipment due to the new construction as indicated on the drawings and/or in specification. Contractor shall remove, reroute or alter all services, ductwork, etc., as required or as indicated on the drawings.

1. The Contractor shall maintain all services in the existing building. In case, where new service connections are to be made to existing services and service interruptions can in no way be avoided, the service interruptions shall be with the minimum of inconvenience to the Owner and the work shall be done at such time of any day, Saturday and Sunday included, and only as directed by the Owner or the Architect.

3.5 ERECTION & WORKMANSHIP

A. Contractor is to be responsible for all work fitting into place in satisfactory, neat and workmanlike manner in every particular, to approval of Engineer.

B. Unless explicitly stated to contrary, each Contractor shall furnish and install each item of equipment or material hereinafter specified, complete with all necessary fittings, supports, trim, piping, insulation, etc., as required for complete and operating installation.

C. Equipment and materials shall be installed according to manufacturer's instruction unless otherwise specifically directed by Contract Documents.

D. Contractor shall provide all necessary OSHA approved rigging, scaffolding, tools, tackle, labor, etc., necessary for the complete installation of the equipment.

E. Contractor shall adapt his work to job conditions and make such changes as required and permitted by the Architect such as moving his work to clear beams, joints, light fixtures, etc., adjusting risers, etc. avoiding interferences with windows and openings, etc. raising or lowering his work to permit the passing of ductwork or the work of other trades, etc., all as required or as job conditions dictate, without any additional costs to the Owner.

F. All appliances and equipment shall be installed and connected with best engineering practices and in accordance with the manufacturer's best instructions and recommendations.

G. Work done by Contractor at the site in the execution of this project shall be performed only by skilled mechanics, recognized as such in their respective trades in the direct employ either of the Contractor proper or of affiliate firms which have a longstanding and continuing formal agreement with the Contractor for providing the rendered services on similar work of this type.

3.6 PROTECTION FROM INJURY

A. All pipes, fixtures, traps, equipment, and other parts of the Work shall be protected against injury by freezing or exposure to the weather during construction while stored or installed in place.

3.7 MECHANICAL AND ELECTRICAL WORK COORDINATION

A. Refer to General Conditions and Division 01.

3.8 CUTTING AND PATCHING

A. Refer to General Conditions and Division 01.

3.9 ACCESS PANELS

A. Where control valves, shutoff valves, drip traps, heating coils, dampers, pull boxes or other specialties, which require service or adjustment, are installed above inaccessible type furred ceilings or within furred walls, Contractor whose equipment is involved shall furnish and install access panels as required.

B. Access panels shall be of sufficient size to make possible servicing, adjustment, removal and replacement of concealed equipment through opening provided. Panels shall be sized as shown on drawings, or if sizes are not shown, shall be minimum of 16" x 24" in walls and 24" x 24" in ceilings.

C. Contractor shall confer with other trades with respect to access panel locations and shall, wherever practical, group valves, traps, dampers, etc. in such way as to be accessible from single panel and eliminate as many access panels as possible.

D. Submit shop drawings for review before ordering panels. Where fire rating is required, furnish label doors compatible with fire rating of assembly.

3.10 PROTECTION OF ELECTRICAL EQUIPMENT

A. Contractor shall furnish and install sheet metal drain pans beneath piping that is routed above electrical equipment and/or above the 3' access space in front of such equipment. Electrical equipment, for the purpose of addressing drain pan requirements, shall be defined as free-standing or wall-mounted switchgear, transformers, distribution boards or motor control centers. Piping includes, but is not limited to, plumbing, fire suppression, mains (not branch piping with sprinkler heads), hydronic heating or cooling, steam and condensate, and fuel systems.

1. Drain pans shall be 20-gauge galvanized sheet metal with a minimum 4" high turned-up edge. Bottom of drain pan shall slope to a single drainage point at ⅛" per foot. A 1" diameter clear plastic tube shall allow collected fluid to drain to the nearest open site floor drain. Secure plastic tubing to building structure only.

2. Drain pan shall be hung from building structure with angle iron trapeze hangers (no hanger shall penetrate the drain pan). Consider drain pan to be full of water for hanger load calculations.

3. Drain pans shall include liquid detectors with alarms only if noted on the drawings.

B. Provide sprinkler heads beneath drain pan only as required by NFPA.

C. Contractor shall include provisions to adjust the local lighting layout, at no extra cost to Owner, in order to accommodate any detrimental effect the drain pan has on the illumination of the electrical equipment and access space.

3.11 STARTING OF SYSTEMS

A. Refer to General Conditions and Division 01.

3.12 TESTING, ADJUSTING AND BALANCING

A. Contractor shall appoint, employ and pay for services of independent firm to perform testing, adjusting and balancing.

B. Independent firm will perform services specified in Division 01 Section 01 4000, "Quality Control Services" and Division 23 Section 23 0593, "Testing, Adjusting, and Balancing for HVAC," except for factory tests.

C. Reports will be submitted by independent firm to Engineer indicating observations and results of tests and indicating compliance or non-compliance with specified requirements and with requirements of Contract Documents.

3.13 ALTERATION PROJECT PROCEDURES

A. Refer to General Conditions and Division 01.

3.14 DEMONSTRATIONS AND INSTRUCTIONS TO OWNER PERSONNEL

A. Refer to General Conditions and Division 01.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 20\20 0500 Basic Requirements for M-P-FP.docx

SECTION 20 0501
MINOR MECHANICAL, PLUMBING, AND FIRE SUPPRESSION DEMOLITION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Minor demolition specifically applicable to Divisions 20, 21, 22, 23, 27, and 28.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Refer to General Conditions and Division 01.

B. Materials and equipment for patching and extending work: As specified in individual Sections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify field measurements, equipment location, piping and ductwork sizes and arrangements as shown on drawings.

B. Verify that abandoned piping, ductwork and equipment serve only abandoned facilities.

3.2 PREPARATION

A. Disconnect mechanical systems in walls, floors and ceilings scheduled for removal.

B. Coordinate utility service shut-downs with utility companies.

C. Provide temporary connections to maintain existing systems in service during construction.

D. Existing mechanical systems: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and new connections. Notify Owner/Engineer at least 72 hours before partially or completely disabling system. Minimize shut-down duration. Make temporary connections to maintain service in areas adjacent to work area.

3.3 DEMOLITION AND EXTENSION OF EXISTING SYSTEMS

A. Demolish and extend existing work under provisions of General Conditions, Division 01,and this Section.

B. In general, mechanical, plumbing, fire suppression, medical gas, and electrical remodeling work is shown on drawings but carefully study all drawings for all contracts for “demolition” and “remodeling” work in existing building and field check to verify locations where such work is being done to determine exact extent of work required. No extra will be allowed for additional work required because of demolition or remodeling whether or not work is specifically noted, itemized or shown on drawings.

C. Remove existing equipment and materials pertaining to contract as specified or as required, whether shown on drawings or not, to prepare for new work of all contracts.

D. Where necessary, reroute piping, ducts, etc. from within walls, floors, ceilings, etc. being removed. Contractor involved with interrupted service shall be responsible for accomplishing required work whether shown on drawings or not.

E. Cap all abandoned or terminated piping, etc. below floor, behind wall surface, above ceiling, etc., as required to be completely concealed after new work is complete.

F. Cap or plug all pipes, valves, fittings, etc. left open after demolition if they are not to be reused.

G. Maintain access to existing mechanical installations which remain active. Modify installation or provide access panel as appropriate.

H. Extend existing installations using materials and methods compatible with existing mechanical installations, or as specified.

3.4 DISPOSITION OF REMOVED EQUIPMENT

A. Where existing materials or equipment are specified to be removed from service, respective Contractor shall take possession of same, coordinate with Owner where items are to be stored or remove unwanted items from site promptly, except as specified below or unless otherwise noted on drawings.

B. All salvageable material and equipment, including but not necessarily limited to plumbing fixtures, heating units, air conditioning units, piping, valves, etc., shall be removed and maintained in as good condition as possible and turned over to Owner. However, if Owner decides any such materials are of no value to him, then they shall become property of Contractor who shall remove such discarded work from premises and dispose of same.

C. Existing equipment or systems, etc. which are specified to be replaced by new equipment, or system etc. shall not be removed from service until the new equipment, materials, systems, etc. have actually arrived at project site.

3.5 INSTALLATION

A. Install relocated materials and equipment under the provisions of Division 01.

3.6 CLEANING AND REPAIR

A. Clean and repair existing materials and equipment which remain or are to be reused.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 20\20 0501-Minor M-P-FP Demolition.docx

SECTION 20 0513
MOTOR REQUIREMENTS FOR MECHANICAL, PLUMBING, AND FIRE SUPPRESSION EQUIPMENT

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Motor requirements specifically applicable to Divisions 20, 21, 22, and 23, including:

1. Single-phase general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 volts.
2. Three-phase general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 volts.

B. Coordination

1. Coordinate features of motors, installed units, and accessory devices to be compatible with the following such that all items furnished constitute a properly related package:
   a. Motor starters
   b. Motor controllers
   c. Variable frequency drives
   d. Torque, speed and horsepower requirements of the load
   e. Ratings and characteristics of supply circuit and required control sequence
   f. Ambient and environmental conditions of installation location
2. Providing a motor to satisfy the efficiency requirements specified herein, is the responsibility of the Contractor. If any given manufacturer or supplier of the motorized equipment cannot provide a motor that satisfied the specified efficiency requirements, the Contractor is responsible for any and all steps necessary to provide an adequate motor including but not necessarily limited to:
   a. Coordinating delivery and installation of an acceptable motor to the motorized equipment supplier for factory-installation.
   b. Field-installation of an acceptable motor on the motorized equipment. Field installation shall not void the warranty of the motorized equipment.

1.2 DEFINITIONS

A. Factory-installed motor: A motor installed by the motorized equipment manufacturer at the equipment manufacturer's factory as a component of the equipment.

B. Field-installed motor: A motor installed on the motorized equipment at the Project site.

1.3 CODES AND STANDARDS (UTILIZE LATEST EDITION)

A. ASHRAE 90: Energy Standard for Buildings except Low-Rise Residential Buildings

B. AFBMA 9: Load Ratings and Fatigue Life for Ball Bearings

C. ANSI/IEEE 112B: Test Procedure for Polyphase Induction Motors and Generators

D. EISA: The Energy Independence and Security Act of 2007

E. IECC: International Energy Conservation Code

F. IEEE 112-2004: Standard Test Procedure for Polyphase Induction Motors and Generators

G. IEEE 841-2001: Standard for Petroleum and Chemical Industry - Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 370 kW (500 hp)

H. NETA ATS: Acceptance Testing Specification

I. NFPA 70: National Electrical Code

J. NEMA MG : Motors and Generators

K. UL 1004: Electric Motors

1.4 QUALITY ASSURANCE

A. Manufacturer shall be a company specializing in manufacture of electric motors for the intended use and their accessories, with minimum three years documented product development, testing and manufacturing experience.

B. All motors shall be UL 1004 listed.

C. Motor efficiencies shall be based on the IEEE 112, Test Method B.

1.5 SUBMITTALS

A. Preconstruction – Prior to construction provide the following in accordance with Division 01 and Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Product data
    a. Submit manufacturer's literature indicating:
        (1) Type and size of motor
        (2) Name plate data and rating
        (3) Weight
        (4) Conduit entry and ground lug locations
        (5) Enclosure type and mounting arrangement
        (6) Insulation class
        (7) Information on coating or finishes
        (8) Nominal minimum efficiency
            (a) Provide statement that all motors 1 hp and larger meet "premium efficiency" requirements specified herein.
        (9) Nominal minimum power factor
        (10) Sound power levels in dba
    b. Submit manufacturer's test results verifying guaranteed minimum efficiency and power factor for all three phase motors larger than 1 hp.
    c. Submit manufacturer's literature for bearing protection grounding rings. If not integral to the motor supplied, but field installed as an option, also provide manufacturer's installation instructions.
2. Manufacturer's installation and operating manuals.

B. Contract Closeout – At contract closeout provide the following in accordance with Division 01 and Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Operating and Maintenance Data including:
    a. Product data
    b. Installation instructions
    c. Assembly drawings
    d. Replacement parts list
    e. Maintenance and operation instructions
2. Test Reports
    a. Field installed motor test
    b. Field installed bearing protection ring tests
3. Warranties

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver products to site.

B. Protect motors stored on-site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

1.7 SPARE PARTS

Not Applicable

1.8 WARRANTY

A. Provide five year manufacturer's warranty for motors 1 hp and larger.

PART 2 - PRODUCTS

2.1 MOTORS

A. Acceptable manufacturers

1. Baldor Electric
2. Emerson Motors
3. GE Motors
4. Leeson (Lincoln)
5. Marathon Electric
6. Siemens
7. TECO – Westinghouse

B. General motor requirements applicable to all motors

1. Comply with the requirements in this section except when stricter requirements are specified on the drawings or Division 23 Equipment Sections.
2. Comply with NEMA MG 1.

3. Motor size:
    a. Motors shall be capable of driving the intended load and not exceeding the design horsepower.
    b. Motors shall be selected such that the brake horsepower (bhp), including drive losses of the driven equipment, does not exceed 90% of the motor nameplate rating at design conditions.
4. Visible nameplate:
    a. Provide a visible motor nameplate indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, and service factor.
    b. Nameplates for all three-phase motors shall also indicate power factor and efficiency.
    c. Nameplate shall indicate "Premium Efficiency" where such a motor is provided.
5. Motor characteristics:
    a. Duty rating:
        (1) Continuous duty at ambient temperature of 104°F (40°C) and at altitude of 3,300 feet above sea level.
        (2) Motors shall be capable of not less than six starts in a 24-hour period.
    b. Capacity and torque characteristics:
        (1) Sufficient to start, accelerate and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or service factor.
6. Enclosures:
    a. Enclosure material:
        (1) Cast iron for motor frame 25 hp and larger.
        (2) Rolled steel for motor frame sizes smaller than 25 hp.
    b. Open drip proof (ODP) for indoor locations not in an airstream.
    c. Totally enclosed fan cooled (TEFC) for all motors located within an airstream including within air handling unit housings, ducted airstreams, and ceiling or floor air plenums.
        (1) Totally enclosed air over (TEAO) motors are acceptable for air handling units with fan arrays provided they meet the efficiency requirements of the TEFC motors.
    d. Motors located in exterior locations shall be TEFC with weatherproof cover.
        (1) Totally enclosed air over (TEAO) motors are acceptable for cooling tower applications provided they meet the efficiency requirements of the TEFC motors.

C. Three-phase motors

1. Efficiency:
    a. Motor efficiencies shall at a minimum comply with the most recent editions of the International Energy Conservation Code and ASHRAE Standard 90.1.
    b. All general purpose, three-phase motors from 1 hp up to 200 hp driving Division 21-, 22-, and/or 23-specified equipment (e.g. stand-alone fans, fans within air handling units, heating hot water pumps, chilled water pumps, domestic water pumps) except those

motors defined in Paragraph [C] below shall be premium efficiency and meet the minimum efficiencies specified in the following table:

HP	TOTALLY ENCLOSED, FAN COOLED MOTORS			OPEN, DRIP-PROOF MOTORS		
	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm
1	82.5	85.5	77.0	82.5	85.5	77.0
1.5	87.5	86.5	84.0	86.5	86.5	84.0
2	88.5	86.5	85.5	87.5	86.5	85.5
3	89.5	89.5	86.5	88.5	89.5	85.5
5	89.5	89.5	88.5	89.5	89.5	86.5
7.5	91.0	91.7	89.5	90.2	91.0	88.5
10	91.0	91.7	90.2	91.7	91.7	89.5
15	91.7	92.4	91.0	91.7	93.0	90.2
20	91.7	93.0	91.0	92.4	93.0	91.0
25	93.0	93.6	91.7	93.0	93.6	91.7
30	93.0	93.6	91.7	93.6	94.1	91.7
40	94.1	94.1	92.4	94.1	94.1	92.4
50	94.1	94.5	93.0	94.1	94.5	93.0
60	94.5	95.0	93.6	94.5	95.0	93.6
75	94.5	95.4	93.6	94.5	95.0	93.6
100	95.0	95.4	94.1	95.0	95.4	93.6
125	95.0	95.4	95.0	95.0	95.4	94.1
150	95.8	95.8	95.0	95.4	95.8	94.1
200	95.8	96.2	95.4	95.4	95.8	95.0

c. The following motor types and sizes driving Division 21, 22, and/or 23 specified equipment shall meet the minimum efficiencies defined in the table below:

(1) Fire pump motors

(2) General purpose motors greater than 200 hp up to 500 hp

(3) U-frame motors

(4) Design C motors

(5) Motors for close-coupled pumps

(6) Footless motors

(7) Vertical solid shaft normal thrust motors

(8) Eight-pole motors (900 rpm)

(9) Three-phase motors smaller than 600 volts and operating at voltages other than 230 or 460 volts

HP	TOTALLY ENCLOSED, FAN COOLED MOTORS			OPEN, DRIP-PROOF MOTORS		
	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm
1	80	82.5	75.5	80	82.5	NR
1.5	85.5	84	82.5	84	84	82.5
2	86.5	84	84	85.5	84	84
3	87.5	87.5	85.5	86.5	86.5	84
5	87.5	87.5	87.5	87.5	87.5	85.5
7.5	89.5	89.5	88.5	88.5	88.5	87.5
10	89.5	89.5	89.5	90.2	89.5	88.5
15	90.2	91	90.2	90.2	91	89.5
20	90.2	91	90.2	91	91	90.2
25	91.7	92.4	91	91.7	91.7	91
30	91.7	92.4	91	92.4	92.4	91
40	93	93	91.7	93	93	91.7
50	93	93	92.4	93	93	92.4
60	93.6	93.6	93	93.6	93.6	93
75	93.6	94.1	93	93.6	94.1	93
100	94.1	94.5	93.6	94.1	94.1	93
125	94.1	94.5	94.5	94.1	94.5	93.6
150	95	95	94.5	94.5	95	93.6
200	95	95	95	94.5	95	94.5
250	95	95	95.4	95.4	95.4	94.5
300	95	95.4	95.4	95.4	95.4	95
350	95	95.4	95.4	95.4	95.4	95
400	NR	95.4	95.4	NR	95.4	95.4
450	NR	95.4	95.4	NR	95.8	95.8
500	NR	95.8	95.4	NR	95.8	95.8

2. Service factor
   a. Per the following NEMA Service Factor Table

HP	900 RPM	1200 RPM	1800 RPM	3600 RPM
1/6 to 1/3	1.35	1.35	1.35	1.35
½	1.15	1.25	1.25	1.25
¾	1.15	1.15	1.25	1.25
1	1.15	1.15	1.15	1.25
1½ to 150	1.15	1.15	1.15	1.15

   b. Do not take advantage of service factors in selection of motors.
3. Rotor: Random-wound, squirrel cage.

4. Bearings:
    a. Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for re-lubrication, rated for minimum AFBMA 9, L 10 life of 150,000 hours for direct-coupled applications and 50,000 hours for belted applications. Calculate bearing load with NEMA minimum V belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
    b. Motors not installed in horizontal position shall be provided with suitable bearings.
    c. Grease fittings shall be provided. Both fittings and drain plugs shall be fully accessible while the motor is in operation. Where motors are installed in an inaccessible location, the grease fitting shall be extended to an accessible location. High pressure hydraulic steel tubing and fittings shall be used.
5. Temperature rise and insulation:
    a. Motors smaller than 1 hp: NEMA Class B temperature rise with Class B insulation.
    b. Motors 1 hp and larger: NEMA Class B temperature rise with Class F insulation.
6. Starting code designation:
    a. Motors smaller than 15 hp: Manufacturer's standard starting characteristics.
    b. Motors 15 hp and larger: NEMA starting Code F or Code G.
7. Motor windings shall be first grade copper.

D. Additional requirements for three-phase motors used with variable frequency drives
1. Motor shall be "inverter-ready" by complying with or exceeding the NEMA MG1 Part 31 requirements regarding special purpose motors for use with variable frequency drives.
2. Windings shall be copper magnet wire with moisture-resistant insulation, varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses, produced by pulse-width modulated inverters.
3. Motors shall be equipped with shaft grounding ring(s) to dissipate potential VFD-induced motor shaft currents by grounding through the motor housing.
    a. Provide one grounding ring per motor.
    b. Provide solid ring or split ring, based on grounding ring manufacturer's recommendations.
    c. Shaft grounding brushes or insulated bearings are not acceptable.
    d. Shaft grounding rings shall be factory-installed or field-installed by the motor manufacturer or field-installed by the contractor.
    e. Acceptable product: Aegis SGR Bearing Protection Ring as manufactured by Electric Static Technology.
    f. This provision for grounding devices shall not apply to motors used in environments defined as Class 1 Division 1, Division 2, or Class 1 Zone 1, Zone 2 hazardous locations.

E. Additional requirements for motor-driven equipment located outdoors
1. Epoxy seal windings using vacuum and pressure with rotor and stator surfaces protected with epoxy enamel.
2. Bearings shall be double shielded with waterproof non-washing grease.
3. Provide weatherproof enclosure for motor.

F. Additional requirements for motors 100 hp and larger

1. Provide with thermistor system: Three PTC thermistors imbedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter; refer to Electrical Specifications.

G. Single-phase motor

1. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
    a. Permanent-split capacitor
    b. Split phase
    c. Capacitor start, inductor run
    d. Capacitor start, capacitor run
2. Multispeed motors: Variable-torque, permanent-split-capacitor type.
3. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
4. Motors 1/20 hp and smaller: Shaded-pole type.
5. Thermal protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal protection device shall automatically reset when motor temperature returns to normal range.
6. For fractional horsepower motors where connection is made directly, provide conduit connection in end frame.

PART 3 - EXECUTION

3.1 APPLICATION

A. Electrical service

1. Motors ¾ hp and larger shall operate on 480 or 208 volt, three-phase 60 Hertz, alternating current, except as otherwise noted.
2. Motors smaller than ¾ hp shall operate on 120 volt, single-phase, 60 Hertz, alternating current, except as otherwise noted.

B. Motor speed shall not exceed 1,750 rpm unless otherwise specified.

3.2 INSTALLATION

A. Factory-installed motors

1. Not used

B. Field-installed motors

1. Examine area to receive field installation for compliance with required tolerances and other conditions affecting performance. Examine roughing-in of conduit systems to verify actual locations. Correct any deficiencies found during examination.
2. Anchor motor assembly to base, adjustable rails or other support according to manufacturers' instructions. Level and align.

3. Clean motors according to manufacturers' written instructions.

C. Field-installed bearing protection rings

1. Verify applicable maximum and minimum temperature and humidity allowances with manufacturer's technical support.

2. Based on motor application, motor size, motor frame, and bearing types, use shaft grounding ring kit that corresponds to shaft grounding ring manufacturer's installation recommendations and instructions.

3. Based on manufacturer's installation instructions, clean the motor shaft and other motor surfaces to remove any coatings, paint or other nonconductive material to prepare all conducting surfaces.

4. Apply conductive shaft surface coating per manufacturer's recommendations and installation instructions.

5. As required by the installation and per manufacturer's recommendations and installation instructions:

a. Drill and tap installation holes in the motor end bracket per manufacturer's installation instructions.

b. Apply manufacturer supplied adhesive and hold in place until the adhesive sets.

3.3 TESTING

A. Field-installed motor test

1. Run each motor. Demonstrate correct rotation, alignment and speed.

2. Test interlocks and control features for proper operation.

3. Verify that current in each phase is within nameplate rating.

4. NETA Acceptance Test

a. Perform an acceptance test in accordance with NETA Acceptance Testing Specification, Section 7.15.1.

b. Correct any deficiencies found by test and repeat acceptance test.

5. Provide test result report within two weeks of testing indicating that each of the above tests was completed and the results of those tests.

B. Field-installed bearing protection ring tests

1. Pre-installation test:

a. Place the positive and negative meter leads on the shaft at a place where the grounding ring fibers will contact the shaft and read the resistance.

b. If the reading is higher than 2 ohms, provide additional cleaning and retest.

c. Provide test result report within two weeks of testing indicating the resistance of each motor.

2. Post-installation test:

a. Place one meter lead on the grounding ring and the other on the motor frame and read the resistance. NOTE: Motor must be grounded to common earth ground with drive according to application standards.

b. Provide test result report within two weeks of testing indicating the resistance of each motor.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 20\20 0513-Motor Requirements for M-P-FP.docx

SECTION 20 0519
METERS AND GAUGES FOR MECHANICAL, PLUMBING, AND FIRE SUPPRESSION

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Meters and gauges specifically applicable to Divisions 20, 21, 22, and 23, including:

1. Thermometers for piping
2. Thermometers for ductwork
3. Pressure gauges for piping
4. Test plugs for piping

1.2 CODES AND STANDARDS (USE LATEST EDITION)

A. American Society of Mechanical Engineers (ASME)

1. ASME B40.100: Pressure Gauges and Gauge Attachments
2. ASME B40.200: Thermometers, Direct Reading and Remote Reading
3. ASME B40.3: Bimetallic Actuated Thermometers

B. National Sanitation Foundation (NSF)

1. NSF/ANSI 61: Drinking Water System Components – Health Effects
2. NSF/ANSI 372: Drinking Water System Components – Lead Content

1.3 QUALITY ASSURANCE

A. All thermometers, pressure gauges, valves, test plugs or other materials in contact with potable water shall not contain more than 0.25% lead by weighted average, as required by section 1417 of the United States Environmental Protection Agency's Safe Drinking Water Act, and be certified to NSF/ANSI 61 Annex G and NSF/ANSI 372.

1.4 SUBMITTALS

A. Preconstruction – Prior to construction provide the following in accordance with Division 01 and Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Product Data: Submit manufacturer's product literature for each type of product indicate and a schedule indicating manufacturer's model number, scale range, and location for each device.

B. Contract Closeout – At contract closeout provide the following in accordance with Division 01 and Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Operating and Maintenance Data including:
    a. Product data
    b. Installation instructions
    c. Assembly drawings
    d. Replacement parts list
    e. Maintenance and operation instructions
    f. Schedule indicating device type and location

2. Warranties

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS OR DIGITAL THERMOMETERS FOR PIPING

A. Acceptable manufacturers

1. Ashcroft Inc.
2. H.O. Trerice Company
3. Miljoco Corporation
4. Weiss Instruments, Inc.

B. Direct reading liquid-in-glass thermometer complying with ASME B40.200

1. Case: Die-cast aluminum, 7” long
2. Tube: Blue colored spirit (organic) filled, lens front
3. Tube Background: Aluminum white with permanently etched scale calibration in °Fahrenheit
4. Window: Clear acrylic or glass; provide glass for steam and condensate applications
5. Connector: Adjustable angle joint with positive locking device
6. Stem: Brass of length to suit installation
7. Accuracy: ±1% scale division
8. Thermowells: Brass, pressure-tight, socket-type fitting made for insertion into piping and of type, diameter, and length required to hold thermometer clear of any pipe insulation. Utilize lead free thermowells as manufactured by Weiss for potable water service.
9. Basis of Design: H.O. Trerice Company Model AX9-2

C. Digital thermometers

1. Light powered, no batteries shall be required.
2. Sensor: Glass passivated thermistor
3. 7” aluminum case size (case sizes may differ by manufacturer).
4. 9/16” LCD Display with Max/Min Feature and °C/F switchable.
5. Range -40° to 300°F
6. Provide thermowell – see above.
7. 1% or 1°F accuracy whichever is greater, 10 second update interval.
8. Minimum illumination required 10 lux (one candle).
9. Stem shall be industrial aluminum 3.5” or 6” as required to fit application.
10. Basis of design H.O. Trerice model SX-9 Solar Therm.

2.2 BIMETALLIC-ACTUATED DIAL OR DIGITAL THERMOMETERS FOR DUCTWORK

A. Acceptable manufacturers

1. Ashcroft Inc.

2. H.O. Trerice Co.
3. Miljoco Corporation
4. Weiss Instruments, Inc.

B. Direct mounting, bimetallic actuated dial thermometer complying with ASME B40.3
1. Case: 5” diameter dial in stainless steel
2. Element: Bimetallic helix actuated with silicone fluid damping
3. Dial and pointer: White dial face calibrated in °F with black markings and black pointer
4. Window: Hermetically sealed glass lens
5. Connector: Adjustable angle with front recalibration
6. Stem: Stainless steel stem of length to suit installation with zinc plated steel mounting flange for fastening to sheet metal duct
7. Accuracy: ±1% of full scale
8. Basis of Design: H.O. Trerice Company Model B856

C. Digital thermometers
1. Provide digital thermometers similar to digital piping thermometer (see above) except stem shall be air-duct aluminum type, 6” long for ductwork up to 18” width or diameter and 12” long for ductwork larger than 19” complete with duct mounting stem.

2.3 PRESSURE GAUGES FOR PIPING

A. Acceptable manufacturers
1. Ashcroft Inc.
2. H.O. Trerice Co.
3. Miljoco Corporation
4. Weiss Instruments, Inc.

B. Dial type pressure gauge complying with ASME B40.100
1. Case: 4½” diameter black aluminum
2. Pressure Element Assembly: Bronze bourdon tube, lead free for potable water use.
3. Pressure Connection: Brass socket, lead free for potable water use.
4. Movement: Rotary stainless steel
5. Dial: Aluminum with permanently etched black scale calibrated in psi on white background
6. Window: Clear glass
7. Accuracy: ±0.5% of full scale
8. Basis of Design: H.O. Trerice Company Model 500XB

C. Pressure gauge accessories
1. Valves
a. ¼ NPT brass needle valve for a maximum pressure of 600 psig

b. Basis of Design: Weiss #25NVBRLF lead free for potable water use.

2. Impulse dampeners
   a. Brass with ¼ NPT connection
   b. Basis of Design: Weiss #PSN-B-E-25LF, lead free for potable water service.
3. Coil syphons
   a. Seamless brass, schedule 40, ¼ NPT connections
   b. H.O. Trerice Company Series 885

2.4 TEST PLUGS FOR PIPING

A. Acceptable manufacturers
   1. Petersen Products Co.
   2. Sisco Manufacturing Company, Inc.
   3. H.O. Trerice Company
   4. Watts Water Technologies

B. Test plug (for uninsulated pipe)
   1. ¼" by 1½" long brass fitting for receiving ⅛" outside diameter pressure or temperature probe
      a. Core inserts: Two self-sealing rubber valve cores with a color coded cap strap with gasket
         (1) Neoprene (maximum 200°F) at 500 psi
         (2) Nordel (maximum 275°F) at 500 psi
      b. Minimum Pressure and Temperature Rating: 1000 psi at 140°F
      c. Basis of Design: Model 100 (neoprene core) or Model 110 (Nordel core) manufactured by Petersen Products Co. For Potable water systems use lead free plugs, Weiss #BP25-NP-LF (Neoprene core) or #BP25-NR-LF (Nordel core).

C. Test plug (for insulated pipe)
   1. ¼" by 3" long brass fitting for receiving ⅛" outside diameter pressure or temperature probe
      a. Core Inserts: Two self-sealing rubber valve cores with a color coded cap strap with gasket
         (1) Neoprene (maximum 200°F) at 500 psi
         (2) Nordel (maximum 275°F) at 500 psi
      b. Minimum pressure and temperature rating: 1,000 psi at 140°F
      c. Basis of Design: Model 100XL (neoprene core) or Model 110XL (Nordel core) manufactured by Petersen Products Co. For Potable water systems use lead free plugs, Weiss #BP25L-NP-LF (Neoprene core) or #BP25L-NR-LF (Nordel core).

D. Test kit: Furnish one test kit containing one 0-100 psig range pressure gauge, two gauge adapters with ⅛" probes, one 25°F to 125°F low range thermometer, one 0°F to 220°F high range thermometer, and one internally padded and fitted carrying case. Model 1500XL manufactured by Petersen Products Co.

2.5 HYDRONIC INDICATION SYSTEM (COMPOUND PRESSURE GAUGE AND TRUMPET VALVE)

A. Acceptable manufacturers
   1. Flow Conditioning Corp.

B. Hydronic indication systems shall consist of hydronic indicator (compound gauge) and four-port trumpet valve model TV-4 by Flow Conditioning Corp.

1. Hydronic indicator shall have 1% accuracy. Steel case shall be 4½", stem mounted with screwed ring and crystal. Indicator shall have re-calibrator, compound scale calibrated in psi and feet from full vacuum to selected pressure and quick set dial for pressure comparison. Maximum indicator pressure shall exceed pump working pressure by minimum 50 psi.

2. Trumpet valve shall have spring return push button manifold of rugged brass construction with ports for connection to system at indicated points and with test connection for gauge calibration.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Pressure gauges

1. Provide pressure gauges in locations indicated on drawings with a scale range of those shown below such that the range is between 1½ and 2 times the operating pressure of the system.
   a. 0-15 psi
   b. 0-30 psi
   c. 0-60 psi
   d. 0-100 psi
   e. 0-160 psi
   f. 0-200 psi
   g. 0-300 psi
   h. 0-400 psi

B. Thermometers

1. Install liquid-in-glass thermometers in all piping applications in locations shown on drawings and with ranges as shown in the following table:

SYSTEM	RANGE (°F)
Heating hot water	30F to 240F with 2F scale divisions
Domestic hot water	30F to 180F with 2F scale divisions
Chilled water, domestic cold water	0F to 100F with 1F scale divisions
Condenser water	0F to 160F with 2F scale divisions
Steam and condensate	30F to 300F with 2F scale divisions

2. Install bimetallic-actuated dial thermometers with range of -40°F to 110°F with 2°F scale divisions in air ducts in the following locations:
   a. Outside air intake ducts or plenums
   b. Return air ducts
   c. Mixed air ducts or plenums

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install gauges and thermometers in locations where they are easily read from normal operating level.

C. Thermometers for pipes

1. Install direct-mounting thermometers and adjust vertical and tilted positions.

2. Install thermometers in piping systems in thermowells with socket extending to center of pipe or a minimum of 2" into fluid for piping less than 4". Enlarge pipes smaller than 2½" for installation of thermowells.

D. Thermometers for ducts

1. Install direct-mounting thermometers and adjust vertical and tilted positions.

2. Install thermometers in air duct systems on flanges and attach to duct with screws.

E. Pressure gauges for pipes

1. Install direct-mounting pressure gauges in piping tees with pressure gauge located on pipe at most readable position.

2. Provide needle valve and impulse dampener for each pressure gauge installed in pipe carrying all fluids except steam.

3. Provide needle valve and coil siphon fitting for each pressure gauge installed in pipe carrying steam.

F. Install test plugs in tees in piping where indicated.

G. Hydronic indication system for pumps

1. Install hydronic indication system on pumps as indicated on drawings.

2. Hydronic indication system shall be reliably and permanently attached to piping with heavy bracket at convenient height. Connect the system to the following ports:

a. Upstream of strainer/suction diffuser

b. Downstream of strainer/suction diffuser (pump inlet).

c. Pump discharge

d. Downstream of discharge isolation valve

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 20\20 0519-Meters and Gauges for M-P-FP.docx

SECTION 20 0529
HANGERS AND SUPPORTS FOR MECHANICAL, PLUMBING AND FIRE SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Hangers and supports specifically applicable to Divisions 20, 21, 22, and 23, including:

1. Pipe hangers and supports
2. Duct hangers
3. Equipment hangers and supports
4. Thermal hanger shields and inserts
5. Upper attachments
6. Multiple pipe supports
7. Hanger rods
8. Roof supports
9. Miscellaneous materials

1.2 CODES AND STANDARDS

A. American Society of Mechanical Engineers (ASME)

1. ASME B31.1: Power Piping
2. ASME B31.5: Refrigeration Piping
3. ASME B31.9: Building Services Piping

B. American Society for Testing and Materials (ASTM)

1. ASTM A1011: Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability *(Formerly ASTM A570)*
2. ASTM A123: Specification for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strip
3. ASTM A36: Steel Plates, Shapes and Bars
4. ASTM A653: Specification for Steel Sheet, Zinc-Coated by the Hot-Dip Process
5. ASTM B633: Specification for Electrodeposited Coatings of Zinc on Iron and Steel
6. ASTM C150: Portland Cement
7. ASTM C404: Uniformly Graded Natural Sand
8. ASTM E-814: Fire Tests of Through-Penetration Fire Stops

C. American Welding Society (AWS)

1. Specifications for Qualification of Welding Procedures and Welders

D. American Water Works Association (AWWA)

E. Building Officials and Code Administrators International (BOCAI)

1. BOCA: National Building Code
2. BOCA: National Mechanical Code

F. International Conference of Building Officials (ICBO)

1. ICBO: Uniform Building Code

G. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)

1. MSS SP 58: Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation
2. MSS SP 89: Pipe Hangers and Supports - Fabrication and Installation Practices

H. National Fire Protection Association (NFPA)

1. NFPA 13: Standard for the Installation of Sprinkler Systems
2. NFPA 14: Standard for the Installation of Standpipe and Hose Systems
3. NFPA 101: Code for Safety to Life from Fires in Buildings and Structures

I. Southern Building Code Congress International (SBCCI)

1. SBCCI: Standard Building Code

J. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)

1. SMACNA: HVAC Duct Construction Standards, Metal and Flexible

K. Underwriters Laboratories, Inc. (UL)

1. UL 1479: Fire Tests of Through Penetration Firestops and Building Joint Systems

L. Factory Mutual (FM)

1.3 QUALITY ASSURANCE

A. Supports for mechanical and plumbing piping: Provide products in compliance with MSS Standards:

1. Provide pipe hangers and supports of which materials, design and manufacture comply with MSS SP-58.
2. Select and apply pipe hangers and supports, complying with MSS SP-58.
3. Fabricate and install pipe hangers and supports, complying with MSS SP-89.
4. Terminology used in this section is defined in MSS SP-90.

B. Supports for sprinkler piping: Provide products which are UL listed and FM approved and in conformance with NFPA 13.

C. Supports for standpipes: Provide products which are UL listed and FM approved and in conformance with NFPA 14.

D. Structural steel welding qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

E. Pipe welding qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

1.4 SUBMITTALS

A. Preconstruction – Prior to construction provide the following in accordance with Division 01 and Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Product data: Submit product data on all hanger and support devices, including shields and attachment methods. Product data to include, but not limited to materials, finishes, approvals, load ratings, and dimensional information.

B. Contract Closeout – At contract closeout provide the following in accordance with Division 01 and Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Warranties

1.5 DELIVERY, STORAGE AND HANDLING

A. Accept materials on site in original factory packaging, labeled with manufacturer's identification.

B. Protect from weather and construction traffic, dirt, water, chemical, and damage, by storing in original packaging.

PART 2 - PRODUCTS

MSS Types are shown in diagrams at end of document for reference.

2.1 PIPE HANGERS AND SUPPORTS

A. Acceptable manufacturers

1. B-Line Systems, Inc.
2. Fee and Mason Manufacturing Company
3. Anvil International
4. Hilti

B. Construction

1. General service
    a. Interior insulated pipe: Carbon steel with plain primer finish
    b. Exterior insulated pipe: Carbon steel with hot-dip galvanized finish after fabrication
    c. Interior uninsulated steel, cast iron, ductile iron and plastic pipe: Carbon steel with plain primer finish
    d. Exterior uninsulated steel, cast iron, ductile iron and plastic pipe: Carbon steel with hot-dip galvanized finish after fabrication
    e. Interior uninsulated copper pipe: Carbon steel with copper plated or epoxy coated finish
    f. Exterior uninsulated copper pipe: Carbon steel with copper plated or epoxy coated finish
    g. Interior glass pipe: Carbon steel with plastic or vinyl coated finish
    h. Interior insulated pipe: Stainless steel with plain finish
    i. Exterior insulated pipe: Stainless steel with plain finish
    j. Interior uninsulated steel, cast iron, ductile iron and plastic pipe: Stainless steel with plain finish
    k. Exterior uninsulated steel, cast iron, ductile iron and plastic pipe: Stainless steel with plain finish

l. Interior uninsulated copper pipe: Stainless steel with epoxy coated finish

m. Exterior uninsulated copper pipe: Stainless steel with epoxy coated finish

n. Interior glass pipe: Stainless steel with plastic or vinyl coated finish

C. Piping system classification

1. Type A-1 Hot Systems (120°F - 450°F)
   a. Heating water
2. Type B Ambient Systems (60°F - 119°F)
   a. Condenser water
   b. Sanitary sewer and vent
   c. Fire suppression
3. Type C-1 Cold Systems (33°F - 59°F)
   a. Chilled water
   b. Domestic cold water

Pipe supports shall be provided as indicated in the table below.

PIPE HANGER AND SUPPORT MSS TYPES – PART 1

Class		**A-1**				**B**			
Pipe Size		**≤2"**		**>2"**		**≤2"**		**>2"**	
Insulation[1]		**YES**	**NO**	**YES**	**NO**	**YES**	**NO**	**YES**	**NO**
Horizontal Pipe Attachments	Steel Clips	24 w/ 39	24 & 26	24 w/ 39	24 & 26	24 & 26	24 & 26	24 & 26	24 & 26
	Malleable Iron Rings	N/A	6, 11, & 12	N/A	6, 11, & 12	N/A	6, 11, & 12	N/A	6, 11, & 12
	Steel Bands	1 w/ 40	1	1 w/ 39	1	1 w/ 40	1	1 w/ 40	1
	Steel Clamps	2 & 3	3 & 4	2 & 3	3 & 4	3 & 4	3 & 4	3 & 4	3 & 4
	Cast Iron Hanging Rolls	N/A	N/A	41 & 43 w/ 39	41 & 43	N/A	N/A	41 & 43 w/ 39	41 & 43
	Cast Iron Supporting Rolls	N/A	N/A	44, 45, & 46 w/ 39	44, 45, & 46	N/A	N/A	44, 45, & 46 w/ 39	44, 45, & 46
	Steel Trapezes	59 w/ 40	59	59 w/ 39	59	59 w/ 40	59	59 w / 39	N/A
	Steel Protection Saddles and Shields	39 & 40	N/A	39	N/A	40	N/A	39	N/A
	Steel or Cast-Iron Stanchions	36, 37, & 38 w/ 40	36, 37, & 38	36, 37, & 38 w/ 39	36, 37, & 38	36, 37, & 38 w/ 40	36, 37, & 38	36, 37, & 38 w/ 39	36, 37, & 38
	Steel Welded Attachments	35[2]		35[2]		35[2]		35[2]	

1. Hangers on insulated systems shall incorporate protection saddles or shields or shall be clamped or welded to the pipe and project through the insulation to provide external attachment.
2. The design shall be in accordance with MSS SP-58.

PIPE HANGER AND SUPPORT MSS TYPES – PART 2									
Class		**C-1**				**C-2**			
Pipe Size		**≤2"**		**>2"**		**≤2"**		**>2"**	
Insulation[1]		**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Horizontal Pipe Attachments	Steel Clips	26 w/40	24 & 26	26 w/40	24 & 26	N/A	N/A	N/A	N/A
	Malleable Iron Rings	N/A	6, 11, & 12	N/A	6, 11, & 12	N/A	N/A	N/A	N/A
	Steel Bands	1 w/ 40	1	1 w/ 40	1	1 w/ 40	1	1 w/ 40	1
	Steel Clamps	3 & 4	3 & 4 w/ 40	3 & 4	3 & 4 w/ 40	N/A	3 & 4	N/A	3 & 4
	Cast Iron Hanging Rolls	N/A	N/A	41 & 43 w/ 40	41 & 43	N/A	N/A	41 & 43 w/ 40	41 & 43
	Cast Iron Supporting Rolls	N/A	N/A	44, 45 & 46, w /39	44, 45, & 46	N/A	N/A	44, 45 & 46, w /39	44, 45, & 46
	Steel Trapezes	59 w/ 40	N/A	59 w/ 40	N/A	N/A	N/A	N/A	N/A
	Steel Protection Saddles and Shields	40	N/A	40	N/A	40	N/A	40	N/A
	Steel or Cast-Iron Stanchions	36, 37, & 38 w/40	36, 37, & 38	36, 37, & 38 w/40	36, 37, & 38	36, 37, & 38 w/40	36, 37, & 38	36, 37, & 38 w/40	36, 37, & 38
	Steel Welded Attachments	35[2]		35[2]		35[2]		35[2]	

1. Hangers on insulated systems shall incorporate protection saddles or shields or shall be clamped or welded to the pipe and project through the insulation to provide external attachment.
2. The design shall be in accordance with MSS SP-58.

PIPE HANGER AND SUPPORT MSS TYPES – PART 3						
Class			A-1	B	C-1	C-2
Vertical Pipe Attachments		Steel Riser Clamps (2-Bolt)	8	8	8	8
		Steel Riser Clamps (4-Bolt) [1]	42	42	42	42
Hanger Rod Fixtures	Steel or Malleable Iron	Turn Buckles	13 & 15	13 & 15	13 & 15	13 & 15
		Swing Eyes	16 & 17	16 & 17	16 & 17	16 & 17
		Clevises	14	14	14	14
Building Structure Attachments	Steel and/or Malleable Iron	Inserts[2]	18	18	18	18
		C-Clamps[3]	19 & 23	19 & 23	19 & 23	19 & 23
		Beam Clamps[4]	20, 21, 25, 27, 28, 29, & 30	20, 21, 25, 27, 28, 29, & 30	20, 21, 25, 27, 28, 29, & 30	20, 21, 25, 27, 28, 29, & 30
		Welded Attachments[1]	22, 57, & 58	22, 57, & 58	22, 57, & 58	22, 57, & 58
		Brackets	31, 32, 33, & 34	31, 32, 33, & 34	31, 32, 33, & 34	31, 32, 33, & 34

1. The design shall be in accordance with MSS SP-58.
2. Refer to 2.7 – Upper Attachments for approved inserts.
3. All C-Clamps shall be provided with a retaining strap held securely to the clamp with a hex nut of locking slot. C-Clamps shall not be used with bar joist structure.
4. Clamps for direct attachment to bar joist structure shall be MSS Type 21 center beam clamp located at the plates along the bottom or top chord of the joist.

2.2 DUCT HANGERS

A. Threaded rod type

1. Duct hangers shall be strips of galvanized steel or round steel rod and shall comply with SMACNA - HVAC Duct Construction Standards, Metal and Flexible.

2. Trapeze and riser supports:
   a. Supports for galvanized-steel ducts: Galvanized-steel shapes and plates
   b. Supports for stainless-steel ducts: Stainless-steel shapes and plates
   c. Supports for aluminum ducts: Aluminum or galvanized steel coated with zinc chromate

3. Attachments: Equipment support shall be directly attached to the building structure utilizing an upper attachment or by utilizing a building structure attachment as indicated in the Pipe Hanger and Support MSS Types – Part 3 table as specified in Division 20 Section "Hangers and Supports for Mechanical, Plumbing, Medical Gas, and Fire Suppression."

B. Cable type

1. Approved manufacturers
    a. Gripple
    b. Duro Dyne
2. Cable type duct hangers shall be an engineered manufactured product supplied as a complete duct hanging system by the manufacturer.
3. Cable type duct hangers shall be provided and installed according to the manufacturer's recommendations.
4. Cable lock
    a. Cable locks shall have an ultimate breaking strength of at least 5 times the published working load limit.
    b. Cable locks shall be constructed of zinc alloy for interior use and stainless steel for exterior use.
    c. Cable locks shall be suitable for use up to 300°F.
5. Cable
    a. Wire rope shall be galvanized steel of $^{3}/_{16}$" or ⅛" diameter.
    b. All wire rope shall have an ultimate breaking strength of at least 5 times the published working load limit.
6. Duct trapeze
    a. Duct trapeze bracket shall include a cable lock which fastens to the duct utilizing sheet metal screws.
    b. Duct trapeze bracket shall have an ultimate breaking strength of at least 5 times the published working load limit.
7. Upper attachments
    a. Stud
        (1) Zinc coated steel threaded rod stud for connection of cable to building structure.
        (2) Stud shall be connected to structure by screwing into a drop-in anchor set in concrete structure or by screwing into a C-clamp (MSS Type 19 or 23) or beam clamp (MSS Types 20, 21, 25, 27, 28, 29, or 30) attached to steel structure.
        (3) Stud shall have an ultimate breaking strength of at least 5 times the published working load limit.
    b. Loop
        (1) Loop cable around building structure and lock utilizing cable lock.

2.3 EQUIPMENT HANGERS AND SUPPORTS

A. Equipment pads

1. Pads shall be nominal 4" high and shall extend a minimum of 4" beyond all equipment and supports while generally conforming to the shape of the equipment.
2. Pads shall be minimum 2500 psi (28-day) concrete reinforced with No. 6 – 6" x 6" welded wire mesh. Pad tops and sides shall be hard troweled smooth with a ¾" bull nose on all external corners. Refer to Division 03 for additional requirements.

3. Furnish galvanized anchor bolts with layout templates for installation in equipment pads. Bolts shall be of the size and quantity recommended by the manufacturer and where vibration isolators are used, they shall be anchor bolted to the equipment pad.

4. Equipment mounted to pads shall be provided with vibration isolation supports indicated in Division 20 Specification "Vibration Isolation for Mechanical, Plumbing, and Fire Suppression"].

B. Hanging equipment

1. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2. Structural steel: ASTM A36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

3. Attachments: Equipment support shall be directly attached to the building structure utilizing an upper attachment or by utilizing a building structure attachment as indicated in the Pipe Hanger and Support MSS Types – Part 3 table as specified in Division 20 Section "Hangers and Supports for Mechanical, Plumbing, Medical Gas, and Fire Suppression."

4. Hanging equipment shall be provided with vibration isolation hangers indicated in Division 20 Specification "Vibration Isolation for Mechanical, Plumbing, and Fire Suppression."

2.4 THERMAL HANGER SHIELDS AND INSERTS

A. Acceptable manufacturers:

1. Clement Support Services, Inc.

2. Pipe Shields, Inc.

3. Value Engineered Products, Inc.

B. Thermal hanger shields shall be used on all horizontal insulated pipe systems at each point of support. Manufactured units shall comply with MSS SP-58 standards and be tested per MSS SP-89 guidelines. Thermal hanger shields shall meet the requirements of MSS Type 40. Each assembly shall closely fit the various pipe diameters and match the outside diameter of the adjoining pipe insulation.

C. Individual components shall not exceed a Flame Spread and Smoke Developed rating of 25/50 per ASTM E84.

D. Safety ratio shall be minimum 3:1.

E. Insulation-insert material for cold piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig. Non-reactive vapor barrier jacket.

F. Insulation-insert material for hot water piping up to 200F: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig minimum compressive strength or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength. All service jacket.

G. Insulation-insert material for steam or other hot piping up to 1200F: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig minimum compressive strength. All service jacket.

H. For trapeze or clamped systems: Insert and shield shall cover entire circumference of pipe.

I. For clevis or band hangers: Insert and shield shall cover lower 180° of pipe.

J. A rolled shield of G-90 galvanized steel shall be an integral part of the unit and shall be of a gauge and length appropriate for the compressive strength of the insert material and type of hanger.

K. Insert length: Extend 2 inches beyond sheet metal shield to provide a complete, neat and vapor-tight seal with the adjoining insulation.

L. Hanger types and span between hangers shall govern the type of thermal hanger shield used.

2.5 UPPER ATTACHMENTS

A. Concrete inserts

1. Continuous
    a. Approved manufacturers
        (1) B-Line Systems, Inc.
        (2) Fee and Mason Manufacturing Company
        (3) Anvil International
        (4) Unistrut
    b. MSS type 18 12 gauge ASTM A1011 SS Grade 33 structural carbon steel cast in place channel with styrofoam insert and end caps with nail holes for attachment to forms.
2. Adjustable spot
    a. Approved manufacturers
        (1) B-Line Systems, Inc.
        (2) Fee and Mason Manufacturing Company
        (3) Anvil International
    b. MSS type 18 malleable iron spot cast in place insert with lateral adjustment
    c. MSS type 18 12 gauge ASTM A1011 SS Grade 33 structural carbon steel cast in place channel with styrofoam insert and end caps with nail holes for attachment to forms
3. Spot
    a. Approved manufacturers
        (1) Cooper B-Line
        (2) Hilti
        (3) Powers
    b. Color coded, six sided cast in place wood knocker insert with nails for attachment to forms, capable of accepting threaded rod from ¼" to ¾" in diameter

B. Concrete and masonry drilled in anchors

1. Wedge anchor
    a. Approved manufacturers
        (1) ITW Red Head
        (2) Hilti
        (3) Powers
    b. Wedge type, torque-controlled, with impact section to prevent thread damage complete with required nuts and washers. Provide anchors with length identification markings conforming to ICC ES AC01 or ICC ES AC193.
    c. Anchor shall be listed with ICC-ES.
    d. Interior use: Carbon steel anchors with zinc plating

e. Exterior use: Stainless steel anchors of AISI Type 304 stainless steel provided with stainless steel nuts and washers of matching alloy group and minimum proof stress equal to or greater than the specified minimum full-size tensile strength of the externally threaded fastener. Stainless steel nuts shall conform to ASTM F594 unless otherwise specified. Avoid installing stainless steel anchors in contact with galvanically dissimilar metals.

f. Basis of Design: Hilti Kwik Bolt 3

2. Screw anchors

a. Approved manufacturers

(1) ITW Red Head

(2) Hilti

(3) Powers

b. Screw type: Pre-drilling of the hole requires a standard ANSI drill bit with the same diameter as the anchor and installing the anchor will be done with an impact wrench. Provide anchors with a diameter and anchor length marking on the head.

c. Anchor shall be listed with ICC-ES.

d. Interior use: Carbon steel anchors with zinc plating

e. Basis of Design: Hilti Kwik-Hus

3. Drop-in anchor

a. Approved manufacturers

(1) ITW Red Head

(2) Hilti

b. Drop-in, shell type internally threaded anchor with expansion cone insert and flush embedment lip

c. Anchor shall be listed with ICC-ES.

d. Interior use: Carbon steel anchors with zinc plating

e. Exterior use: Stainless steel

f. Anchors shall be listed by ICC-ES

g. Basis of Design: Hilti HDI

C. Metal deck

1. Metal deck with concrete topping on structural steel: Support hangers from 1½" x 1½" x ⅛" x 12" long angles set on deck over holes drilled in deck and across corrugations, before pouring of concrete topping or from beam clamps fastened to structural steel

2. Metal deck on beams: Support hangers from clamps fastened to beams or to auxiliary steel between beams

3. Metal deck on bar joist: Support hangers from MSS type 21 center beam clamps fastened at the plates along the top or bottom chord or to auxiliary steel between bar joists

D. Precast concrete

1. Precast concrete with concrete topping or roof insulations: Support hangers from 4" x 4" x ¼" thick drilled steel plates set on deck over drilled holes before pouring of concrete topping or placing of roof insulation or from cinch anchors located in the precast deck

2.6 MULTIPLE PIPE SUPPORT SYSTEMS

A. Acceptable manufacturers

1. Cooper B-Line
2. Anvil International
3. Unistrut Corporation

B. Multiple pipe supports: Pipe supporting elements mounted to cold formed 12 gauge strip steel channel framing with thermoset acrylic finish. Provide specified pipe supporting elements to keep pipe in alignment and allow for expansion. Provide all channel nuts and accessories required to mount pipe supporting elements. Model P1000 by Unistrut.

C. Strut type trapeze hangers shall be limited to copper tubing systems less than 2" diameter and selected for maximum deflection of ¼".

D. Provide tubing clamps at each pipe support.

1. Provide insulation couplings with strut clamp for all insulated piping. Insulation thickness to match that specified for piping.
2. Provide cushion inserts for uninsulated tubing.

E. Select hanger rods for two times the trapeze loads but not less than ⅜" diameter.

F. Secure hanger rod with square washers and locking nuts on top and bottom of strut.

2.7 HANGER RODS

A. Dry or non-corrosive environments: Continuously threaded carbon steel or 304 stainless steel rods and hardware.

B. Moist or corrosive environments:

1. Continuously threaded zinc plated (hot dipped galvanized) carbon steel rods and hardware with threads painted with zinc-chromate primer after installation.
2. Continuously threaded 304 stainless steel rods and hardware.

2.8 MISCELLANEOUS MATERIALS

A. Metal framing: Provide products complying with NEMA STD ML 1.

B. Steel plates, shapes and bars: Provide products complying with ASTM A 36.

C. Cement grout: Portland cement (ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C 404, Size No. 2). Mix at a ratio of 1.0 part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration.

PART 3 - EXECUTION

3.1 PIPE HANGERS AND SUPPORTS

A. Hanger and support installation

1. Pipe hanger installation: Comply with MSS SP-58 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

2. Trapeze pipe hanger installation: Comply with MSS SP-58 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
    a. Pipes of various sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
    b. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
3. Thermal-hanger shield installation: Install in pipe hanger or shield for insulated piping.
4. Thermal hanger shields and inserts: Install in accordance with manufacturer's instruction. Seal jacket to adjacent insulation and provide continuous vapor barrier.
5. Fastener system installation:
    a. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
    b. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
6. Pipe stand installation:
    a. Pipe stand types except curb-mounted type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
    b. Curb-mounted-type pipe stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb.
7. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
8. Equipment support installation: Fabricate from welded-structural-steel shapes.
9. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
10. Install lateral bracing with pipe hangers and supports to prevent swaying.
11. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, 2-1/2" and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
12. Load distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
13. Pipe slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

B. Hanger and support spacing
    1. Pipe shall be adequately supported by pipe hanger and supports specified in Part 3. Hangers for insulated pipes shall be sized to accommodate insulation thickness.

2. Horizontal steel piping shall be supported in accordance with MSS SP-58 Tables 3, 4, and 5, excerpts of which follow below:

MAXIMUM HORIZONTAL PIPE HANGER AND SUPPORT SPACING WITHOUT MSS TYPE 40 SHIELDS (FEET)									
Nominal Pipe or Tube Size	Standard Weight Steel Pipe		Copper Tube		Fire Protection	Ductile Iron Pipe	Cast Iron Soil	Glass	Plastic
	Water Service	Vapor Service	Water Service	Vapor Service					
¼	7	8	5	5	Follow require-ments of the NFPA.	20 feet maximum spacing; minimum of one hanger per pipe section close to the joint behind the bell and at change of direction and branch connections. For pipe sizes 6 inches and under subjected to loadings other than weight of pipe and contents, the span shall be limited to the maximum spacing for water service steel pipe.	10 feet maximum spacing; minimum of one hanger per pipe section close to joint on the barrel and at change of direction and branch connections.	8 feet maximum spacing, follow manufacturer's recommendations.	Follow pipe manufacturer's recommenda-tions for material and service condition.
⅜ – ½	7	8	5	6					
¾	7	9	5	7					
1	7	9	6	8					
1¼	7	9	7	9					
1½	9	12	8	10					
2	10	13	8	11					
2½	11	14	9	13					
3	12	15	10	14					
4	14	17	12	16					
5	16	19	13	18					
6	17	21	14	20					
8	19	24	16	23					
10	22	26	18	25					
12	23	30	19	28					
14	25	32	—	—					
16	27	35	—	—					
18	28	37	—	—					
20	30	39	—	—					
24	32	42	—	—					
30	33	44	—	—					

MINIMUM ROD DIAMETER FOR SINGLE RIGID ROD HANGERS		
	Steel, Ductile Iron, and Cast Iron Pipe	Copper, Glass, and Plastic Pipe
Nominal Pipe or Tubing Size (inches)	Nominal Rod Diameter (inches)	Nominal Rod Diameter (inches)
¼ - 2	⅜	⅜
2½ - 3	½	½
4 - 5	⅝	½
6	¾	⅝
8	¾	¾
10 - 12	⅞	¾
14 - 18	1	—
20 - 24	1¼	—

MAXIMUM HORIZONTAL PIPE HANGER, SUPPORT, AND SHIELD SPACING WITH MSS TYPE 40 SHIELDS (FT)			
Standard Weight Steel Pipe			
Nominal Pipe Size (inches)	**Shield Length (inches)**	**Shield Thickness (gage)**	**Hanger and Support Spacing (feet)**
½ - 1¼	12	18	7
1½	12	18	9
2 - 3	12	18	10
4	12	16	10
5 - 6	18	16	10
8 - 14	24	14	10
16 - 24	24	12	10
Copper Tubing			
Nominal Pipe Size (inches)	**Shield Length (inches)**	**Shield Thickness (gage)**	**Hanger and Support Spacing (feet)**
¼ – ¾	12	18	5
1	12	18	6
1¼	12	18	7
1½ - 2	12	18	8
2½	12	18	9
3	12	18	10
4	12	16	10
5 - 6	18	16	10
8	24	14	10

3.2 DUCT HANGERS

A. Duct hanging system shall be at contractor's option. Comply with SMACNA - HVAC Duct Construction Standards, Metal and Flexible and meet with approval of Engineer.

B. Vertical ducts through floor slabs: Are to be supported on two sides by galvanized steel angles bolted to duct and resting on floor slab. Supporting angles are to be bolted to floor, ceiling or wall to prevent vibration.

C. Vertical ducts in open shafts: Provide additional galvanized structural steel members to span openings for support of ducts and angles at each floor.

D. Ducts along walls: Are to have supports spaced not more than 8 feet apart.

E. Provide hangers at the center of every ell or change in direction of horizontal ductwork.

F. Wire strap or perforated hangers will not be permitted.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports. Ensure that lateral motion under equipment at start-up, shut-down or when unbalanced is no more than ¼ inch.

D. Provide templates, anchor bolts and accessories for mounting and anchoring equipment.

E. Provide rigid anchors for pipes after vibration isolation components are installed.

F. Provide corrosion resistant mounting systems when exposed to the elements and other corrosive environments.

3.4 UPPER ATTACHMENTS

A. Provide inserts for placement in formwork before concrete is poured.

B. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.

C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4".

D. Where concrete slabs form finished ceiling, provide inserts to be flush with slab surface.

E. Where inserts are omitted, drill through concrete slab from below and provide thru bolt with recessed square steel plate and nut flush with top of slab.

F. In remodeled areas, provide expanding concrete anchors. Holes for expanding fasteners to be drilled either by carbide bit or by teeth on fastener itself. Expansion shield to be "set" by driving it into hole and expanding it with conical plug.

3.5 ROOF SUPPORTS

A. Verify that roofing system is complete and roof surfaces are smooth, flat, and ready to receive work of this section.

B. Clean surfaces of roof in areas to received supports.

C. Install in accordance with manufacturer's instructions. Provide flexible sheet flash and counterflash with sheet metal and caulk as necessary to make installation water tight. Weld, bolt, or screw roof curbs as instructed by manufacturer.

D. Equipment supports

1. Locate bases and support framing as required by equipment manufacturer. Provide complete and adequate support of equipment whether or not all required devices are shown.

E. Pipe and duct supports

1. Locate bases and support framing as indicated on drawings and as specified herein. Provide complete and adequate support of all piping and ducts whether or not all required devices are shown.

2. The use of wood for supporting piping is not permitted.

3. Provide supports spaced so deflection of piping does not exceed L/240 of span.

4. Install framing at spacing indicated, but in no case at greater than 10 feet (3 m) on center.

3.6 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.7 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 1½".

C. Support adjustment: Provide grout under supports so as to bring piping and equipment to proper level and elevations.

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

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 20\20 0529 Hangers and Supports for M-P-FP.docx

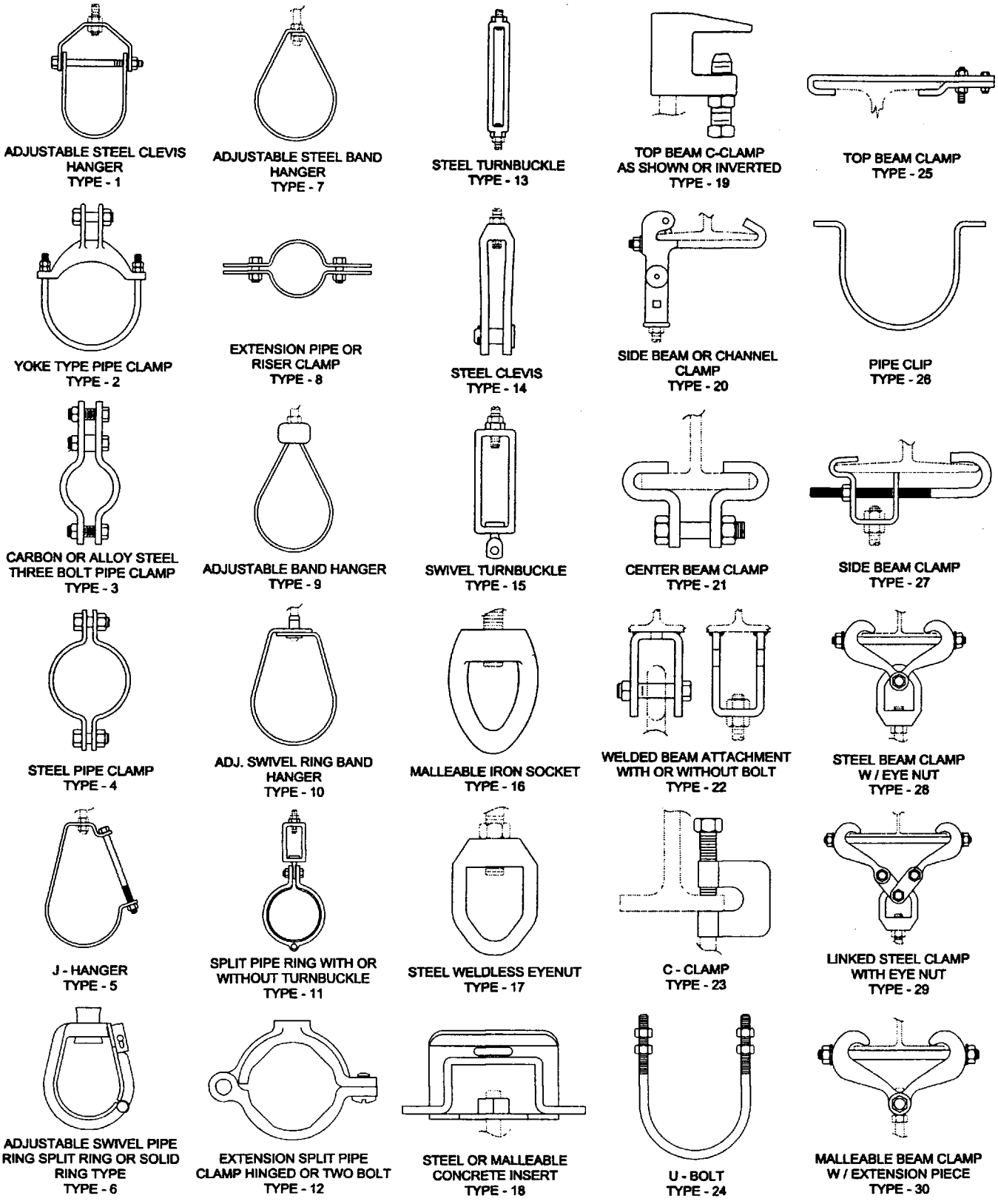

FIGURE 1. TYPE CHART

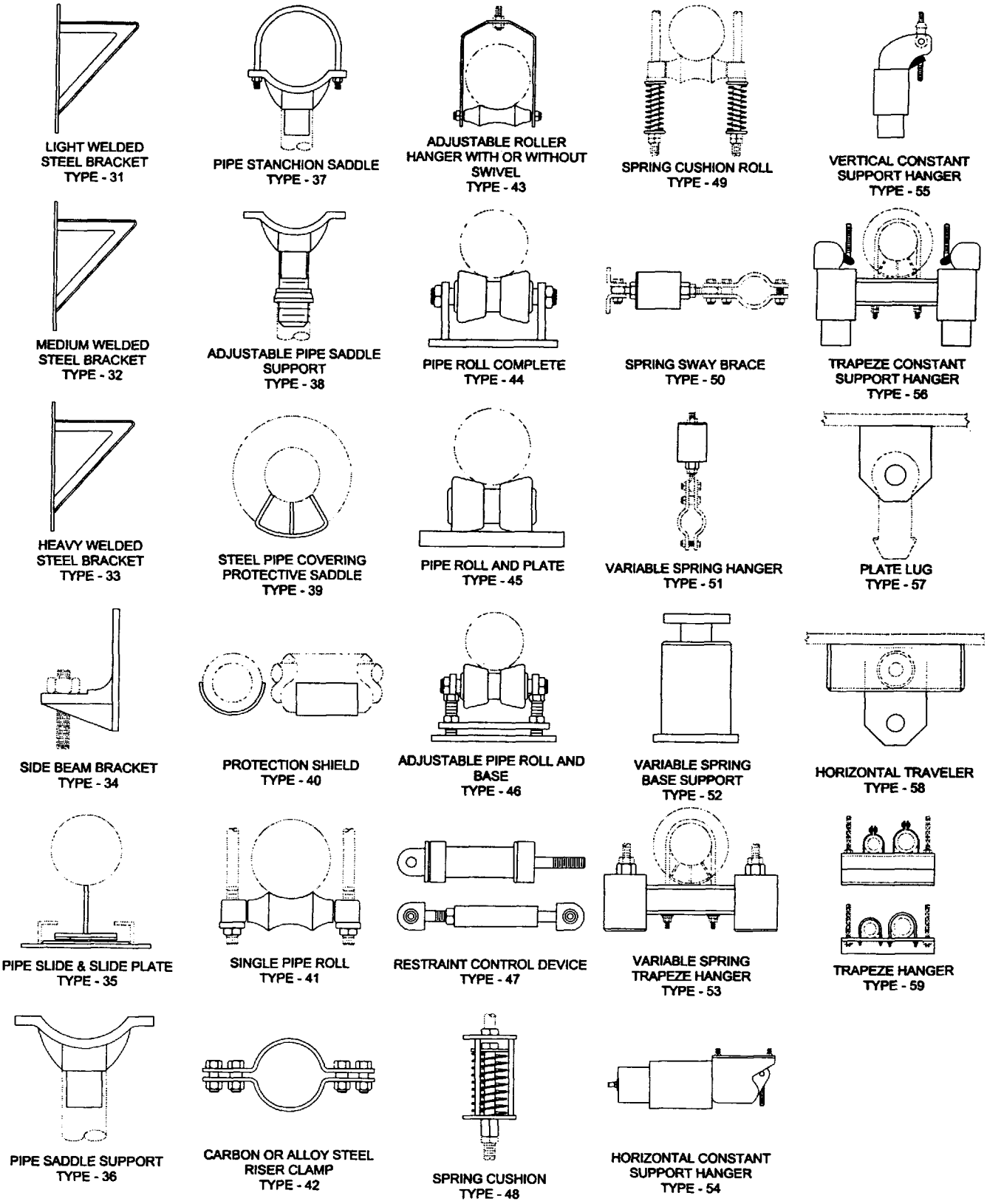

FIGURE 1. TYPE CHART

SECTION 20 0548
VIBRATION ISOLATION FOR MECHANICAL, PLUMBING, AND FIRE SUPPRESSION

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Vibration isolation devices specifically applicable to Divisions 20, 21, 22, and 23, including:

1. Vibration isolators
    a. Neoprene pads (Type VI-1)
    b. Neoprene mounts (Type VI-2)
    c. Free-standing spring isolators (Type VI-3)
    d. Restrained spring isolators (Type VI-4)
    e. Spring hangers (Type H-3)
    f. Pre-compressed spring hangers (Type H-4)
2. Air mounting systems
    a. Air springs/pneumatic isolators (Type VI-AS)
3. Bases
    a. Structural rails (Type Base-A)
    b. Structural steel base (Type Base-B)
    c. Steel and concrete inertia base (Type Base-C)
4. Flexible pipe connectors
    a. EPDM flexible connectors
    b. Stainless steel hose flexible connectors
    c. Bronze hose flexible connectors
5. Horizontal thrust restraints

1.2 DEFINITIONS

A. ICC-ES: ICC-Evaluation Service.

B. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

C. OSHPD: Office of Statewide Health Planning and Development for the State of California

1.3 CODES AND STANDARDS (USE LATEST EDITIONS)

A. American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE)

1. ASHRAE 2011 Applications Handbook Chapter 48, Noise and Vibration Control

B. International Building Codes

1. International Building Code (IBC)

C. Manufacturers Standardization Society (MSS)

1. MSS SP-58-02: Pipe Hangers and Supports – Materials, Design and Manufacture

D. NSF International

1. NSF/ANSI Standard 61 including Annex G: Drinking Water System Components – Health Effects
2. NSF/ANSI Standard 372: Drinking Water System Components – Lead Content

E. Occupational Safety and Health Administration (OSHA)

1. 29CFR 1910.95: Occupational Noise Exposure

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code – Steel."

1.5 SUBMITTALS

A. Preconstruction – Prior to construction provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Prior to submitting product data provide a complete set of shop drawings for all equipment to receive vibration isolation from which the Vibration Isolation Manufacturer's Representative shall base the selection of vibration isolators and design of supplementary bases. The drawings shall include locations of all mechanical equipment to receive vibration isolation devices, operating weight of the equipment to be isolated and the distribution of weight to the support points. Any information regarding the components, spacing, and design approaches comprising the structural systems supporting the equipment shall also be provided to the Vibration Isolation Manufacturer's Representative.
2. Product data: For each type of product, including the following:
    a. Manufacturer name
    b. Isolator type and model number
    c. Material and construction of finish
    d. Dimensional data
    e. Rated load, rated deflection, and overload capacity
    f. For spring vibration isolation devices include:
        (1) Spring diameters
        (2) Static deflection
        (3) Free height
        (4) Compressed spring height and solid spring height
    g. Drawings or schedule indicating which isolators are to be used on which equipment at a particular locations
3. For flexible pipe connectors provide the following:
    a. Maximum allowable temperature and pressure rating
    b. Overall face-to-face length
    c. Live length

d. Hose wall thickness, if applicable
e. Hose corrugations per foot and per assembly, if applicable
f. Fundamental frequency of assembly
g. Braid structure and total number of wires in braid (for stainless steel only)

4. Provide a complete layout of piping to be isolated, including vertical risers, showing size or weight and support points of the piping system to the vibration isolation materials manufacturer for selection and layout of isolation hangers.
5. Welding certificates.
6. Manufacturer's installation and operating manuals.

B. Contract Closeout – At contract closeout provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Operating and Maintenance Data including:
   a. Product data
   b. Installation instructions
   c. Assembly drawings
   d. Replacement parts list
   e. Maintenance and operation instructions
   f. Minimum and maximum airflows
2. Test reports
   a. Manufacturer Installation Inspection Report
   b. Air Mounting System Test Report
3. Warranties

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Acceptable manufacturers

1. Kinetics Noise Control
2. Mason Industries
3. Vibro-Acoustics

B. General requirements applicable to all isolators:

1. Outside spring diameter: Not less than 80% of the compressed height of the spring at rated load.
2. Minimum additional travel distance to solid: 50% of the required deflection at rated load.
3. Lateral stiffness: More than 80% of rated vertical stiffness.
4. Overload capacity: Support 200% of rated load, fully compressed, without deformation or failure.
5. Operating static deflection: Refer to the Applications table in Part 3.

6. Materials:
    a. Indoor: Housings and springs shall be powder coated steel and hardware shall be electro-galvanized.
    b. Outdoor: Hot dip galvanized housings and cadmium plated spring elements in compliance with ASTM A123.
7. Springs shall be color coded to indicate load capacity.

C. Neoprene pads **(Type VI-1)**

1. One layer of ¾" thick neoprene pad of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates; factory cut to sizes that match requirements of supported equipment.
2. Basis of Design: Mason Industries Type Super "W"

D. Neoprene mounts **(Type VI-2)**

1. Double-deflection neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. All metal surfaces shall be neoprene covered and have friction pads both top and bottom.
2. Basis of Design: Mason Industries Type ND

E. Free standing spring isolators **(Type VI-3)**

1. Free standing, laterally stable open (without any housing)
2. Baseplates: Bonded to ¼" thick, neoprene acoustical friction pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
    a. Baseplates shall be provided with bolt holes for any equipment which is to be mounted on framing or structural steel. Bolt holes are not required for equipment being mounted directly on the slab or on a concrete pad.
3. Top plate and adjustment bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment. Adjustment bolts shall be rigidly bolted to the equipment. Installed and operating heights shall be equal.
4. Basis of Design: Mason Industries Type SLF (without bolt holes) or SLFH (with baseplate bolt holes)

F. Restrained spring isolators **(Type VI-4)**

1. Freestanding, steel, open-spring isolators with limit-stop restraint
2. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; baseplate with factory drilled bolt holes for bolting to mounting surface, bonded to ¼" thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation. Vertical limit stops shall be out of contact during normal operation. Horizontal clearance on the sides between the spring assembly and the housing shall be a minimum of ½" to avoid bumping and interfering with the spring action.
3. For equipment located outside, limit stops shall resist wind velocity up to 130 mph.
4. Restraint: Limit stop as required for equipment. Restraining bolts shall have rubber grommets to provide cushioning in the vertical as well as horizontal directions. The hole through the bushing shall be a minimum of ¾" larger in diameter than the restraining bolt.

5. Basis of Design: Mason Industries Type SLR

G. Spring hangers **(Type H-3)**

1. Hangers shall consist of rigid steel frames containing minimum 1¼" thick neoprene elements at the top and a steel spring seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. In order to maintain stability, the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc from side to side before contacting the cup bushing and short circuiting the spring.
    a. Elastomeric element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
    b. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.
2. Basis of Design: Mason Industries Type 30N

H. Pre-compressed spring hangers **(Type H-4)**

1. Hanger specification shall be the same as Type H-3 Spring Hangers, but they shall be pre-compressed and locked at the rated deflection by means of a resilient up-stop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale.
2. Basis of Design: Mason Industries Type PC30N

2.2 AIR MOUNTING SYSTEMS

A. Acceptable manufacturers

1. Kinetics Noise Control
2. Mason Industries

B. Restrained air springs **(Type AS-4)**

1. Assembly: Upper and lower steel sections connected by a replaceable, flexible, nylon-reinforced neoprene element with multiple bellows, with angle-iron frame having vertical-limit stops and channel-section top with leveling adjustment and attachment screws. The housing shall serve as a block during erection. A minimum clearance of ½" shall be maintained around restraining bolts and between the housing and the air spring so as not to interfere with the air spring action. Limit stops shall be out of contact during normal operation. Provide with height saving brackets.
2. Maximum natural frequency: 3 Hz.
3. Operating pressure range: 25 to 100 psig.
4. Burst pressure: At least three times manufacturer's published maximum operating pressure.
5. Leveling valves: Minimum of three required to maintain leveling within ±⅛".
6. Compressor and accessories shall be supplied with the air springs.
7. Basis of Design: Mason Type SLR-MT with LV-206 leveling valves and air compressor as recommended by manufacturer.

2.3 BASES

A. Acceptable Manufacturers

1. Kinetics Noise Control
2. Mason Industries
3. Vibro-Acoustics

B. General requirements applicable to all bases:

1. Design requirements: Lowest possible mounting height with not less than 1" clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
2. Support brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
    a. Provide height saving brackets for floor supported fans.

C. Structural steel base **(Type Base-B)**

1. Factory-fabricated, welded, structural-steel base or rails
2. Structural steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment. Perimeter members shall be steel beams with minimum depth equal to $1/10$ of the longest dimension of the base.
3. Basis of Design: Mason Industries Model WF

D. Steel and concrete inertia base **(Type Base-C)**

1. Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
2. Structural steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall include concrete reinforcing rebars consisting of a minimum of ½" bars welded in place on 6" min centers both ways in a layer 1½" above bottom. Bases shall have shape to accommodate supported equipment. Perimeter members shall be steel beams with minimum depth equal to $1/10$ of the longest dimension of the base.
3. All bases shall have a minimum thickness of 6" or $1/12$ of the longest dimension of the base, whichever is greater.
4. Basis of Design: Mason Industries Model K or BMK (as recommended by the isolator equipment manufacturer for specific equipment)

2.4 EPDM FLEXIBLE SPHERICAL PIPE CONNECTORS

A. Acceptable manufacturers

1. Mason Industries

B. EPDM flexible spherical pipe connectors

1. Spherical pipe connectors shall consist of EPDM body and liner and Kevlar® tire cord reinforcing. The connector shall be of double sphere design with molded-in middle ring and shall allow for compression, elongation and angular movement complete with stabilizing solid steel ring embedded in EPDM body. Stabilizing steel ring shall not be flexible cable wire.
2. Minimum compression shall be 1¼" for sizes up to 6" and 1½" for larger sizes.

3. Rated for a minimum operating pressure and temperature of 250 psi up to 170°F and 215 psi at 250°F.

4. The connector shall be furnished with steel cables or control rods which act as control units as recommended by the manufacturer. Control rods shall incorporate neoprene washer bushings, minimum ½" thick, to prevent acoustical short-circuits via metal-to-metal contact.

5. Basis of Design: Mason Industries Safeflex SFDEJ. No substitutions allowed.

2.5 STAINLESS STEEL AND BRONZE HOSE FLEXIBLE PIPE CONNECTORS

A. Acceptable manufacturers

1. Mason Industries

2. Metraflex

B. Potable water service

1. For potable water service, connectors shall be UL classified in accordance with NSF/ANSI 61 and NSF/ANSI 372 standards.

C. Stainless steel hose flexible pipe connectors

1. Flexible hose shall be 304 stainless steel close pitch annular corrugated hose with a braided 304 stainless steel outer covering.

2. For pipe diameters up to 2½":

a. End connections shall be male carbon steel nipples with NPT threads carbon steel and shall be the minimum lengths as defined below.

b. Rated for a minimum operating pressure of 345 psi at up to 70°F.

c. The overall length shall allow for a minimum of ½" static offset, ¼" intermittent flexing, or per manufacturer's recommendations for additional motion.

PIPE DIAMETER (INCHES)	OVERALL LENGTH (INCHES)
½	10
¾	10
1	10
1¼	10
1½	12
2	14
2½	16

d. Basis of Design: Metraflex Model SST

3. For pipe diameters 3" and larger:

a. End connections to be ANSI class 150 carbon steel plate flanges and shall be the minimum lengths as defined below.

b. Rated for a minimum operating pressure of 170 psi at up to 70°F.

c. The overall length shall allow for ¾" static offset and ⅜" intermittent flexing offset or, per manufacturer's recommendations, for additional motion.

PIPE DIAMETER (INCHES)	FLANGE-TO-FLANGE LENGTH (INCHES)
3	18
4	18
5	18
6	24
8	24
10	24
12	36
14	36
16	36

d. Basis of Design: Mason Model FFL

D. Bronze hose flexible connectors

1. For pipe up to 2":
   a. Connectors shall be constructed of bronze hose and braided outer covering. End connections shall be female copper tube designed for braze connections.
   b. Connectors shall be cleaned, de-greased, and bagged to protect from contamination.
   c. Connectors shall be tested and approved by Underwriters Laboratories for refrigeration service.
   d. Rated for a minimum operating pressure of 190 psi at up to 70°F.
   e. Length shall be per manufacturer's recommendations.
   f. Basis of Design: Metraflex Model BBS

2.6 HORIZONTAL THRUST RESTRAINTS

A. Acceptable manufacturers

1. Kinetics Noise Control
2. Mason Industries
3. Vibro-Acoustics

B. Requirements

1. Horizontal thrust restraints shall consist of a spring element in series with a neoprene molded cup as described in the free-standing spring isolator specification with the same deflection as specified for the vibration isolators or hangers supporting the equipment.
2. The spring element shall be designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of ¼" movement at start and stop. The assembly shall be furnished with a rod and angle brackets for attachment to both the equipment and the duct work or the equipment and the structure.
3. Horizontal restraints shall be attached at the centerline of thrust and symmetrical on either side of the unit.
4. Basis of Design: Mason Industries Type WB

PART 3 - EXECUTION

3.1 EXAMINATION

A. The Contractor shall consult with the local representative of the vibration isolation materials manufacturer, prior to installing any devices, in order to obtain guidance for this project's specific installation requirements.

3.2 APPLICATION

A. Provide vibration isolation devices for equipment per the following schedule.

1. The base type defined below indicates that bases independent of the equipment are required; the base type is not intended to define an equipment-specific factory base. Where "none" is indicated, the equipment and its integral factory-provided base shall be mounted directly on the defined isolators.

ISOLATED EQUIPMENT			SLAB-ON-GRADE OR BASEMENT			UPPER FLOORS (SPANS UP TO 30 FT.)			COMMENT
Type	HP or Size	RPM	Base Type	Vibration Isolator		Base Type	Vibration Isolator		
				Type	Min. Defl. Rating		Type	Min. Defl. Rating	
Centrifugal Fans Up to 22 in. diameter	All	All	Base-B	VI-3	1″	Base-B	VI-3	1″	
Centrifugal Fans ≥24 in. diameter	≤40	≤300	Base-B	VI-3	3″	Base-B	VI-3	4″	
		301 to 500	Base-B	VI-3	2″	Base-B	VI-3	3″	
		≥501	Base-B	VI-3	1″	Base-B	VI-3	1″	
Centrifugal Fans ≥24 in. diameter	≥50	≤300	Base-C	VI-3	3″	Base-C	VI-3	4″	
		301 to 500	Base-C	VI-3	2″	Base-C	VI-3	3″	
		≥501	Base-C	VI-3	1″	Base-C	VI-3	2″	
In-line Centrifugal or Axial, Cabinet Fan, Utility Sets									
Up to 22 in. diameter	All	All	None	Note 1	1″	Base-C	Note 1	1″	1. VI-3 for floor-mounted; H-3 for suspended 2. Provide horizontal thrust restraints
≥24 in. diameter	≤2 in. sp	≤300	Base-B	Note 1	3″	Base-C	Note 1	4″	
		301 to 500	Base-B	Note 1	1″	Base-C	Note 1	3″	
		≥501	Base-B	Note 1	1″	Base-B	Note 1	2″	
≥24 in. diameter	≥2.1 in. sp	≤300	Base-C	Note 1	3″	Base-C	Note 1	4″	
		301 to 500	Base-C	Note 1	2″	Base-C	Note 1	3″	

B. Provide vibration isolation for pipe connected to any isolated equipment per the following table:

PIPE DIAMETER	LOCATION REQUIRING ISOLATED HANGERS (DISTANCE FROM EITHER SIDE OF ISOLATED EQUIPMENT)	SUSPENDED PIPE HANGER TYPE	FLOOR MOUNTED PIPE ISOLATOR TYPE	MINIMUM STATIC DEFLECTION
Up to 4"	First 3 points of support on either side of isolated equipment	H-3	VI-3	Deflection of isolated equipment (2" maximum)
5" to 8"	First 4 points of support on either side of isolated equipment	H-4	VI-4	First three points: Deflection of isolated equipment (2" maximum) Remaining point: 0.75"
10" and over	First 6 points of support on either side of isolated equipment	H-4	VI-4	First three points: Deflection of isolated equipment (2" maximum) Remaining three points: 0.75"
Over 4"	All hung piping connected to isolated equipment and located within a mechanical room with an occupied space directly above	H-4	N/A	First three points: Deflection of isolated equipment (2" maximum) Remaining point: 0.75"
Over 4"	All floor-supported piping connected to isolated equipment and located within a mechanical with an occupied space directly below	N/A	VI-4	First three points: Deflection of isolated equipment (2" maximum) Remaining point: 0.75"
Over 2"	All piping connected to isolated equipment in locations not mentioned above	H-3	VI-3	First three points: Deflection of isolated equipment (2" maximum)

3.3 INSTALLATION

A. General vibration isolation requirements:

1. The vibration isolator manufacturer or the manufacturer's representative shall:
   a. Supply isolators and other related equipment including rails, resilient pipe supports, fan and motor bases and structural steel forms for concrete inertia blocks wherever required.
   b. Be responsible for proper isolator sizing to accomplish the uniform static deflection according to distribution of weight based on factory certified manufacturer's drawings of equipment to be isolated and available information regarding the existing or proposed structural design of the building.
   c. Select springs to operate at ⅔ maximum compression or provide alternate recommendation.
2. Refer to Applications Table for base type, isolator type and required deflection for each type of equipment.
3. All motor-driven mechanical equipment shall be isolated from the building structure by means of vibration isolators. If specific equipment type is not listed in the Application Table, the Contractor shall notify Engineer in writing and obtain specification from Engineer or provide vibration isolation per 2011 ASHRAE Handbook HVAC Applications Table 47.

4. No rigid connections between isolated equipment and building structure shall be made that degrades the vibration isolations systems; electrical conduit connections to isolated equipment shall be looped to allow free motion of isolated equipment. Coordinate with Electrical Contractor and Division 26 Specifications.

B. Requirements for vibration isolation of equipment with spring type vibration isolators:

1. Vibration isolators shall be of such design so that the limit stops are out of contact during normal operation. Should the isolator mounts be “driven solid” leaving no gap for normal isolator operation, the Contractor shall correct the installation by adding vibration isolation hangers to support connected pipe and/or duct or replacing the vibration isolator with a properly selected isolator.

2. For restrained spring isolators with vertical limit stops (to prevent spring extension when weight is removed), provide temporary steel spacers between the upper and lower housings. Housings shall serve as blocking during erection. When the equipment is at full operating weight, the springs shall be adjusted to assume the weight and the spacers removed without changing the installed and operating heights.

3. All equipment shall be adjusted level.

C. Requirement for bases:

1. Set structural steel bases to have 1” clearance between housekeeping pad and base.

2. Steel and concrete bases fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

3. Concrete shall be 3000 psi at 28 days unless noted otherwise. Forms shall be furnished with steel templates to hold the anchor bolt sleeves and anchor bolts while concrete is being poured.

4. Inertia bases shall have frame or pouring form placed on roofing felt or plastic sheeting and filled with concrete. After the equipment is set, mounting adjustment bolts are to be used to both raise and level base to achieve proper operating height.

5. Support pipe elbows entering and leaving pumps from the inertia base.

D. Requirements for flexible pipe connectors:

1. Install flexible pipe connectors on pipes connected to all rotating or reciprocating equipment and equipment supported by vibration isolation.

2. Provide the following types of flexible connectors at equipment:

SYSTEM/LOCATION	FLEXIBLE CONNECTOR TYPE	COMMENTS
Chilled water pumps with vibration isolation	EPDM	
Heating hot water pumps with vibration isolation	EPDM	
Chilled water pumps without vibration isolation	Stainless steel hose	
Heating hot water pumps without vibration isolation	Stainless steel hose	

3. Provide flexible connectors suitable for pressure, temperature and fluid involved.

4. Pump flexible connection shall be sized based on pipe size and not the pump inlet or outlet size.

5. Equipment flexible connectors shall be located between shutoff valves and the equipment.
6. Flexible connectors shall not be used as compensators for piping misalignment. Pipe connections shall be properly center-to-center aligned.

E. Requirements for horizontal piping vibration isolation

1. Provide spring isolators on piping connected to equipment with vibration isolators per the Application Table above.
2. Heat exchangers, air separators and other non-rotating equipment located in piping runs, shall be considered part of the piping system and isolated according to the requirements of the piping to which it is connected. Thus, if the associated piping adjacent to the suspended equipment requires vibration isolation, the equipment shall be isolated with the same vibration isolators used to support the pipe.
3. Hangers shall be located as close to the overhead support steel or structural slab as practical.
4. Piping shall pass through walls and floors without rigid connections to building structures. Penetration points shall be sleeved or otherwise formed to allow passage of piping and maintain spacing required by the UL listed wall fire suppression penetration assembly.

F. Requirements for vertical piping riser supports

1. For all vertical risers, Contractor to provide a fully engineered riser/support isolation system to minimize deflections into the building structure. The Vibration Isolation Equipment Manufacturer Representative shall design and provide required brackets or clamps at riser spring guide and anchor locations. The Contractor to install and adjust isolators under supervision of the isolation equipment manufacturer's representative.
2. Vertical pipe risers shall be designed to support the riser piping filled with fluid. Assigned loads must be within the building design limits at the support points. Neutral central resilient anchors close to the center of the run shall direct movement up and down.
3. The anchors shall be capable of holding an upward force equal to the fluid weight when the system is drained. If one level cannot accommodate this force, anchors shall be located on 2 or 3 adjacent floors. Resilient guides shall be spaced and sized in accordance with the pipe diameter and insulation thickness.
4. Vertical pipe risers shall be supported using vertical pipe riser resilient supports and resilient pipe guides for vertical pipe risers.

G. Requirements for ductwork isolation

1. Ductwork with working static pressures of 4" or greater and connected to isolated equipment shall be isolated with spring isolator type VI-4 (suspended) of H-4 (floor mounted) within the confines of the mechanical equipment room or within 50 ft proximity to mechanical equipment, whichever is greater.

H. On completion of installation of all isolation materials and before start-up of isolated equipment all debris shall be cleared from areas surrounding and from beneath all isolated equipment, leaving equipment free to move on the isolation supports.

3.4 TESTING

A. Manufacturer Installation Inspection Report - Provide report prepared by manufacturer's representative, stating that systems installed and services provided under this Section are in accordance with manufacturer's recommendations and are properly operating.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 20\20 0548-Vibration Isolation for M-P-FP.docx

SECTION 20 0553
IDENTIFICATION FOR MECHANICAL, PLUMBING, AND FIRE SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Identification of mechanical products installed under Divisions 20, 21, 22, and 23 as defined below:

1. Pipe labels
2. Duct labels
3. Equipment labels
4. Valve tags
5. Labels for miscellaneous electrical for temperature controls
6. Underground utility warning tape

1.2 DEFINITIONS

A. AHU: Air-handling unit

B. DI: Deionized

C. OD: Outer diameter based on pipe outside diameter; for the purpose of this specification section, the outer diameter of pipe with insulation includes the insulation.

D. RO: Reverse osmosis

E. TC: Temperature controls

1.3 CODES AND STANDARDS (USE LATEST EDITION)

A. American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME)

1. ANSI/ASME A13.1: Scheme for the Identification of Piping Systems.

B. American Public Works Association (APWA)

1. APWA Uniform Color Code for marking underground utility lines.

C. ASTM International (ASTM)

1. ASTM D882: Standard Test Method for Tensile Properties of Thin Plastic Sheeting
2. ASTM D2103: Standard Specification for Polyethylene Film and Sheeting
3. ASTM D2578: Standard Test Method for Wetting Tension of Polyethylene and Polypropylene Films

D. International Codes

1. International Mechanical Code (IMC)

E. Underwriters Laboratories Inc. (UL)

1. UL E-84-03: Standard Test Method for Surface Burning Characteristics of Building Materials.

1.4 QUALITY ASSURANCE

A. For hydronic piping, conform to ANSI/ASME A13.1 requirements for color, length of color field and letter height.

B. Label fire dampers, smoke dampers and combination fire/smoke dampers per IMC.

C. Stencils shall not be used.

D. Labels/markers listed by the manufacturer as “economy” or “value” shall not be used.

1.5 SUBMITTALS

A. Preconstruction – Prior to construction provide the following in accordance with Division 01 and Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Product Data: For each type of product indicated provide:
    a. Manufacturer’s data including colors, materials, wording, symbols, letter size, methods of attachment and color coding for mechanical and electrical identification of piping, ductwork and equipment.
    b. Submit manufacturer’s installation instructions.
    c. Valve Schedule: Submit proposed valve identification for approval prior to installing valve tags. Include valve tag number, location, system served, and function.

B. Contract Closeout – At contract closeout provide the following in accordance with Division 01 and Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Valve Schedule: Provide “as-installed” valve tag schedule indicating valve tag number, location, system served, and function for Owner at completion of project.
2. Warranties

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Brimar Identification and Safety Products

B. Kolbi Pipe Marker Co.

C. Marking Services Inc. (MSI)

D. Seton Identification and Safety

2.2 PIPE LABELS

A. General requirements for all pipe labels:

1. Preprinted, color-coded, with lettering indicating service, and showing flow direction
2. Pipe label contents:
    a. Include identification of piping service using same designations or abbreviations as used on drawings, pipe size, and arrows indicating flow direction.
    b. Flow-direction arrows: Integral with piping system service lettering or as separate unit on each pipe label to indicate flow direction.

3. Minimum marker width and lettering height shall be per the following table:

PIPE OD	MINIMUM MARKER WIDTH	MINIMUM LETTER HEIGHT
Up to 1"	8"	½"
1⅛" through 2¼"	8"	¾"
2⅜" through 7⅞"	12"	1¼"
8" through 10"	24"	2½"
Larger than 10"	32"	3½"

B. Normal service coiled pipe labels

1. Precoiled, semi-rigid plastic formed with a service temperature range of -40°F to 160°F. Label shall be formed to partially or fully cover the circumference of pipe and to attach to pipe without adhesive.
   a. Where required by pipe OD, provide galvanized straps for indoor applications and stainless steel straps for outdoor application for securing coiled pipe labels.
2. Basis of Design: MSI MS-970

C. Self-adhesive pipe labels

1. Printed plastic with contact-type, permanent-adhesive backing used in association with flow directional arrow tape which wraps fully around the pipe.
2. Basis of Design: MS-900 with MS-900 Flow Directional Arrow Tape

2.3 DUCT LABELS

A. General requirements for all duct labels:

1. Comply with ANSI/ASME A13.1 requirements for color, length of color field and letter height.
2. Duct label contents: Include identification of duct service using same designations or abbreviations as used on drawings, duct size, and an arrow indicating flow direction.

B. Standard duct labels

1. Multilayer, multicolor, plastic labels for mechanical engraving and having predrilled holes for attachment hardware. Able to withstand temperatures up to 160°F. Minimum plastic label thickness shall be as follows:
   a. 1/16" for labels up to 2" x 6"
   b. ⅛" for labels longer than 6" or taller than 2"
2. Label size:
   a. For ductwork and plenums up to 12" in height, duct markers shall be a minimum of 2¼" x 13".
   b. For ductwork and plenums larger than 12" in height, duct markers shall be 4" x 24".
3. Lettering size:
   a. A minimum letter size of ½" high lettering for labels that are normally viewed from distances up to 6'.
   b. If label must be viewed from greater than a 6' distance (e.g. duct is at a high elevation and must be viewed from the floor), the minimum text size is 1½".

c. Secondary lettering shall be two-thirds to three-fourths the size of principal lettering.

4. Contact-type permanent adhesive, compatible with label and with substrate shall be utilized.

5. Basis of Design: MSI Engraved Plastic Signs

2.4 EQUIPMENT LABELS

A. General requirements for equipment labels

1. Label content: Include equipment's Drawing designation or unique equipment number.

2. Equipment label schedule: For each item of equipment to be labeled provide am equipment label schedule on 8½" x 11" bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

3. Label size: Length and width may vary for required label content shall not be less than 2" x 4".

4. Lettering size: A minimum letter size of 1½" high. If label must be viewed from greater than 72" away, the minimum text size is 1½". Secondary lettering shall be two-thirds to three-fourths the size of principal lettering.

B. Indoor equipment labels

1. Multilayer, multicolor, three-ply plastic labels for mechanical engraving and having predrilled holes for attachment hardware. Able to withstand temperatures up to 160°F. Minimum plastic label thickness shall be as follows:

a. 1/16" for labels up to and including either a maximum area of 18 square inches or 6" in lengths.

b. ⅛" for labels larger than either 18 square inches in area or 6" in length.

2. Contact-type permanent adhesive, compatible with label and with substrate shall be utilized.

3. Basis of Design MSI Engraved Plastic Equipment Tags & Signs

2.5 VALVE TAGS

A. 2" diameter or 2" square 19 gauge valve tags each marked with ¼" abbreviated service indicator on the top line and ½" numbers below (example: HTG/309).

1. Tag material: Minimum 19 gauge (0.032") brass with predrilled or stamped holes for attachment hardware.

2. Fasteners: Brass S-hook.

2.6 LABELS FOR MISCELLANEOUS ELECTRICAL FOR TEMPERATURE CONTROLS

A. Self-adhesive pipe labels

1. Printed plastic with contact-type, permanent-adhesive backing

2. Black text on orange labels

3. Basis of Design: MSI-900 Conduit and Electrical ID

PART 3 - EXECUTION

3.1 APPLICATION

A. Piping label types shall be as follows:

APPLICATION	LABEL TYPE
Hydronic, plumbing, and fire suppression pipe less than 6" OD located indoors, except steam or condensate pipe (e.g. chilled water, condenser water, heating hot water, domestic hot water recirculation, domestic cold water, domestic hot water)	Normal service coiled pipe labels with coil-on fastening
Pipe 6" OD and larger located indoors, except steam or condensate pipe (e.g. chilled water, condenser water, heating hot water, domestic hot water recirculation, domestic cold water, domestic hot water)	Normal service coiled pipe labels with strap-on fastening **or** Self-adhesive pipe labels with full wrap-around tape

B. Pipe label colors shall be as defined below; where a pipe fluid is not shown provide colors per ASME A13:

PIPE FLUID	BACKGROUND COLOR	LETTERING COLOR
Cold water systems including, but not limited to, chilled, condenser, domestic cold, and RO water.	Green	White
Hot water system including, but not limited to, heating hot water and domestic hot water	Yellow	Black
Steam and associated condensate systems	Yellow	Black
Fire-quenching fluids including fire sprinkler water	Red	White
Natural gas and other flammable liquids	Yellow	Black

C. Duct label colors shall be as follows:

DUCT AIR TYPE	BACKGROUND COLOR	LETTERING COLOR
Supply air	Blue	White
Outside, return and relief air	Green	White
Exhaust air (all types)	Yellow	Black

3.2 INSTALLATION

A. General installation requirements

1. 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.

2. Install marking in accordance with manufacturer's installation instructions.

3. Install identification prior to installation of acoustic ceiling and similar removable concealment.
4. Provide custom pipe and duct labels when standard labels meeting the requirements of this specification are not available.

B. Additional requirements for pipe labels

1. Install pipe labels on all Divisions 20, 21, 22, and 23 pipe shown on drawings. Contractor shall coordinate between piping systems so that each pipe system is labeled with a distinct name.
    a. Labeled pipes include, but are not necessarily limited to, chilled water supply/return, condenser water supply/return, heating hot water supply/return, steam, condensate return, boiler feed, domestic cold water, domestic hot water, domestic hot water recirculation, tempered water, medical air, medical vacuum, oxygen, lab air, lab vacuum, sprinkler, fire main, acid waste and acid vent.
2. Labels shall indicate pipe content as shown on drawings (e.g. REHEAT HOT WATER SUPPLY, CHILLED WATER SUPPLY) and direction of fluid flow. For steam and condensate less than 100 lb operating pressure, indicate ”LOW PRESSURE STEAM” or “MEDIUM PRESSURE STEAM” as indicated on drawings. For steam and condensate operating at 100 lbs or greater, labels shall indicate the system working pressure (e.g.130 LB STEAM).
3. Install pipe labels after application of insulation and/or final painting.
4. Label all piping, both exposed and concealed, including piping located in accessible maintenance spaces such as shafts, tunnels, and plenums. Locate labels as follows:
    a. Near each valve and control device.
    b. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
    c. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
    d. At access doors, manholes, and similar access points that permit view of concealed piping.
    e. Near major equipment items and other points of origination and termination.
    f. Space at maximum intervals of 25 feet along each straight portion of pipe. Each straight run must have an individual label regardless of its length.
5. Install in clear view and align with axis of piping.
6. Where self-adhesive pipe labels are allowed, wrap each end of the pipe labels with directional tape. Directional tape shall be wrapped circumferentially completely around pipe at both ends of the pipe marking label. Arrow tape color shall match marker color.
    a. Tape shall be 1” wide on piping up to and including 10” OD and 2” wide on piping larger than 10” OD.

C. Additional requirements for duct labels

1. Duct labels shall indicate the air handling equipment serving the duct and the area served (e.g. “AHU-7 3RD FLOOR SUPPLY AIR, EF-3 KITCHEN EXHAUST”, etc.).
2. Label ductwork at the following locations:
    a. In each space where ducts are exposed or concealed by removable ceiling system at maximum intervals of 50 feet
    b. Entering and leaving an air handling unit
    c. Entering and leaving any supply, return or exhaust fan

d. At each side of a penetration of structure or enclosure

3. At each duct access door located in ductwork or housings, provide label indicating purpose of access (to what equipment) and other maintenance and operating instructions and appropriate safety and procedural information.
    a. Where access doors are concealed, such as above acoustical ceilings, provide secondary plasticized tags in visible locations if desired and acceptable to the Owner.

D. Additional requirements for equipment labels

1. Provide labeling for all mechanical and plumbing equipment including but not limited to the equipment defined below. Equipment label text shall provide the name and number of the identified equipment, as well as the system or location which the equipment serves. Indicate when equipment is stand-by. Examples of the required text is given below:
    a. AHUs: (e.g. AHU-1, air handling unit serving 1st floor west)
    b. Fans: (e.g.TE-1, toilet exhaust for lobby toilets)
    c. Pumps: (P-1, heating hot water pump)
    d. Variable frequency drives: (VFD-1, VFD for AHU-1 supply fan)
    e. Heat exchangers: (HX-1 heat exchanger for reheat hot water loop)
    f. Humidifiers
    g. Temperature control panels and other major control equipment
2. Confirm equipment numbering scheme with Owner; provide different numbering scheme than that shown on drawings if required by Owner. If Owner has no preference, number as shown on drawings.

E. Additional requirements for valves tags

1. Customize tags in accordance with system. Coordinate the valve system numbering sequence with the Owner.
2. Install tags on all valves and control devices located in main and branch piping systems.
    a. Exceptions: Check valves, convenience and lawn-watering hose connections. List tagged valves in a valve schedule. Identify valves in main and branch piping with tags.
3. Secure tags to valves in visible position using brass jack or bead chain.
4. Provide valve chart and schedule at completion of project. Provide in aluminum frame with clear plastic shield, and install at Owner-directed location.

F. Additional requirements for labels for miscellaneous electrical for temperature controls

1. Identify temperature control conduit and electrical conduit installed as part of the temperature control work.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 20\20 0553-Identification for M-P-FP.docx

SECTION 20 0700
THERMAL INSULATION FOR MECHANICAL, PLUMBING AND FIRE SUPPRESSION

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Products furnished and installed under this section:

1. Pipe insulation
2. Pipe insulation jackets
3. Duct and equipment insulation
4. Duct and equipment insulation jackets
5. Insulation accessories

B. Repairs to all existing insulation cut or damaged by work performed under this Contract.

1.2 DEFINITIONS

A. ASJ: All Service Jacket (no outer film)

B. ASJ+: All Service Jacket with an outer film layer leaving no paper exposed.

C. Concealed applications: Insulation on ductwork, piping or equipment that is located in a concealed area not visible to the building occupants such as behind walls and above ceilings.

D. Ductwork insulation: Thermal insulation applied to limit or reduce heat transmission to or from a duct system.

E. EPA: Environmental Protection Agency.

F. Equipment insulation: Thermal insulation applied to limit or reduce heat transmission to or from a piece of equipment that is part of a plumbing, heating or cooling system.

G. Exposed applications: Insulation on ductwork, piping or equipment that is located in an area such that is visible by the building occupants such as within a mechanical room or located in a space where there is no ceiling and all ductwork and piping is exposed.

H. FSK: Foil Scrim Kraft; jacketing

I. Insert: Spacer placed between the equipment support system and the equipment to allow for the space required for insulation.

J. Insulation shield: Buffer material placed between the equipment support system and the insulation to prevent the insulation material from being crushed.

K. Jacket: Protective covering over insulation; may be factory-applied or field-applied to provide additional protection; of such materials as canvas, polyvinyl chloride (PVC), aluminum or stainless steel.

L. Piping insulation: Thermal insulation applied to limit or reduce heat transmission to or from a piping system.

M. PSK: Poly Scrim Kraft; jacketing

N. PVC: PolyVinyl Chloride

O. SSL: Self-Sealing Lap

P. SSL+: Self-Sealing Lap with Advanced Closure System

Q. Thermal conductivity (K value): Units of Btu-inch/hour per square foot per °F.

R. Vapor retarder jacket: Insulation jacket material which impedes the transmission of water vapor.

S. WHO: World Health Organization

1.3 CODES AND STANDARDS (USE LATEST EDITION)

A. ASTM International (ASTM)

1. ASTM A167: Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
2. ASTM A240: Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
3. ASTM B209: Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate).
4. ASTM C165: Test Method for Measuring Compressive Properties of Thermal Insulation
5. ASTM C177: Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus.
6. ASTM C195: Standard Specification for Mineral Fiber Thermal Insulating Cement.
7. ASTM C196: Specification for Expanded or Exfoliated Vermiculite Thermal Insulating Cement.
8. ASTM C335: Standard Test Method for Steady-State Heat Transfer Properties of Pipe Insulation
9. ASTM C449: Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
10. ASTM C450: Practice for Fabrication of Thermal Insulation Fitting Covers for NPS Piping, and Vessel Lagging
11. ASTM C518: Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
12. ASTM C533: Specification for Calcium Silicate Block and Pipe Thermal Insulation
13. ASTM C534: Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
14. ASTM C547: Standard Specification for Mineral Fiber Preformed Pipe Insulation.
15. ASTM C552: Specification for Cellular Glass Thermal Insulation.
16. ASTM C553: Mineral Fiber Blanket and Felt Insulation (Industrial Type).
17. ASTM C585: Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).
18. ASTM C612: Mineral Fiber Block and Board Thermal Insulation.
19. ASTM C795: Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
20. ASTM C871: Test Methods for Chemical Analysis of Thermal Insulation Materials for Leachable Chloride, Fluoride, Silicate, and Sodium Ions.

21. ASTM C921: Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
22. ASTM C1136: Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
23. ASTM C1290: Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts.
24. ASTM C1393: Specification for Perpendicularly Oriented Mineral Fiber Roll and Sheet Thermal Insulation for Pipes and Tanks.
25. ASTM C1617: Standard Practice for Quantitative Accelerated Laboratory Evaluation of Extraction Solutions Containing Ions Leached from Thermal Insulation on Aqueous Corrosion of Metals"
26. ASTM D1644: Test Methods for Nonvolatile Content of Varnishes.
27. ASTM D1784: Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
28. ASTM E84: Standard Test Method for Surface Burning Characteristics of Building Materials.
29. ASTM E96: Standard Test Methods for Water Vapor Transmission of Materials.
30. ASTM E136: Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C
31. ASTM F249: Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor.

B. ASHRAE
   1. ASHRAE Standard 90.1: Energy Standard for Buildings Except Low-Rise Residential Buildings.

C. Code of Federal Regulations
   1. 40 CFR - Protection of Environment, Chapter I - Environmental Protection Agency, Part 59 - "National Volatile Organic Compound Emission Standards for Consumer and Commercial Products," Subpart D - "National Volatile Organic Compound Emission Standards for Architectural Coatings."

D. Midwest Insulation Contractors Association (MICA)
   1. MICA: Commercial and Industrial Insulation Standards.

E. Military Specifications
   1. MIL-A-24179A: Adhesive, Flexible Unicellular-Plastic Thermal Insulation
   2. MIL-A-3316C: Adhesives, Fire-Resistant, Thermal Insulation
   3. MIL-C-20079H: Cloth, Glass; Tape, Textile Glass and Thread, Glass and Wire-Reinforced Glass
   4. MIL-PRF-19565C: Coating Compounds, Thermal Insulation, Fire- and Water-Resistant, Vapor Barrier
   5. MIL+PRF-22344E (except pH requirements): Military Specification: insulation, Pipe, Thermal
   6. MIL+24244D: Insulation Material with Special Corrosion, Chloride and Fluoride Requirements

F. National Fire Protection Association (NFPA)
   1. NFPA-90A: Installation of Air Conditioning and Ventilation Systems.
   2. NFPA-90B: Warm Air Heating and Air-Conditioning Systems.

3. NFPA 255: Standard Method of Test of Surface Burning Characteristics of Building Materials.

G. North American Insulation Manufacturers Association (NAIMA)

1. NAIMA: National Insulation Standards.

H. Underwriters Laboratories Inc. (UL)

1. UL 723: Standard for Test for Surface Burning Characteristics of Building Materials.

2. Underwriter's Laboratories Environmental (UL Environment)

1.4 QUALITY ASSURANCE

A. Installer qualifications: Company specializing in performing the work of this section with minimum five years documented experience utilizing skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-burning characteristics: For insulation and related materials, UL/ULC Classified per UL 723 as determined by UL testing. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors and Outdoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

C. Manufacturer’s qualifications: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience.

D. Insulation thickness shall be per Part 3 of this specification or as required by the latest edition of ASHRAE Standard 90.1 and the applicable energy code(s), whichever is greater.

E. Low-emitting materials: For all thermal and acoustical applications of glass wool insulation products, provide materials complying with the testing and products requirements of UL GREENGUARD Gold Certification.

F. Products shall not contain asbestos, lead, mercury, or mercury compounds.

G. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

H. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

I. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

J. No insulation product shall support or promote mold or fungus growth.

1.5 SUBMITTALS

A. Preconstruction – Prior to construction provide the following in accordance with Division 01 and Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Product data: Provide a schedule, listing each type of insulation, thickness, density, type of protective covering, etc., and the work and service to which each type of insulation is to be applied. The schedule shall be submitted in quantities consistent with that required in the Conditions of the Contract. No insulation shall be purchased or installed until the schedule is reviewed by the Engineer.

2. Manufacturer's installation instructions: Indicate specific installation instructions per the manufacturers of the various products and indicate how the system (combination of products) will be assembled. Highlight critical environmental factors such as drying time, etc., as well as any variations between the manufacturer's installation instructions and the specified installation instructions along with a reason for the difference.

3. Manufacturer's certificate: Certify that products meet or exceed specified requirements.

B. Contract Closeout – At contract closeout provide the following in accordance with Division 01 and Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Test Reports
    a. Insulation Inspection Test
2. Warranties

1.6 DELIVERY, STORAGE AND HANDLING

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

B. Protect products against dirt, water, chemical and mechanical damage before, during and after installation. Do not install damaged or wet insulation; remove from project site. Damage to products prior to final acceptance of the Work shall be repaired or replaced at no additional cost to Owner.

C. Maintain ambient conditions required by the manufacturer of each product.

PART 2 - PRODUCTS

2.1 PIPE INSULATION

A. **Type GWP**: Glass wool preformed pipe insulation

1. Acceptable manufacturers and products
    a. Basis of Design: Knauf Insulation; Earthwool 1000-Degree Pipe Insulation with ASJ+ jacket with SSL+ with advanced closure system
    b. Johns Manville; Micro-Lok
    c. Manson Insulation; Alley- K
    d. Owens Corning; Fiberglas Pipe Insulation
2. Glass wool bonded with a sustainable bio-based thermosetting conductivity resin. Comply with Comply with ASTM C585, ASTM C411, ASTM C795, and ASTM C547, Type I, Grade A, for use up to 850°F. Product shall contain a minimum of 50% post-consumer recovered and recycled materials. Mineral or glass insulation products shall be GreenGuard Certified for low VOC emissions.
3. Thermal ('k' value) per ASTM C335 of:
    a. 0.23 Btu in/hr ft^2 °F or less at 75°F mean temperature
    b. 0.29 Btu in/hr ft^2 °F or less at 200°F mean temperature
    c. 0.43 Btu in/hr ft^2 °F or less at 400°F mean temperature

4. With factory-applied ASJ+ jacket with SSL+: All service jacket with outer film - self-sealing advance closure system
    a. Factory applied white All Service Jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C 1136 Type I, II, III, IV and VII.
    b. Integral self-sealing positive closure longitudinal laps and matching ASJ+ butt strips. Jacket shall be sealed without the use of tools, staples, adhesives, ties or tape. Vapor permeability shall not exceed .02 perms.

B. **Type FEP**: Flexible elastomeric pipe insulation:

1. Acceptable manufacturers and products:
    a. Aeroflex USA, Inc.; Aeroflex EPDM.
    b. Armacell LLC; AP Armaflex.
    c. K-Flex USA; K-Flex LS.
2. Closed-cell, sponge- or expanded-rubber materials for use up to 220°F. Comply with ASTM C534, Type I for tubular materials.
3. Thermal conductivity (k-value) of 0.25 Btu in/hr ft^2 °F or less at 75°F mean temperature per ASTM C518 and C177.
4. Without factory applied jacket.

C. Removable insulation blankets

1. Acceptable manufacturers
    a. Advance Thermal Corporation
    b. Fit Tight Covers
    c. Thermaxx
2. Insulation: Type E fiberglass mat suitable for use to 450°F, 2” thick.
3. Thermal conductivity (k-value) of 0.29 Btu in/hr ft^2 °F or less at 75°F mean temperature.
4. Jacket: Silicon impregnated fiberglass or PTFE fiberglass.
5. One-piece jacket body with three-ply braided Teflon or Kevlar thread and insulation sewn as part of jacket. Jackets shall be fastened using hook and loop (Velcro) straps and 1” slide buckles.

2.2 PIPE INSULATION JACKETS – FIELD APPLIED

A. **Type PVC**: PVC jacket

1. Acceptable manufacturers and products:
    a. Johns Manville; Zeston
    b. Proto Corporation
    c. Speedline
2. High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; stock ready for shop or field cutting and forming.
3. Thickness
    a. 20 mils for indoor applications
    b. 30 mils for outdoor applications

4. Adhesive: As recommended by jacket material manufacturer.
5. Fitting covers: Provide factory-fabricated fitting covers to match jacket.

2.3 DUCT AND EQUIPMENT INSULATION

A. **Type MF-FB**: Mineral or glass fiber flexible blanket insulation.

1. Acceptable manufacturers and products
   a. Basis of Design: Knauf Insulation; Atmosphere Duct Wrap
   b. Johns Manville; Microlite EQ
   c. Owens Corning; SoftR Duct Wrap
2. Mineral or glass fibers bonded with a sustainable bio-based thermosetting resin. Comply with ASTM C553, Types I, II and III and ASTM C 1290 Types I, II and III; for use to 250°F. Density: ¾ lb/ft^3 minimum. Increase density if required to meet specified 'k' value.
3. Thermal conductivity (k-value) of 0.29 Btu in/ hr ft^2 °F or less at 75°F mean temperature per ASTM C518.
4. Jacket: Factory applied type FSK.

B. **Type MF-RB**: Mineral or glass fiber rigid board insulation

1. Acceptable manufacturers and products
   a. Basis of Design: Knauf Insulation; Earthwool Insulation Board
   b. Johns Manville; 800 Series Spin-Glas
   c. Manson Insulation; AK Board
2. Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or IB; for use up to 450°F. Density: 3 lb/ft^3 minimum. Increase density if required to meet specified 'k' value.
3. Thermal conductivity (k-value) of 0.23 Btu in/ hr ft^2 °F or less at 75°F mean temperature per ASTM C518 and C177.
4. Jacket: Factory applied type FSK.

C. **Type MF-SRB**: Mineral or glass fiber semi-rigid board pipe and tank insulation

1. Acceptable manufacturers and products
   a. Basis of Design: Knauf Insulation; Earthwool Pipe and Tank Insulation
   b. Johns Manville
   c. Manson Insulation
   d. Owens Corning
2. Mineral or glass fibers bonded with a sustainable bio-based thermosetting resin. Comply with ASTM C1393, Type II or IIIA, for use up to 850°F.
3. Thermal conductivity (k-value) of 0.26 Btu in/ hr ft^2 °F or less at 100°F mean temperature per ASTM C177.
4. Compressive strength 120 PSF or greater @ 10% deformation per ASTM C165.
5. Product to contain a minimum 50% recycled content.
6. Factory-applied ASJ jacket.

D. **Type FE**: Flexible elastomeric sheet insulation

1. Acceptable manufacturers and products:
    a. Aeroflex USA, Inc.; Aeroflex EPDM
    b. Armacell LLC; AP Armaflex of AP Armaflex FS for thickness 1½" and greater
    c. K-Flex USA; Insul-Sheet
2. Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials.
3. Thermal conductivity (k-value) of 0.25 Btu in/ hr ft^2 °F or less at 75°F mean temperature per ASTM C518 and C177.

2.4 DUCT AND EQUIPMENT INSULATION JACKETS

A. Factory-applied insulation jackets

1. **Type ASJ**: All-service jacket
    a. Factory applied white, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing and self-sealing longitudinal lap, pressure sensitive, acrylic-based adhesive covered by a removable protective strip. Comply with ASTM C1136, Type I. Vapor permeability shall not exceed .02 perms.
2. **TYPE ASJ+/SSL+**: All-service jacket with advanced closure system self-sealing lap
    a. All-service jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C 1136 Type I, II, III, IV and VII. Vapor retarder; with a self-sealing adhesive and matching ASJ+ butt strips. Vapor permeability shall not exceed .02 perms.
3. **Type FSK**: Foil-scrim kraft jacket
    a. Factory applied aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing. Comply with ASTM C1136, Type I. Vapor permeability shall not exceed .02 perms.
4. **Type PSK**: Polypropylene scrim kraft jacket
    a. Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing. Complying with ASTM C 1136, Type II, white, conforming to ASTM C 1136 Type 1. Vapor permeability shall not exceed .02 perms.

B. Field-applied insulation jackets:

1. **Type PVC**: PVC jacket
    a. Acceptable manufacturers and products:
        (1) Johns Manville; Zeston
        (2) P.I.C. Plastics
        (3) Proto Corporation
        (4) Speedline
    b. High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; stock ready for shop or field cutting and forming.
    c. Thickness
        (1) 20 mils for indoor applications
        (2) 0 mils for outdoor applications

d. Adhesive: As recommended by jacket material manufacturer.

e. PVC corner angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D1784, Class 16354-C.

2.5 INSULATION ACCESSORIES

A. Adhesives and insulating cements

1. Acceptable manufacturers:
   a. Foster
   b. Minnesota Mining
   c. Chicago Mastic
2. Adhesives and insulating cements shall meet the following requirements:
   a. Mineral-fiber insulating cement: Comply with ASTM C195;
   b. Mineral-fiber, hydraulic-setting insulating and finishing cement: Comply with ASTM C449
   c. Mineral-fiber adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   d. Cellular-glass adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100F - 200F
   e. Flexible elastomeric and polyolefin adhesive: Comply with MIL-A-24179A, Type II, Class I.
   f. ASJ adhesive jacket adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
   g. PVC jacket adhesive: Compatible with PVC jacket.
3. For indoor applications, adhesive and insulating cement shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24). Exception: Mineral-Fiber Adhesive shall have a VOC content of 80 g/L or less.
4. Adhesives and insulating cements shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Sealants

1. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Joint sealants:
   a. Fire and water resistant permanently flexible, elastomeric sealant.
   b. Service temperature range: Minus 100°F - 300°F
   c. Color: White or gray.
   d. Elastomeric: Permanently flexible.
   e. Cellular glass: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100°F - 200°F. Materials in first paragraph below are for sealing metal jacket seams and joints.
4. FSK and metal jacket flashing sealants:
   a. Fire- and water-resistant, flexible, elastomeric sealant.
   b. Service temperature range: Minus 40°F - 250°F.

c. Color: Aluminum.

5. ASJ flashing sealants, and vinyl, PVDC, and PVC jacket flashing sealants:
   a. Fire- and water-resistant, flexible, elastomeric sealant.
   b. Service temperature range: Minus 40°F - 250°F.
   c. Color: White.

C. Mastics

1. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
2. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Vapor-barrier mastic, indoor: Water based; suitable for indoor use on below-ambient services.
   a. Water-vapor permeance: ASTM F 1249, 0.08 perm at 37-mil dry film thickness.
   b. Service temperature range: Minus 20°F - 180°F.
   c. Solids content: ASTM D1644, 58% by volume and 70% by weight.
   d. Color: White.
4. Vapor-barrier mastic, outdoor: Water based; suitable for outdoor use on below-ambient services.
   a. Water-vapor permeance: ASTM F1249, 1.8 perm at 30-mil dry film thickness.
   b. Service temperature range: Minus 20°F - 180°F.
   c. Solids content: ASTM D1644, 60% by volume and 66% by weight.
   d. Color: White.

D. Tapes

1. ASJ tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
   a. Width: 3 inches.
   b. Thickness: 11.5 mils.
   c. Adhesion: 90 ounces force/inch in width.
   d. Elongation: 2%.
   e. Tensile strength: 40 lbf/inch in width.
2. PVC tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
   a. Width: 2 inches.
   b. Thickness: 6 mils.
   c. Adhesion: 64 ounces force/inch in width.
   d. Elongation: 500%.
   e. Tensile strength: 18 lbf/inch in width.
3. FSK tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
   a. Width: 3 inches.

b. Thickness: 6.5 mils.

c. Adhesion: 90 ounces force/inch in width.

d. Elongation: 2%.

e. Tensile strength: 40 lbf/inch in width.

4. Aluminum-foil tape: Foil face vapor-retarder tape with acrylic adhesive.

a. Width: 2 inches

b. Thickness: 3.7 mils.

c. Adhesion: 100 ounces force/inch in width.

d. Elongation: 5%.

e. Tensile strength: 34 lbf/inch in width.

E. Securements

1. Stainless steel bands: ASTM A167 or ASTM A240, Type 304; 0.015 inch thick, ½-inch wide with wing seal. Provide closed seal when strapping on tanks or vessels with diameter greater than or equal to 8 feet.

2. Aluminum bands: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020-inch thick, ½-inch wide with wing seal. Provide closed seal when strapping on tanks or vessels with diameter greater than or equal to 8 feet.

3. Band springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

4. Staples: Outward-clinching insulation staples, nominal ¾-inch wide, stainless steel or Monel.

5. Wire: 16-gauge annealed galvanized steel.

6. Insulation pins and hangers:

a. Capacitor-discharge-weld pins: Zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106" diameter shank, length to suit depth of insulation indicated.

b. Cupped-head, capacitor-discharge-weld pins: Zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106" diameter shank, length to suit depth of insulation indicated with integral 1½" galvanized carbon-steel washer.

c. Metal, adhesively attached, perforated-base insulation hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

(1) Baseplate: Perforated, galvanized carbon-steel sheet, 0.030" thick by 2" square.

(2) Spindle: Zinc-coated, low-carbon steel or Aluminum, fully annealed, 0.106" diameter shank, length to suit depth of insulation indicated.

(3) Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

d. Insulation-retaining washers: Self-locking washers formed from 0.016" thick, galvanized-steel or aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1½" in diameter.

F. Finishes

1. Type FE and FEP insulation:
    a. Water-based latex enamel for use on flexible elastomeric insulation.
    b. Color: White
    c. Weather resistant, UV and ozone resistant
    d. ArmaFlex WB finish, or equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine for possible asbestos-containing insulation and notify Owner. Do not remove insulation thought to contain asbestos.

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

C. Verify that systems to be insulated have been tested and are free of defects.

D. Verify that surfaces to be insulated are clean and dry.

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

F. Install products only after piping, ductwork and equipment have been pressure testing and the pressure testing approved by the Engineer.

G. Provide drop cloths or other means of protecting all equipment from drops, spattering, etc. which may be caused by the application of insulating products.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Insulate all cold surfaces that can condense and all warm surfaces 105°F or higher. This includes, but is not limited to, surfaces supplied as part of a manufacturer's packaged equipment assembly.

B. Install products in accordance with manufacturer's and NAIMA instructions.

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

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

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

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

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

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

I. Keep insulation materials dry during application and finishing.

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

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

L. Install insulation with least number of joints practical.

M. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

5. Duct mounted sensors and other devices to be installed on the outside of the insulation. Seal and provide complete vapor barrier at any penetrations of the insulation.

N. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

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

P. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.

2. Cover circumferential joints with 3” wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4” o.c.

3. Overlap jacket longitudinal seams at least 1½”. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2” o.c.

4. For below-ambient services, apply vapor-barrier mastic over staples.

5. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

6. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

Q. Cut insulation in a manner to avoid compressing insulation more than 75% of its nominal thickness.

R. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

S. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4” beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

T. Where existing insulation has been removed or disturbed, due to new connections and/or alterations, repair and replace existing insulation per the requirements of this specification.

U. Penetrations:

1. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
    a. Seal penetrations with flashing sealant.
    b. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
    c. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
    d. Seal jacket to roof flashing with flashing sealant.
2. Insulation installation at underground exterior wall penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
3. Insulation installation at aboveground exterior wall penetrations: Install insulation continuously through wall penetrations.
    a. Seal penetrations with flashing sealant.
    b. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
    c. Extend jacket of outdoor insulation outside of wall flashing and overlap wall flashing at least 2 inches.
    d. Seal jacket to wall flashing with flashing sealant.
4. Insulation installation at interior wall and partition penetrations (that are not fire-rated): Install insulation continuously through walls and partitions.
5. Insulation installation at fire-rated wall and partition penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Comply with requirements in Division 20 Section 20 0517: Penetrations for Mechanical, Plumbing, And Fire Suppression Systems for firestopping and fire-resistive joint sealers.
6. Insulation installation at floor penetrations:
    a. Pipe: Install insulation continuously through floor penetrations.
    b. Duct: For penetration through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
    c. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 20 0517: Penetrations for Mechanical, Plumbing, And Fire Suppression Systems.

3.3 INSTALLATION - PIPE INSULATION

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

B. Insulation installation on fittings, valves, strainers, flanges, and unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity.

2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.

3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.

4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. For services not specified to receive a field-applied jacket (except for Type CGP and Type FEP), install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

9. Label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

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

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

E. Install vapor stops at all insulation terminations on either side of valves, pumps and equipment and particularly in straight lengths of pipe insulation.

F. Installation of **Type GWP** insulation

1. Insulation installation on straight pipes and tubes:
    a. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
    b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
    c. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
    d. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
    e. Longitudinal jacket laps for pipe insulation installed on piping systems with operating temperatures below ambient shall be vapor sealed with factory-applied pressure-sensitive adhesive vapor retarder, self-sealing lap. For proper sealing, firmly rub lap joints with reasonable pressure being applied with a plastic squeegee or sealing tool. Vapor seal all circumferential joints with factory-furnished, matching pressure-sensitive butt strips installed with reasonable pressure being applied with a plastic squeegee or sealing tool. Additionally, coat raw edges of pipe insulation sections with vapor retarder mastic at 12 foot to 21 foot intervals on straight piping, and on either side of all fittings, flanges, or valves. Vapor retarder mastic shall completely coat the ends of the pipe and extend onto the bore of the pipe insulation and onto the jacketing a minimum of 2 inches.
2. Insulation installation on pipe flanges:
    a. Install preformed pipe insulation to outer diameter of pipe flange.
    b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
    c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
    d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.
3. Insulation installation on pipe fittings and elbows:
    a. Install preformed sections of same material as straight segments of pipe insulation when available.

b. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

c. Flexible fiberglass insert shall be wrapped completely around bare fitting. Multiple layers may be necessary to ensure adequate insulating thickness. Cover the fitting and insert with the fitted jacket cover. Fitting shall be tacked or taped in place on hot piping. Cold piping will require vapor barrier tape or mastic to ensure complete vapor barrier.

4. Insulation installation on valves and pipe specialties:

a. Install preformed sections of same material as straight segments of pipe insulation when available.

b. When preformed sections are not available, install mitered sections of pipe insulation to valve body.

c. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

d. Install insulation to flanges as specified for flange insulation application.

G. Installation of **Type CS** insulation

1. Insulation Installation on Straight Pipes and Tubes:

a. Secure single-layer insulation with stainless-steel bands at 12-inch intervals and tighten bands without deforming insulation materials.

b. Install two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with stainless steel wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.

c. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

2. Insulation Installation on Pipe Flanges:

a. Install preformed pipe insulation to outer diameter of pipe flange.

b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.

d. Finish flange insulation same as pipe insulation.

3. Insulation Installation on Pipe Fittings and Elbows:

a. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

b. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with adhesive, wire or bands.

c. Finish fittings insulation same as pipe insulation.

4. Insulation Installation on Valves and Pipe Specialties:

a. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

b. Install insulation to flanges as specified for flange insulation application.

c. Finish valve and specialty insulation same as pipe insulation.

H. Installation of **Type CGP** insulation

1. Insulation installation on straight pipes and tubes:

a. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.

b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.

c. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

2. End joints shall be sealed with minimum 3” wide factory finished vapor retarder strips applied with adhesive.

3. Insulation installation on pipe flanges:

a. Install preformed pipe insulation to outer diameter of pipe flange.

b. Apply a 1” inch wide circumferential band of sealant to the inner bore of the Foamglas insulation. Apply sealant at each end of each section of pipe covering. The sealant will mate with the inside of the pipe covering to the pipe and provide a vapor stop.

c. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

d. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.

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

4. Insulation installation on pipe fittings and elbows:

a. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

b. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

5. Insulation installation on valves and pipe specialties:

a. Install preformed sections of cellular-glass insulation to valve body.

b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

c. Install insulation to flanges as specified for flange insulation application.

I. Installation of **Type FEP** insulation

1. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

2. On below ambient piping, the insulation shall be adhered directly to the piping at the high end with manufacturer's recommended adhesive on the interior of the piping. All endcuts of the insulation shall be sealed with adhesive for a complete vapor barrier seal.

3. Insulation installation on pipe flanges:
    a. Install pipe insulation to outer diameter of pipe flange.
    b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
    c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
    d. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
4. Insulation installation on pipe fittings and elbows:
    a. Install mitered sections of pipe insulation.
    b. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
5. Insulation installation on valves and pipe specialties:
    a. Install preformed valve covers manufactured of same material as pipe insulation when available.
    b. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
    c. Install insulation to flanges as specified for flange insulation application.
    d. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
6. Outdoor insulation: Finish with two coats of manufacturer’s recommended paint finish for UV protection.

J. Installation of field-applied pipe insulation jackets

1. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
2. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
3. Where metal jackets are indicated, install with minimum 3” overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.4 INSTALLATION – DUCT AND EQUIPMENT INSULATION

A. General

1. Install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2” from one edge and one end of insulation segment. Secure laps to adjacent insulation section with ½” outward-clinching staples, 1” o.c. Install vapor barrier

consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

b. Install vapor stops for ductwork and plenums operating below 50F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3".

c. Install vapor stops at all insulation terminations on either side of pumps and equipment.

2. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6" wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6" o.c.

3. Where insulated ductwork is supported by trapeze hangers, the insulation shall be installed continuous through the hangers. Drop the supporting channels required to facilitate the installation of the insulation. Where rigid board or flexible insulation is specified, install high density inserts to prevent the weight of the ductwork from crushing the insulation.

4. Where insulated ductwork is supported by steel metal straps or wire ropes that are secured directly to the duct, the straps or ropes shall be completely covered with insulation and sealed to provide a complete vapor barrier.

5. Where insulated duct risers are supported by steel channels secured directly to the duct, extend the insulation and vapor barrier jacketing to encapsulate the support channels.

6. Insulation at access panels shall be removable with metal corner beads.

7. Insulation shall be omitted at all equipment name plates and/or data plates.

8. Insulate all duct-mounted hot water booster coils with insulation equivalent to that on the adjacent ductwork.

9. Duct mounted sensors and other devices to be installed on the outside of the insulation. Seal and provide complete vapor barrier at any penetrations of the insulation.

B. Installation of **Type MF-FB** duct insulation

1. Install duct wrap using manufacturer's stretch-out tables to obtain specified R-value using a maximum compression of 25%.

2. Secure blanket insulation with weld pins.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

a. On duct sides with dimensions 18" and smaller, place pins along longitudinal centerline of duct. Space 3" maximum from insulation end joints, and 16" o.c.

b. On duct sides with dimensions larger than 18", place pins 16" o.c. each way, and 3" maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

d. Do not over-compress insulation during installation.

e. Impale insulation over pins and attach speed washers.

f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. Overlap unfaced blankets a minimum of 2" on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18" o.c.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

C. Installation of **Type MF-RB** duct insulation

1. Secure rigid board insulation with weld pins.

2. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

a. On duct sides with dimensions 18" and smaller, place pins along longitudinal centerline of duct. Space 3" maximum from insulation end joints, and 16" o.c.

b. On duct sides with dimensions larger than 18", space pins 16" o.c. each way, and 3" maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

d. Do not over-compress insulation during installation.

e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

3. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

D. Installation of Type **MF-SRB** equipment insulation

1. Apply insulation to equipment shells using weld pins, bonding adhesive, banded and wired in place.

2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.

3. Protect exposed corners with secured corner angles.

4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

a. Do not weld anchor pins to ASME-labeled pressure vessels.

b. Select insulation hangers and adhesive which are compatible with service temperature and with substrate.

c. On tanks and vessels, maximum anchor-pin spacing is 3" from insulation end joints, and 16" o.c. in both directions.

d. Do not over-compress insulation during installation.

e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.

f. Impale insulation over anchor pins and attach speed washers.

g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.

6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch pre-stressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6" from each end. Install wire or cable between two circumferential girdles 12" o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch pre-stressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48" o.c. Use this network for securing insulation with tie wire or bands.

7. Stagger joints between insulation layers at least 3".

8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.

9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.

10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

E. Installation of **Type FE** insulation

1. Apply 100% coverage of adhesive to surface with manufacturer's recommended adhesive.

2. Fabricate a continuous insulation system consisting of cut sections to conform to equipment shape.

3. Place insulation with edge joints firmly butted pressing to surface for full adhesion.

4. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

5. Allow adhesive to fully cure and wipe insulation clean with denatured alcohol.

6. Apply two coats of insulation manufacturer's recommended protective coating.

F. Installation of **Type FR** insulation

1. Install the number of layers of insulation required to provide the specified fire rating for the application.

2. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

3. Strictly adhere to manufacturer's installation instructions and rating requirements for application of fire-stop insulation. Cover all exhaust ducts serving Type I kitchen hoods with fire-stop insulation from a point prior to penetration of ceiling, wall, floor or concealment through building to termination at outside of building. Extend fire-stop insulation through roof curbs.

4. Insulate duct access panels and doors to achieve same fire rating as duct.

5. Access doors shall be removable, and insulated per manufacturer's instructions.

G. Insulation Installation on Chilled Water Pumps with **Type MF-RB** Insulation:

1. Fabricate removable galvanized steel boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Install fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.

2. Install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.5 APPLICATION (PIPING)

A. Schedule

PIPING SYSTEM	OPERATING TEMP (°F)	INSULATION TYPE	INDOOR JACKET	OUTDOOR JACKET
WARM AND HOT HVAC PIPING SYSTEMS				
Low-pressure steam and steam condensate (15 psig and lower)	201F to 250F	GWP	ASJ+	ALUM
Heating water supply and return	141F to 200F	GWP	ASJ+	ALUM
Heating water supply and return: High-temperature	201F to 250F	GWP	ASJ+	ALUM
COLD HVAC PIPING SYSTEMS				
Chilled water	40F to 60F	GWP	ASJ+	ALUM
Cooling coil condensate drain piping	40F to 60F	FEP	None	None
Equipment condensate drain piping (<60F)	All	GWP or FEP	None	PVC/GWP None/FEP
COLD PLUMBING PIPING SYSTEMS				
Domestic cold water (including make-up water, RO and DI systems)	40F to 60F	GWP	ASJ+	ALUM

B. Insulation thickness shall be per the following table, unless specific exceptions are listed.

OPERATING TEMPERATURE (F)	INSULATION CONDUCTIVITY		NOMINAL PIPE SIZE				
	'k' Value (Btu in/hr ft²)	Mean Rating Temp (°F)	<1"	1" to <1½"	1½" to < 4"	4" to < 8"	≥8"
>350F	0.32 to 0.34	250	4.5	5.0	5.0	5.0	5.0
251 to 350F	0.29 to 0.32	200	3.0	4.0	4.5	4.5	4.5
201 to 250F	0.27 to 0.30	150	2.5	2.5	2.5	3.0	3.0
141 to 200F	0.25 to 0.29	125	1.5	1.5	2.0	2.0	2.0
105 to 140F	0.22 to 0.28	100	1.0	1.0	1.5	1.5	1.5
40 to 60F	0.21 to 0.27	75	1.5	1.5	1.5	1.5	1.5
<40F	0.20 to 0.26	50	1.5	1.5	2.0	2.0	2.0

OPERATING TEMPERATURE (F)	INSULATION CONDUCTIVITY		NOMINAL PIPE SIZE				
	'k' Value (Btu in/hr ft^2)	Mean Rating Temp (°F)	<1"	1" to <1½"	1½" to < 4"	4" to < 8"	≥8"
40 – 60F with Type CGP	0.28 to 0.29	75	1.5	1.5	1.5 up to 2" pipe 2.0 above 2" pipe	2.0	2.0 up to 12" pipe 2.5" up to 24" pipe

C. Exceptions to pipe insulation thickness table:

1. Cooling coil condensate drains in mechanical rooms: 1" thick. Condensate drains located above ceilings shall be have insulation thickness per the table above.
2. Refrigerant piping systems:
   a. Refrigerant suction and evaporator lines 20°F to 40°F: 1" thick
   b. Refrigerant hot gas and liquid lines <14°F: 1" thick
3. For the following plumbing services, modify insulation thickness as follows:
   a. Electric water cooler supply, recirculation and waste: 1" thick
   b. Ice maker waste: 1" thick
   c. Roof drains and storm water: 1" thick if not heat traced, 1½" thick if heat traced.
   d. Horizontal waste and sanitary branch piping from floor drains receiving condensate and equipment drain water below 60°F up to the point where the branch connects to the main: 1" thick
4. For piping smaller than 1.5" and located in partitions within conditioned spaces, reduction of these thicknesses by 1-inch shall be permitted, but not to a thickness less than 1-inch.
5. For insulation outside the stated conductivity range, the minimum thickness shall be adjusted as indicated in the International Energy Conservation Code table for Minimum Pipe Insulation Thickness.

D. Field-applied jacket schedule

1. Outdoor piping insulated with **Type GWP** shall be provided with a **Type ALUM** protective metal jacket.

E. For systems with fluid temperatures 65°F or less, furnish and install removable elastomeric insulation covers, plugs or caps for all mechanical equipment and devices that require access by balancing contractors or service and maintenance personnel. Examples include but are not limited to: flow sensing devices, balancing valves, manual ball valve air vents, drain valves, blowdown valves, pressure/temperature test plugs, grease fittings, pump bearing caps, equipment labels, etc. Covers shall be tight fitting to ensure a complete vapor barrier.

F. For above ambient services, do not install insulation on vibration control devices.

3.6 APPLICATION – DUCTWORK

A. Provide insulation on new ductwork and modified portions of existing ductwork per the following schedule:

SERVICE	INSULATION TYPE	INSULATION THICKNESS	JACKET
Outdoor air ducts and plenums: Indoor, exposed	MF-RB	1.5″	FSK
Mixed air ducts and plenums: Indoor, exposed	MF-RB	1.5″	FSK
Return air ducts: Indoor	None	N/A	N/A
Supply air ducts: Indoor, concealed	MF-FB	1.5″	FSK
Supply air ducts: Indoor, exposed	MF-RB	1.5″	FSK
Exhaust ducts from exhaust damper to outside	MF-RB	1.5″	FSK
Outdoor air and exhaust air louver blank-off panels	MF-RB	1.5″	FSK

B. Insulate all duct-mounted hot water booster coils with insulation equivalent to that on the adjacent ductwork.

C. The following systems do not require insulation:

1. Metal ducts with duct liner
2. Factory insulated plenums and casings
3. Factory insulated flexible ductwork
4. Factory insulated access panels and doors

3.7 APPLICATION – EQUIPMENT

A. Provide insulation on new equipment per the following schedule:

EQUIPMENT	INSULATION TYPE	INSULATION THICKNESS	JACKET
COLD EQUIPMENT			
Heat exchangers for cooling service	FE	1.5″	None
Expansion/Compression tanks	FE	1.5″	None
Air separators	FE	1.5″	None
Chilled water filter housing	FE	1.5″	None
WARM AND HOT EQUIPMENT			
Expansion/Compression tanks	MF-SRB	2″	PVC
Air separators	MF-SRB	2″	PVC
Chemical pot feeders	MF-SRB	1.5″	PVC

EQUIPMENT	INSULATION TYPE	INSULATION THICKNESS	JACKET
Hot water filter housing	MF-SRB	To 200F: 2” 201 to 250F: 3”	PVC

B. Where Type FE equipment insulation is specified, finish with manufacturer’s protective finish.

C. Chillers: Insulate all cold surfaces on chillers, including, but not limited to, evaporator bundles, heat-recovery bundles, suction piping, compressor inlets, tube sheets, water boxes, and nozzles. Comply with chiller manufacturer’s requirements. All surfaces subject to condensation shall be insulated.

D. Plate heat exchangers: Only insulate fixed end plates and exterior side of splash guards. Do not insulate interior side of splash guards.

E. Provide removable sections of insulation where required for service.

F. For above ambient services, do not install insulation to the following:

1. Vibration control devices
2. Nameplates and data plates
3. Manholes and handholes
4. Cleanouts

3.8 TESTING

A. Insulation Inspection Test

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Engineer, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
2. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.
3. Provide test result report within two weeks of testing indicating satisfactory compliance with specification.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 20\20 0700-Thermal Insulation for M-P-FP.docx

SECTION 20 2923
VARIABLE FREQUENCY DRIVES FOR MECHANICAL, PLUMBING, AND FIRE SUPPRESSION

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This Section includes solid-state VFDs with bypass as scheduled for speed control of three-phase, squirrel-cage induction motors specifically applicable to Divisions 20, 21, 22, and 23 for mechanical, plumbing, and fire suppression systems (variable torque).

1.2 DEFINITIONS

A. BMS: Building management system

B. IGBT: Integrated gate bipolar transistor

C. LAN: Local area network

D. PID: Control action, proportional plus integral plus derivative

E. PWM: Pulse-width modulated

F. VFD: Variable frequency drive

1.3 CODES AND STANDARDS (USE LATEST EDITION)

A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.

1. ANSI/IEC 60529: Degrees of Protection Provided by Enclosures (IP Code)
2. CSA C22.2 No. 14-13 (Industrial Control Equipment)
3. FCC CFR 47 Part 15 Subpart B
4. IEC 61800-3 – Adjustable speed electrical power drive systems – Part 3: EMC requirements and specific test methods
5. IEEE Standard 519: Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
6. NEMA ICS 3.1: Guide for the Application, Handling, Storage, Installation, and Maintenance of Medium-Voltage AC Contactors, Controllers, and Control Centers
7. NEMA ICS 7.1: Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable-Speed Drive Systems
8. NEMA 250: Enclosures for Electrical Equipment (1000 Volts Maximum)
9. OSHPD: California Office of Statewide Health Planning and Development
10. UL 508A: Standard for Industrial Control Panels
11. UL 508C: Standard for Power Conversion Equipment
12. UL 61800-5-1: Standard for Adjustable Speed Electrical Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy

1.4 QUALITY ASSURANCE

A. Manufacturer qualifications: Maintain, within 100 miles (160 km) of project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Testing agency qualifications: An independent testing agency, acceptable to authorities having jurisdiction, with the experience and capability to conduct the testing indicated; NETA member.

C. Source limitations: Obtain VFDs of a single type through one source from a single manufacturer.

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.

E. Product selection for restricted space: Drawings indicate maximum dimensions for VFDs, minimum clearances between VFDs, and adjacent surfaces and other items. Comply with indicated dimensions and clearances.

F. Comply with NFPA 70.

G. Minimum meantime between failure (MTBF) ratings of 25 years (219,000 hours).

1.5 SUBMITTALS

A. Preconstruction – Prior to construction provide the following in accordance with Division 01 and Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Product data: For each type of VFD provide:
    a. Dimensioned plans, elevations, and sections
    b. Mounting arrangements
    c. Location for conduit entries
    d. Shipping and operating weights
    e. Features
    f. Performance
    g. Electrical ratings
    h. Characteristics
    i. Finishes
    j. Required clearances and service space
    k. Each installed unit's type and details
    l. Nameplate legends
    m. Short-circuit current ratings of integrated unit
    n. Factory settings
    o. Wiring diagrams
2. Coordination drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around VFDs where pipe and ducts are prohibited. Show VFD layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
3. Qualification data: For testing agency and manufacturer.
4. Manufacturer's installation and operating manuals.

B. Contract Closeout – At contract closeout provide the following in accordance with Division 01 and Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Operating and Maintenance Data including:
    a. Product data
    b. Installation instructions
    c. Assembly drawings
    d. Replacement parts list
    e. Maintenance and operation instructions
    f. Instructions for testing and adjusting overcurrent protective devices
    g. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that VFD programming settings and the solid state overload relay settings (in the bypass circuit) have been set to suit actual motor to be protected.
2. Test Reports
    a. Manufacturer Start-Up Report
3. Warranties

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store VFDs indoors in clean, dry space with uniform temperature to prevent condensation. Protect VFDs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

B. If stored in areas subject to weather, cover VFDs to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

1.7 WARRANTY

A. Warranty shall be 24 months from the date of certified start-up. The warranty shall include all parts, labor, travel, and expenses.

1.8 MAINTENANCE

A. Cooperate with the Owner during testing, adjusting, and balancing (TAB), phase of construction, to minimize conflicts.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers and products: Subject to compliance with specified requirements, provide products from a single manufacturer from the following:

1. VFDs 75 HP and less (six-pulse with built-in 5% line impedance):
    a. ABB ACH580
    b. Eaton HMAX (H-Max)
    c. Danfoss VLT FC-102
    d. Yaskawa HV600

2.2 VARIABLE FREQUENCY DRIVES

A. Description: NEMA ICS 2, IGBT, PWM, VFD; listed and labeled as a complete unit and arranged to provide variable speed of a standard NEMA MG 1, Parts 30 and 31, three-phase, induction motor by adjusting output voltage and frequency.

B. PWM design:

1. For motors 75 HP and less, the drive shall use a minimum of six-pulse PWM technology with 5% built-in line impedance.

2. For motors 100 HP and above 18-pulse PWM or Matrix technology shall be used.

C. Design and rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power transmission connection.

D. Output frequency rating: Three-phase; 0 to 120 Hz.

E. Unit operating requirements

1. Input AC voltage tolerance of ±10% of voltage rating shown on plans

2. Input frequency tolerance of 60 Hz, ±5 Hz

3. Capable of driving full load, under the following conditions, without derating:

a. Ambient Temperature: 14°F to 104°F

b. Humidity: Less than 95% (non-condensing)

c. Altitude: 3,300 feet (1,000 m); higher altitudes achieved by derating

4. Minimum efficiency: 96% at half speed; 98% at full speed

5. Minimum displacement primary-side power factor: 98%

6. Overload capability (variable torque): 110% the rated full load current for 60 seconds, 180% of rated full load current

7. Starting torque: 100% of rated torque or as indicated

8. Speed regulation: ±3%

9. Isolated control interface to allow controller to follow control signal over an 11:1 speed range

F. Internal adjustability capabilities

1. Minimum speed: 5 to 25% of maximum rpm

2. Maximum speed: 80 to 100% of maximum rpm

3. Acceleration: Adjustable from 0 to 6,000 seconds

4. Deceleration: Adjustable from 0 to 6,000 seconds

5. Current limit: 50% to a minimum of 110% of maximum rating

G. Self-protection and reliability features

1. Input transient protection by means of surge suppressors

2. Under- and over-voltage trips; inverter over-temperature, overload, and overcurrent trips

3. Adjustable motor overload relay, Class 20

4. Instantaneous line-to-line and line-to-ground overcurrent trips

5. Loss-of-phase protection
6. Reverse-phase protection
7. Short-circuit protection
8. Motor over-temperature fault
9. Dynamic braking

H. Automatic reset and restart: To attempt three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bi-directional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

I. Power-interruption protection: To prevent motor from re-energizing after a power interruption until motor has stopped.

J. Torque boost: Automatically vary starting and continuous torque to at least 1.5 times the minimum torque to insure high-starting torque and increased torque at slow speeds.

K. Input line conditioning:

1. Provide each VFD with a minimum 5% equivalent impedance for harmonic reduction and line conditioning.
2. VFDs equipped with dual DC-bus chokes that provide not less than 5% equivalent impedance are acceptable.
3. Where the VFD does not include at least 5% equivalent impedance integral to the drive, provide separate 5% AC line reactors at the VFD input.

L. Motor Lead Length and dV/dt Filters

1. Where the motor lead length (one-way conduit length between VFD and motor terminals) is 100 feet or greater, provide a dV/dt output filter.
2. Locate and install the dV/dt filter within 10 feet of the VFD output terminals, unless the VFD manufacturer specifically recommends otherwise.
3. Coordinate dV/dt filter selection and installation with the VFD manufacturer's published maximum cable length and motor insulation requirements.

M. Status pilot lights: Door-mounted light indicators or keypad indication of the following conditions:

1. Power on
2. Run
3. Bypass
4. Fault

N. Panel-mounted operator station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter. Equivalent functionality via the VFD's keypad is acceptable.

O. Digital display: The VFD shall provide a LCD display capable of displaying multiple lines of text on the VFD's operating values. The following are to be available at a minimum:

1. Output frequency (Hz)

2. Motor speed (rpm)
3. Motor status (running, stop, fault)
4. Motor current (amperes)
5. Motor torque (percent)
6. Fault or alarming status (code)
7. Motor power (kW)
8. kWh meter
9. DC-link voltage (VDC)
10. Set-point frequency (Hz)
11. Motor output voltage (V)
12. Analog input values
13. Analog output values
14. Digital input status
15. Digital output status

P. Control signal interface: Provide VFD with the following:

1. Electric input signal interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and six programmable digital inputs.
2. Remote signal inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:
    a. 0 to 10-VDC
    b. 4-20 mA
    c. Potentiometer using up/down digital inputs
    d. Fixed frequencies using digital inputs
    e. RS485 and RS232
    f. Keypad display for local hand operation
3. Output signal interface:
    a. A minimum of two analog output signals (0/4-20 mA), which can be programmed to any of the following:
        (1) Output frequency (Hz)
        (2) Output current (load)
        (3) DC-link voltage (VDC)
        (4) Motor torque (percent)
        (5) Motor power
        (6) Motor voltage
        (7) Motor speed (rpm)
    b. A minimum of three programmable dry circuit relay outputs (Form C, 120VAC, 2 amp) for remote indication of the following:
        (1) Motor running

(2) Ready

(3) At speed

(4) Jogging

(5) Fault

(6) Over-temperature

Q. Communications: Coordinate with building BAS provider to provide a VFD compatible with the BAS. At a minimum, VFD shall have one of the following communications capabilities and protocols that are compatible with the building automation system:

1. BACnet
2. Modbus
3. Johnson Controls N2
4. Siemens

R. Two-contactor bypass: Two-contactor bypass with a service switch that allows for service of VFD while bypass is in use shall include a drive input disconnect, a VFD input isolation contactor (or isolation switch), bypass contactor, and an VFD output contactor that is electrically and mechanically interlocked with a bypass contactor. This circuit shall include control logic, optional status lights, and Class 20 motor overcurrent protection. The unit may be set up for manual or automatic bypass operation upon a VFD trip. The bypass shall include a NEMA ICS 2, full voltage, non-reversing enclosed controller with across-the-line starting capability in manual-bypass mode. Provide motor overload protection under both modes of operation with control logic that allows common start-stop capability in either mode.

1. Manual bypass: Drive input disconnect must be manually operated; electronic controls not allowed. Bypass cabinet shall be made up entirely of standard industrial control components.

S. Integral disconnecting means: Provide a NEMA instantaneous-trip 65KAIC circuit breaker to provide disconnecting means and protection during bypass. The handle position shall indicate on, off, and tripped. The disconnect handle shall be able to be padlocked in the off position.

T. The VFD must meet IEC 61800-3 for 1st environment, restricted distribution.

2.3 ENCLOSURES

A. For indoor applications: All standard and optional features shall be housed in a single NEMA 1 plenum-rated enclosure with a U.L. Certification label.

B. For outdoor applications: All standard and optional features shall be housed in a single NEMA 3R enclosure with a UL Certification label.

2.4 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

B. Standard displays

1. Output frequency (Hz)
2. Set-point frequency (Hz)
3. Motor current (amperes)
4. DC-link voltage (VDC)

5. Motor torque (percent)
6. Motor speed (rpm)
7. Motor output voltage (V)

C. Historical logging information and displays
1. Real-time clock with current time and date
2. Running log of total power versus time
3. Total run time
4. Fault log, maintaining last four faults with time and date stamp for each

D. Current-sensing, phase-failure relays for bypass controller: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40%, or loss of supply voltage; with adjustable response delay.

2.5 FACTORY FINISHES

A. Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and factory-tested VFDs before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFDs for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit and motor connection points before VFD installation.

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

3.2 APPLICATIONS

A. Select features of each VFD to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, drive, and load.

B. Select rating of controllers to suit motor controlled.

3.3 INSTALLATION

A. Anchor each VFD assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with VFD mounting surface.

B. Install VFDs on concrete bases, where applicable, complying with Division 20 Section 20 0529, "Hangers and Supports for Mechanical, Plumbing and Fire Suppression Systems."

C. Coordinate layout and installation of VFDs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

D. Coordinate size and location of concrete bases where required. Cast anchor-bolt inserts directly into bases.

E. Where the VFD is mounted above the roof line, coordinate installation of roof curbs, equipment supports, and roof penetrations.

F. Coordinate features of VFDs, installed units, and accessory devices with pilot devices and control circuits to which they connect.

G. Coordinate features, accessories, and functions of each VFD and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

H. Motors intended for use with variable frequency drives shall be “inverter-ready” by complying with or exceeding the NEMA MG1 Part 31 requirements regarding special purpose motors for use with variable frequency drives.

1. Windings shall be copper magnet wire with moisture-resistant insulation, varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses, produced by pulse-width modulated inverters.

2. Motors shall be equipped with shaft grounding ring(s) to dissipate potential VFD-induced motor shaft currents by grounding through the motor housing.

   a. Provide one grounding ring per motor.

   b. Provide solid ring or split ring, based on grounding ring manufacturer’s recommendations.

   c. Shaft grounding brushes or insulated bearings are not acceptable.

   d. Shaft grounding rings shall be factory-installed or field-installed by the motor manufacturer or field-installed by the contractor.

   e. Acceptable product: Aegis SGR Bearing Protection Ring as manufactured by Electric Static Technology.

   f. This provision for grounding devices shall not apply to motors used in environments defined as Class 1 Division 1, Division 2, or Class 1 Zone 1, Zone 2 hazardous locations.

3. Motors are furnished and installed by mechanical or plumbing contractor, wired by electrical contractor.

3.4 IDENTIFICATION

A. Identify VFDs, components, and control wiring according to Division 20 Section 20 0553, “Identification for Mechanical, Plumbing, and Fire Suppression Systems.”

B. Operating instructions: Frame printed operating instructions for VFDs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFD units.

3.5 CONTROL WIRING INSTALLATION

A. Install wiring between VFDs and remote devices according to Electrical Specifications.

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switch and other automatic-control devices where available.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in hand position.

2. Connect selector switches with control circuit in both hand and automatic positions for safety-type control devices such as low-pressure and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.6 CONNECTIONS

A. Conduit installation requirements are specified in Electrical Specifications. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment per the latest edition of NFPA 70 (NEC).

C. 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.

3.7 START-UP SERVICE

A. Engage a factory-authorized service representative to perform start-up service.

B. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 26 Sections.

C. Complete installation and start-up checks according to manufacturer's written instructions.

3.8 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.9 TESTING

A. Manufacturer installation start-up

1. Engage a factory-authorized service representative to inspect field assembled components and equipment installation, including pretesting and adjusting VFDs.

2. Provide start-up report within two weeks of testing indicating completion of the Manufacturer Start-Up Certification for each VFD.

3.10 CLEANING

A. Clean VFDs internally, on completion of installation, according to manufacturer's written instructions. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain VFDs.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 20\20 2923-Variable Frequency Drives for M-P-FP.docx

SECTION 23 0100
COMMON WORK REQUIREMENTS FOR MECHANICAL

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Basic requirements applicable to all Division 23 work.

1.2 RELATED SECTIONS

A. All specification sections in Division 20 are applicable to Division 23. It is the responsibility of the Division 23 Contractor to obtain all Division 20 specifications and conform to all applicable requirements. Division 20 Sections included are:

1. Section 20 0500: Basic Requirements for Mechanical, Plumbing, and Fire Suppression
2. Section 20 0501: Minor Mechanical, Plumbing, and Fire Suppression Demolition
3. Section 20 0513: Motor Requirements for Mechanical, Plumbing, and Fire Suppression Equipment
4. Section 20 0519: Meters And Gauges for Mechanical, Plumbing, and Fire Suppression
5. Section 20 0529: Hangers and Supports for Mechanical, Plumbing and Fire Suppression Systems
6. Section 20 0548: Vibration Isolation for Mechanical, Plumbing and Fire Suppression
7. Section 20 0553: Identification for Mechanical, Plumbing, and Fire Suppression Systems
8. Section 20 0700: Thermal Insulation for Mechanical, Plumbing, and Fire Suppression
9. Section 20 2923: Variable Frequency Drives for Mechanical, Plumbing, and Fire Suppression

PART 2 - PRODUCTS

Not Applicable

PART 3 - EXECUTION

3.1 SCOPE

A. Work included under Divisions 20 and 23 shall include all labor, services, materials, and equipment and performance of all work required for installation of mechanical systems as shown on Drawings and as specified.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 23\23 0100-Common Work Requirements for Mechanical.docx

SECTION 23 0593
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. This Section includes testing, adjusting, and balancing to produce design objectives for the following:

1. Air systems
2. Space pressurization
3. Sound and vibration
4. Hydronic Piping Systems
5. Existing systems TAB

1.2 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.

C. Barrier or boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.

D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

E. NC: Noise criteria.

F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

G. RC: Room criteria.

H. Report forms: Test data sheets for recording test data in logical order.

I. Smoke-control system: An engineered system that uses fans to produce airflow and pressure differences across barriers to limit smoke movement.

J. Smoke-control zone: A space within a building that is enclosed by smoke barriers and is a part of a zoned smoke-control system.

K. Stair pressurization system: A type of smoke-control system that is intended to positively pressurize stair towers with outdoor air by using fans to keep smoke from contaminating the stair towers during an alarm condition.

L. Static head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

M. Suction head: The height of fluid surface above the centerline of the pump on the suction side.

N. System effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

O. System effect factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

P. TAB: Testing, adjusting, and balancing.

Q. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

R. Test: A procedure to determine quantitative performance of systems or equipment.

S. Testing, adjusting, and balancing firm: The entity responsible for performing and reporting TAB procedures.

1.3 CODES AND STANDARDS (USE LATEST EDITIONS)

A. ASHRAE 111: Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-conditioning, and Refrigeration Systems.

B. Associated Air Balance Council (AABC): National Standards for Total System Balance.

C. ANSI S12.1: Physical Measurement of Sound

D. National Environmental Balancing Bureau (NEBB): Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.

E. National Environmental Balancing Bureau (NEBB): Procedural Standard for Fume Hood Performance Testing.

F. National Environmental Balancing Bureau (NEBB): Procedural Standards for Certified Testing of Cleanrooms.

G. National Environmental Balancing Bureau (NEBB): Procedural Standards for Measurement of Sound and Vibration.

H. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): TAB Procedural Guide.

I. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): HVAC Sound and Vibration Manual

1.4 QUALITY ASSURANCE

A. Qualifications

1. Testing agency shall be a certified member of AABC, NEBB, and/or TABB.

2. Testing and Balancing shall be performed by a testing agency who specializes in testing, adjusting, and balancing of heating, ventilating, air-moving equipment, air-conditioning systems and hydronic systems and has a minimum of one year experience.

3. Testing agency shall have successfully completed a minimum of five projects, similar in size and scope.

B. Certifications - TAB Technician shall be certified by a nationally recognized certifying agency.

C. TAB conference: Meet with Owner's and Architect's representatives on approval of TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB

team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven days' advance notice of scheduled meeting time and location.

1. Agenda items: Include at least the following:
    a. Submittal distribution requirements
    b. The Contract Documents examination report
    c. TAB plan
    d. Work schedule and Project-site access requirements
    e. Coordination and cooperation of trades and subcontractors
    f. Coordination of documentation and communication flow

D. Instrumentation type, quantity, and accuracy: As described in AABC's "National Standards for Total System Balance," NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification," or the TABB Instrument List.

E. Instrumentation calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.

1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.5 SUBMITTALS

A. Preconstruction – Prior to construction provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Qualification data: Within 30 days from Contractor's Notice to Proceed, submit evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

2. TAB contract document examination report: Within 30 days from Contractor's Notice to Proceed.

3. Strategies and procedures plan: Within 60 days from Contractor's Notice to Proceed.

B. During Construction – During construction provide and maintain the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Deficiency report

2. Preliminary TAB reports

C. Contract Closeout – At contract closeout provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Certified TAB reports

2. Warranties

1.6 PROJECT 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.

1.7 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

D. Coordinate the following with the Temperature Control Contractor to verify calibration of installed equipment and devices:

1. Field coordinate with the Temperature Control Contractor to establish supply duct static pressure set point for the air-handling unit.
2. Field coordinate with the Temperature Control Contractor to establish minimum outside air damper position for the air-handling unit.
3. Field coordinate with the Temperature Control Contractor to establish offset pressurization set point for return fan tracking.
4. Field coordinate with the Temperature Control Contractor to develop return fan tracking curve based on offset pressurization set point.
5. Field coordinate with the Temperature Control Contractor to establish airflow rate as measured by each air terminal unit inlet flow sensor.

E. Include a summary of the above results in the test and balance report.

1.8 WARRANTY

A. Provide one of the following performance guarantees:

1. AABC National Project Performance Guarantee
2. NEBB Certificate of Conformance Certification
3. TABB Quality Assurance Program Guarantee

B. Guarantee shall include the following provisions:

1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS

2.1 ACCEPTABLE FIRMS

A. Aero Building Solutions., Franklin Park, IL

B. International Test & Balance, Northbrook, IL

C. Mechanical Test & Balance, Crown Point, IN

D. Superior Test & Balance, Inc., Algonquin, IL

2.2 TESTING SCOPE

A. The following systems shall be tested in accordance with the procedures defined in Part 3 of this specification:

1. Air systems
2. Hydronic systems
3. Existing air and hydronic systems
4. Space pressurization
5. Sound and vibration

PART 3 - EXECUTION

3.1 GENERAL

A. Provide sufficient time before completion date to complete balancing operations.

B. Note changes made to the system during construction.

C. Install required test holes complete with removable and replaceable plugs.

D. Make and document revisions to controls, dampers, fan and pump drives, and consult with equipment manufacturers as required to achieve the specified system's performance.

E. Take and report testing and balancing measurements in inch-pound (IP) units.

F. 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 insulation Specifications for this Project.

G. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

3.2 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to review system designs for deficiencies that may prevent proper TAB.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems,"; or in SMACNA's "HVAC Systems – Duct Design,". Compare this data with the design data and installed conditions.

3.3 PREPARATION

A. Prepare a Strategies and Procedures Plan that includes TAB strategies and step-by-step procedures as specified in Part 3 of these specifications.

B. Prior to commencing the TAB verify the following conditions. If deficiencies are evident, submit Deficiency Report to Owner. Do not begin TAB until deficiencies have been remedied.

1. Systems are started and operating in a safe and normal condition.
2. Temperature control systems are installed, complete, and operable.
3. Automatic and manual dampers are operable and fully open.
4. Thermal overload protection is in place for fans, pumps, chillers, and other equipment.
5. Startup air filters are removed.
6. Final filters are clean and properly installed.
7. Duct and fan systems are clean.
8. Fans are rotating correctly.
9. Air coil fins are cleaned and combed.
10. Access doors are closed, and duct end caps are in place.
11. Air outlets are installed and connected.
12. Hydronic systems are pressure tested, flushed, filled, and properly vented.
13. Leak testing on duct system has been performed in accordance with Specification 23 3113 – Metal and Flexible Duct.
14. Start-up/construction strainers have been removed and all permanent strainers are clean and in place.
15. Gauges and/or test ports are properly located for balancing.
16. Service and balance valves are fully open.

3.4 TOLERANCES

A. Air systems

1. Air handling systems: Adjust to within +10% of outlet total plus allowable leakage rate.
2. Air outlets and inlets: Adjust total to within ±10% of design for each space.
3. For applications where differential pressures must be maintained but no specific pressure requirement is listed on the drawings, use the following criteria. Where specific space pressure requirements are listed on the drawings, the pressure requirement criteria on the drawings shall be used to determine final airflow settings.

   Positively pressurized spaces
   - Supply air.....0 to +10%
   - Exhaust air.....0 to -10%
   - Return air.....0 to -10%

   Negatively pressurized spaces
   - Supply air.....0 to -10%
   - Exhaust air.....0 to +10%
   - Return air.....0 to +10%

4. Please note that differentials between supply and exhaust/return airflows, as indicated in the drawings, indicate those spaces with a requirement for differential pressure to be maintained.

B. Hydronic systems

1. Hydronic systems: Adjust to within +10% of design flow.
2. Hydronic terminal devices: Adjust to within ±5% of design flow.

3.5 AIR SYSTEMS PROCEDURE

A. Perform testing and balancing procedures on each system according to any of the following:

1. AABC National Standards for Total System Balance
2. NEBB Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems
3. SMACNA TAB Procedural Guide
4. ASHRAE 111 Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems

B. Minimum air procedures shall include the following:

1. Test and adjust fan RPM to design requirements.
2. Test and record motor full load nameplate rating and actual voltage and ampere draw.
3. Test and record system static pressures, fan suction, and discharge.
4. Adjust all main supply and return air duct to within tolerances of proper design CFM.
5. Test and adjust each diffuser, grille, and register. Reading and tests of diffusers, grilles, and registers shall include design velocity (FPM) and adjusted velocity, design CFM, and adjusted CFM.
6. Test and record outside air, mixed air, and discharge temperatures (D.B. for heating cycle, D.B. and W.B. for cooling cycle).
7. In coordination with the BAS contractor, set adjustments of automatically operated dampers to operate as specified, indicated and/or noted.
8. For terminal units, compare the BAS-reported total airflow to the measured total airflow. If discrepancies exist, the calibration factor in the BAS shall be adjusted to align with actual measurements.
9. Test and adjust air handling and distribution systems to provide required supply, return, outside, and exhaust air quantities within design tolerance.
10. Make air velocity measurements in ducts by Pitot tube traverse across entire cross-sectional area of duct in accordance with SMACNA equal area method or Log Linear method.
11. Measure air quantities at all air inlets and outlets.
12. Use volume control devices to regulate air quantities only to the extent that adjustments do not create objectionable air motion or sound levels.
13. Vary total system air quantities by adjustment of fan speeds. Provide drive changes recommendations. Vary branch air quantities by damper regulation.
14. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for loading of filters and coils.
15. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions within specified tolerances.

16. Where modulating dampers or economizers are provided, take measurement at full return air, minimum outside air, and 100% outside air mode of operation.

3.6 EXISTING AIR SYSTEMS PROCEDURES

A. Preconstruction testing: Perform a preconstruction inspection of existing equipment that is to remain and be reused. Procedures shall be as specified for new air systems.

1. Measure and record the operating speed, airflow, and static pressure of each fan.
2. Measure and record the static pressure profile throughout each air handling unit (across all components).
3. Measure motor voltage and amperage. Compare the values to motor nameplate information.
4. Airflow rates and static pressures in all the branches off the main (not sub-branches or individual outlets).
5. Check the condition of filters.
6. Check the condition of coils.
7. Check the operation of the drain pan and condensate drain trap.
8. Check bearings and other lubricated parts for proper lubrication.
9. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused.

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. Procedures shall be as specified for new air systems.

1. Compare the indicated airflow of the renovated work to the measured fan airflows to determine the new fan speed and filter and coil face velocities.
2. If calculations increase or decrease the airflow rates by more than 5%, make equipment adjustments to achieve the calculated airflow and water flow rates. If increase of decrease is 5% or less, equipment adjustments are not required.
3. Balance airflow of the duct distribution system and each air outlet in renovated areas and where noted on the plans.
4. Balance airflow to areas not included in the renovation to match preconstruction airflow rates.

3.7 SPACE PRESSURIZATION PROCEDURE

A. Perform testing and balancing procedures on each system according to AABC National Standards for Total System Balance – Chapter 25, Testing and Balancing Health Care Facilities.

3.8 SOUND AND VIBRATION PROCEDURE

A. The following systems shall be tested for sound and vibration:

1. Air handling units and associated air and hydronic systems

B. Perform testing procedures on each system according to any of the following:

1. NEBB S&V Procedural Standard for Measurement of Sound and Vibration
2. AABC National Standards for Total System Balance – Chapter 22, Sound, and Chapter 23, Vibration Testing.
3. SMACNA HVAC Sound and Vibration Manual – Chapter 9, Sound Instrumentation and Measurements, and Chapter 10, Vibration Instrumentation and Measurements.

C. Take sound readings in dBA in accordance with ANSI S12.1 to determine equipment sound power levels to confirm compliance.

3.9 HYDRONIC SYSTEMS PROCEDURE

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC - National Standards for Total System Balance, NEBB - Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems, or SMACNA – TAB Procedural Guide and this Section.

B. Minimum hydronic procedures shall include the following:

1. Prepare itemized equipment schedules listing all heating and/or cooling elements and equipment in the systems to be balanced. List in order on equipment schedules, by pump or zone according to the design, all heating and/or cooling elements, all zone balancing valves, and circuit pumps, ending with the last items of equipment or transfer element in the respective zone or circuit. Include on schedule sheet column titles listing the location, type of element or apparatus, design conditions, and measured conditions. Prepare individual pump report sheets for each zone or circuit.
2. Adjust hydronic systems to provide plus or minus 10% of required design quantities.
3. Use calibrated Venturi tubes, orifices, metered fittings, pressure gages, and direct-reading instrumentation to determine flow rates for system balance. Where flow-metering devices are not installed, flow balance on temperature difference across various heat transfer elements in the system is acceptable.
4. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.
5. Effect system balance with automatic control valves fully open to heat or cooling transfer elements.
6. Adjust hydronic distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.

7. Test pumps and adjust flow. Record the following on pump report sheets:
    a. Suction and discharge pressure.
    b. Running amps and brake horsepower of pump motor under full flow and no flow conditions.
    c. Pressure drop across pump in feet of water and total GPM pump is handling under full flow conditions.
8. Where available pump capacity is less than total flow requirements or individual system parts, proportional balancing must be performed.

3.10 REPORTING

A. At project start: The TAB contractor shall examine the Contract Documents as specified in "Examination" Article and prepare a report on the adequacy of design for systems' balancing devices. The report should recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing and recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Upon initial examination of installed system: Prior to balancing, submit report indicating system deficiencies that would prevent proper testing, adjusting, and balancing of systems and equipment to meet specified performance.

C. Preliminary TAB reports: Submit the preliminary testing, adjusting and balancing report without field data, but including any drawings indicating air outlets, thermostats, and equipment identified to correspond with data sheets.

D. Certified TAB reports: Submit reports prepared, as specified in this Section, on forms certified by TAB firm using standard forms from AABC, NEBB or TABB/SMACNA with the following minimum requirements.

1. Report Title and Identification:
    a. Project Name and Address
    b. Engineer Name
    c. HVAC Contractor Name
    d. NEBB/AABC/TABB Certified TAB Firm Name, Address, and Certification Number
    e. Report Date
2. Report Certification:
    a. A certification page bearing the stamp of the Certified TAB Professional.
    b. The signature on the stamp, indicating they have reviewed the report and assume responsibility for all work, test methods, and observed conditions documented within.
3. Table of Contents:
    a. A table of contents with page numbers or clickable links for digital reports, serving as a guide to the report's organization. Bookmarks can be used in digital reports if every data page has a consecutive and unique page number.
4. Report Summary / Remarks:
    a. A narrative description of system set-up conditions established prior to testing, adjusting, and balancing. This should explain the rationale for how the system was configured for testing (e.g., full flow conditions, control configuration).

b. A listing of deficiencies identified during the TAB process in the summary, with references to the specific pages in the report where these deficiencies are detailed.

c. A clear indication of any variances from design quantities that exceed specified tolerances. These deviations should be noted in the Project Summary and often also in the remarks section of the relevant data pages.

5. All Report Pages:
   a. Project name on every page.
   b. Sequentially numbered pages.
   c. A remarks section on each data page to record pertinent information observed during testing and balancing.
   d. If a measured TAB value is also measured by the BAS include these values on the report page and compare them to the design values.
   e. The name of the individual who reported the information and the date the data was collected on each data form.
6. Instrument Calibration:
   a. A report detailing the calibration of all instruments used for testing and balancing, ensuring the accuracy of the measurements.
7. Abbreviation List:
   a. A comprehensive list defining all abbreviations and acronyms used throughout the report.
8. Drawings and Schematics:
   a. Pertinent contract drawings, schematics, sketches, or other mechanical plans (where permissible) that clearly identify the area, location, and equipment being tested and balanced. All tested items must be clearly identified with a unique designation that corresponds to the data forms.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 23\23 0593-Testing Adjusting and Balancing for HVAC.docx

SECTION 23 0800
COMMISSIONING OF MECHANICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. The purpose of this section is to specify the Division 23 responsibilities and participation in the Commissioning Process.

B. Work under this contract shall conform to requirements of Division 01, General Requirements, Conditions of the Contract, and Supplementary Conditions. This specification covers commissioning of mechanical systems which are part of this project.

C. Commissioning work shall be a team effort to ensure that all mechanical equipment and systems have been completely and properly installed, function together correctly to meet the design intent, and document system performance. Commissioning shall coordinate system documentation, equipment start-up, control system calibration, testing, adjusting and balancing, and verification through functional performance testing.

D. The Commissioning Team shall be made up of representatives from the owner, Design Team, General Contractor (GC), manufacturers, and construction trades. The trades represented on the Commissioning Team shall include, but not be limited to: sheet metal, piping and fitting, controls, test and balance, and electrical. The lead person for each trade who will actually perform or supervise the work is to be designated as the representative to the Commissioning Team. Responsibility for various steps of the Commissioning Process shall be divided among the members of the Commissioning Team, as described in this section.

E. The Commissioning Provider (CxP) shall have responsibility for coordinating and directing each step of the Commissioning Process.

F. Mechanical system installation, start-up, testing, balancing, preparation of O&M manuals, and operator training are the responsibility of the Division 23 Contractors, with coordination, observation, verification and commissioning the responsibility of the CxP as per Division 01, Section 01 9113. The 01 9113 Commissioning Process does not relieve Division 23 contractors from the obligations to complete all portions of work in a satisfactory and fully operational manner.

G. Refer to Division 01, Section 01 9113, for a full list of commissioning related definitions. A few critical definitions are included below:

1. *Commissioning*. A systematic process that provides documented confirmation that specific and interconnected fire and life safety systems function according to the intended design criteria set forth in the project documents and satisfy the owner's operational needs, including compliance requirements of any applicable laws, regulations, codes, and standards requiring fire and life safety systems.

2. *CxP (CxP)*. The qualified person, company, or agency that plans, coordinates, and oversees the entire Cx process.

3. *Commissioning Plan*. The document prepared for each project, which identifies the processes and procedures necessary for a successful Cx process.

4. *Functional Performance Testing (FPT)*. Tests performed to verify compliance with manufacturers' specifications, applicable codes and standards, and the project design intent.

1.2 RELATED SECTIONS

A. Division 01 Section 01 9113 - General Commissioning Requirements

B. Division 26 Section 26 0800 - Commissioning of Electrical Systems

1.3 ROLES AND RESPONSIBILITIES

A. Refer to Section 01 9113 for CxP, Owner, Design Team, and General Contractor roles and responsibilities.

B. Mechanical contractor and sub-contractors

1. Include cost to complete commissioning requirements for mechanical systems in the contract price.
2. Include requirements for submittal data, O&M data, and training in each purchase order or sub contract written.
3. Ensure cooperation and participation of all subcontractors.
4. Ensure participation of major equipment manufacturers in appropriate training and testing activities.
5. Attend Construction Phase coordination meetings scheduled by the CxP.
6. Conduct mechanical system orientation and inspection when equipment is set.
7. Respond to (in writing) and address items documented in the Issues Log.
8. Notify the GC a minimum of one weeks in advance of installation tests, such as duct leakage, hydronic system pressure tests and flushing and cleaning activities.
9. Notify the GC a minimum of two weeks in advance of system start-up and testing, so CxP may be on site to witness.
10. Notify the GC a minimum of two weeks in advance, of the time for start of the TAB work. Attend the initial TAB meeting for review of the TAB procedures.
11. Submit copies of all test results to the CxP.
12. Complete manufacturer pre-start checklists for all equipment.
    a. Contractor shall be responsible for completion of manufacturer pre-start checklists for all equipment for which it issued a purchase order.
    b. The lead Contractor (who purchased the equipment) shall coordinate completion of pre-start checklists with all other contractors that have made connections to equipment for which it issued a purchase order.
    c. Remedy any deficiencies identified in pre-start checklists and notify CxP in writing that deficiencies have been addressed.
13. Assist the CxP in all pre-start checklist verifications and Functional Performance Tests.
14. Prepare preliminary schedule for mechanical system orientation and inspections, O&M manual submission, training sessions, pipe and duct system testing, flushing and cleaning, equipment start up, TAB, and task completion for use by the GC and CxP. Update schedule as appropriate throughout the construction period.
15. Conduct mechanical system orientation and inspection when equipment is set in place.
16. Keep drawings updated as changes in the field are made, and review with the GC and CxP.

17. Gather O&M data on all equipment, and assemble in binders as required by the specification. Submit to GC for review prior to the completion of construction.
18. Participate in, and schedule vendors and Contractors to participate in the training sessions as set up by the GC.
19. Submit training syllabus for approval to GC and CxP.
20. Participate in, and schedule vendors and Contractors to participate in the training sessions as set up by the GC. Provide site-specific training information on digital media/electronic format (flash drive, CD, DVD). If training is videotaped, provide on digital media/electronic format (flash drive, CD, DVD).
21. Provide a complete set of as-built records to the GC as specified in the contract documents.

C. Test, Adjust, and Balance contractor

1. Include cost for commissioning requirements in the contract price.
2. Attend initial commissioning coordination meeting scheduled by the CxP.
3. Submit the TAB procedures to the GC, design team and CxP for review and acceptance.
4. Attend the TAB planning meeting scheduled by the GC. Be prepared to discuss the procedures that shall be followed in testing, adjusting and balancing the systems to be commissioned.
5. Support the Cx process during functional performance testing by taking and measurements and assisting in the calibration of selected BAS instrumentation controls devices.
6. Participate in training sessions as scheduled by the GC.
7. Submit a copy of the TAB report to the GC, design team and CxP for review.
8. Participate in verification of the TAB report, which will consist of repeating any selected measurement contained in the TAB report where required by the CxP for verification or diagnostic purposes.

D. Building Automation Controls (BAS) contractors

1. Include cost for commissioning requirements in the contract price, including assisting the CxP with implementation of the FPTs and reviewing control system operation with the CxP.
2. After submission of the controls submittal, attend a controls integration meeting with the CxP, design team, GC and other contractors/vendors that will interface with the BAS such as boilers, chillers, fire, electrical, etc. to review the interoperability and communication needed for the BAS to communicate with all these systems.
3. Submit a revised submittal after receiving comments on the submittal and meeting minutes provided by the CxP from the controls integration meeting.
4. Verify proper installation and performance of BAS controls and provide a copy of documentation to the CxP
5. Integrate BAS installation and programming schedule with construction and commissioning schedules.
6. Provide thorough training to operating personnel on hardware operations and programming, and the application program for the system.
7. Demonstrate system performance to CxP including all modes of system operation (e.g. normal, abnormal, and emergency).

8. Provide control system technician for use during contractor pre-start checklists and Functional Performance Testing.

9. Provide trend logs as required to facilitate the Commissioning Process.

E. Equipment manufacturers and miscellaneous contractors

1. Include cost for commissioning requirements in the contract price.

2. Provide submittals, and appropriate O&M manual section(s).

3. Attend initial commissioning coordination meeting scheduled by the CxP.

4. Participate in training sessions as scheduled by the GC.

5. Demonstrate performance of equipment as applicable.

1.4 SCOPE OF WORK

A. Commissioning work of Division 23 shall include, but not be limited to:

1. Testing and start-up of the equipment.

2. Completion of pre-start checklists.

3. Testing, adjusting and balancing of hydronic and air systems.

4. Cooperation with the CxP.

5. Providing qualified personnel for participation in commissioning tests, including seasonal testing required after the initial testing.

6. Providing equipment, materials, and labor as necessary to correct construction and/or equipment deficiencies found during the Commissioning Process.

7. Providing operation and maintenance manuals and as-built drawings to the CxP for verification.

8. Providing training and demonstrations for the systems specified in this Division.

B. The work included in the Commissioning Process involves a complete and thorough evaluation of the operation and performance of all components, systems, and sub-systems. The following equipment and systems shall be evaluated:

1. **Phase 1 Demolition**

a. The Division 23 contractors shall functionally pre-test the following prior to beginning of any demolition, and provide copies of all testing documentation to the GC, design team and CxP:

(1) AHU-201Supply Fan

(a) Measure CFM at equipment discharge.

(2) AHU-201 Return Fan

(a) Measure CFM at equipment discharge.

(3) AHU-201 Cooling Coil

(a) Measure differential pressure across the coil

(4) AHU-201 Heating Coil

(a) Measure differential pressure across the coil

(5) AHU-202 Supply Fan

(a) Measure CFM at equipment discharge.

(6) AHU-202 Return Fan

(a) Measure CFM at equipment discharge.

(7) AHU-202 Cooling Coil

(a) Measure differential pressure across the coil

(8) AHU-202 Heating Coil

(a) Measure differential pressure across the coil

2. **Phase 2 Construction**

a. This phase of the project includes the following systems and equipment all of which will be commissioned:

(1) Two air handling units and their associated supply and return fan walls (AHU-201 and AHU-202)

(2) Cooling coils in two air handling units

(3) Heating coils in two air handling units

b. Seasonal / deferred testing for all the systems and equipment within this phase is required to test the equipment under both full and part load conditions.

C. Timely and accurate documentation is essential for the Commissioning Process to be effective. All members of the Cx team are expected to provide, review and comment on documentation provided throughout the Cx process. Documentation required as part of the Commissioning Process shall include but not be limited to:

1. Commissioning Process Reports, which may include the following:

a. Commissioning Field Reports

b. Commissioning Issues Logs

c. Meeting Minutes

2. Pre-start, and start-up procedures

3. Pre-start checklists

4. Functional Performance Tests

5. Training agenda and materials

6. As-built records

7. Final commissioning report

8. Operation and maintenance (O&M) manuals

D. Detailed testing maybe performed on all installed equipment and systems to ensure that operation and performance conform to contract documents. Selected tests shall be witnessed by the CxP. The following testing is required as part of the Commissioning process:

1. Contractor pre-start checklists (PFC) are comprised of a full range of checks and tests to determine that all components, equipment, systems, and interfaces between systems operate in accordance with contract documents. Verification is completed by the Division 22, 23 and 26 contractors and documented using pre-start checklists.

2. Contractor installation tests, such as duct leakage, hydronic system pressure tests and flushing and cleaning activities.

3. Contractor / manufacturer system start-up testing.

4. Functional Performance Tests (FPT) shall determine if the mechanical systems are operating in accordance with the design intent. This includes all operating modes, interlocks, control responses, and specific responses to abnormal or emergency conditions.

E. Comprehensive training of O&M personnel shall be performed by the Mechanical Contractor, and where appropriate, by other sub-contractors, and vendors prior to turnover of building to the owner. The training shall include classroom instruction, along with hands-on instruction on the installed equipment and systems.

1.5 DOCUMENTATION

A. The CxP shall oversee and maintain the development of the commissioning document process. The GC shall maintain the commissioning documentation. The commissioning documentation shall include, but not be limited to, the following:

1. Commissioning Plan
2. Commissioning Schedule
3. Commissioning RFIs
4. Commissioning Field Reports
5. Issues Logs
6. Pre-start checklists including contractor testing and manufacturer startups
7. Functional Performance Tests
8. See 01 9113 for additional information on the commissioning documentation.

B. See 01 9113 for additional information on the commissioning documentation.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The appropriate Contractor(s) shall furnish all special tools and equipment required for testing during the commissioning process. A list of all tools and equipment to be used during commissioning shall be submitted to the CxP for approval. The owner shall furnish necessary utilities for the Commissioning Process.

2.2 TEST EQUIPMENT – PROPRIETARY

A. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the Commissioning Process as needed. Proprietary test equipment (and software) shall be returned to the equipment manufacturer / contractor which provided it upon completion of the Commissioning Process.

PART 3 - EXECUTION

3.1 GENERAL

A. A pre-construction meeting of all Commissioning Team members shall be held at a time and place designated by the CxP and GC. The purpose shall be to familiarize all parties with the Commissioning Process, and to ensure that the responsibilities of each party are clearly understood.

B. The Contractor shall complete all phases of work so the systems can be started, tested, balanced, and commissioning procedures undertaken. This includes the complete installation of all equipment, materials, pipe, duct, wire, insulation, controls, etc., per the contract documents and related directives, clarifications, and change orders.

C. A Commissioning Plan shall be developed by the CxP. The Contractor shall assist the CxP in preparing the Commissioning Plan by providing all necessary information pertaining to the actual equipment and installation.

3.2 PARTICIPATION IN COMMISSIONING

A. The Contractor shall provide skilled technicians to start-up and debug all systems within Division 23. These same technicians shall be made available to assist the CxP in completing the commissioning program. Work schedules, time required for testing, etc., shall be requested by the CxP and coordinated by the contractor. Contractor shall ensure that the qualified technician(s) are available and present during the agreed upon schedules and of sufficient duration to complete the necessary tests, adjustments, and/or problem resolutions.

B. System performance problems and discrepancies may require additional technician time, CxP time, reconstruction of systems, and/or replacement of system components. The additional technician time shall be made available for subsequent commissioning periods until the required system performance is obtained.

C. The CxP reserves the right to question the appropriateness and qualifications of the technicians relative to each item of equipment, system, and/or sub-system. Qualifications of technicians shall include expert knowledge relative to the specific equipment involved and a willingness to work with the CxP. Contractor shall provide adequate documentation and tools to start up and test the equipment, system, and/or sub-system.

3.3 DEFICIENCY RESOLUTION

A. In some systems, maladjustments, misapplied equipment, and/or deficient performance under varying loads will result in additional work being required to commission the systems. This work shall be completed under the direction of the GC, with input from the contractor, equipment manufacturer, and CxP. Whereas all members shall have input and the opportunity to discuss, debate, and work out problems, the design team shall make final determination over any additional required work to achieve performance.

B. Corrective work shall be completed in a timely fashion to permit the completion of the Commissioning Process. Experimentation to demonstrate system performance may be permitted. If the CxP deems the experimentation work to be ineffective or untimely as it relates to the Commissioning Process, the CxP shall notify the GC, indicating the nature of the problem, expected steps to be taken, and suggested deadline(s) for completion of activities. If the deadline(s) pass without resolution of the problem, the GC reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs incurred to solve the problems in an expeditious manner shall be the contractor's responsibility.

C. The General Contractors contract with the CxP includes up to two Functional Performance Tests of each piece of equipment or system included in the commissioning scope. CxP time and expenses required for retests beyond two, if required, due to incomplete installation or otherwise, will be paid by the GC and reimbursed by the contractor.

3.4 ADDITIONAL COMMISSIONING

A. Additional commissioning activities may be required after system adjustments, replacements, etc., are completed. The contractor(s), manufacturers, and CxP shall include a reasonable reserve to complete this work as part of their contractual obligations.

3.5 SEASONAL / DEFERRED TESTING COMMISSIONING

A. Seasonal commissioning pertains to testing under full load conditions during peak heating and peak cooling seasons, as well as part load conditions during off-peak periods. Initial commissioning shall be done as soon as contract work is completed, regardless of season. Subsequent commissioning may be undertaken at any time thereafter to ascertain adequate performance during the different peak and off-peak conditions. Each contractor and manufacturer shall be responsible to participate in the initial and the alternate peak and off-peak tests of the systems as required to demonstrate performance.

B. Contractors are responsible to update any and all documentation based on information found through seasonal testing.

C. The CxP shall participate and witness all seasonal / deferred testing.

D. Seasonal / Deferred testing is anticipated for the following systems and equipment:

1. Air Handling Units AHU-201 and AHU-202

3.6 CONSTRUCTION PHASE OBSERVATION

A. Scope of Construction Phase observation

1. The CxP will conduct periodic observations during the Construction Phase to monitor progress and compliance with the design intent and contract documents. It is the responsibility of the contractor to address the issues noted on the Issues Log and notify the CxP of completion.

2. CxP observations may coincide with Design Team observations, however, are not intended to take the place of this work.

B. Documentation and reporting, each site visits shall be documented and distributed to Commissioning Team members with the following:

1. Field Inspection Report

2. Issues Log

3. Photo's and other supporting information

3.7 TESTING PROCEDURES

A. Pre-start checklists

1. Pre-start checklist scope

a. Tests and verifications included in the pre-start checklists shall determine if all components, equipment, systems, and interfaces between systems are installed and are ready to operate in accordance with contract documents.

b. The pre-start checklists shall be the equipment specific manufacturer IOM pre-start and startup checklists.

c. Contractor shall be responsible to obtain these pre-start checklists and complete checklists for all equipment for which it issued a purchase order.

2. Documentation and reporting requirements
    a. Pre-start checklists shall be provided for each component, piece of equipment, system, and sub-system, including all interfaces, interlocks, etc.
    b. The checklists MUST be signed by the lead contractor responsible for the checklist.
    c. Completed checklists shall be submitted to the CxP for acceptance and inclusion in the commissioning report.

B. Test, Adjust, and Balance verification

1. The TAB contractor shall provide a technician to assist the CxP in testing and , verifying critical instrumentation and controls that control systems and equipment, such as static pressure transmitters, differential pressure transmitters, air flow monitoring stations, etc.

C. Functional Performance Testing

1. Scope of Functional Performance Testing
    a. Functional Performance Tests shall determine if equipment, system, and/or sub-system is operating in accordance with the final design intent. This includes all operating modes, interlocks, control responses, and specific responses to abnormal or emergency conditions. The following is a list of test examples:
        (1) Determine capability of the heat hot water system to deliver hot water at the design supply temperature, and required rate of flow.
        (2) Determine capability of chilled water system to deliver chilled water at the design supply temperature, and required rate of flow.
        (3) Determine the ability of the HVAC unit to deliver the cooling and/or heating services to the distribution system, at the design supply air temperature, required static pressure, and proper outside air ventilation rate.
2. Functional Performance Test procedure documents
    a. Detailed procedures for each series of tests will be developed by the CxP for review and acceptance by the GC and design team. The procedures shall include samples of the data sheets that will be part of the reports.
3. Functional Performance Test procedures
    a. The CxP shall supervise and direct all Functional Performance Tests.
        (1) Set the system equipment (i.e. chiller, boiler, pumps, fans, etc.) into the operating mode to be tested (i.e. normal shut-down, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
        (2) The CxP shall inspect and verify the position of each device and interlock identified in the test procedure. Each item shall be signed off as acceptable (yes) or failed (no).
        (3) This test shall be repeated for each operating cycle that applies to the mechanical system being tested.
        (4) Operating checks shall include all safety cutouts, alarms, and interlocks with smoke control and life safety systems during all modes of operation of the mechanical system.
        (5) If during a test an operating deficiency is observed, appropriate comments will be added to the Test Procedure form and the Issues Log.

(6) Confirmation of the TAB results shall be verified utilizing the Building Automation System. This shall include, but not be limited to, the following examples:

(a) Verify supply and return flow rates for VAV and constant volume systems in all modes of operation of the HVAC system.

(b) Verify operation of the terminal units in both heating and cooling cycles.

(c) Verify minimum outdoor air intake in all modes of operation and at minimum and maximum total airflow rates.

(d) Verify building pressurization.

(e) Verify total exhaust airflow, and total outdoor air intake.

(7) Verification of the proper responses of BAS system controllers and sensors shall be as follows:

(a) For each controller or sensor, record the indicated BAS system reading, and the test instrument reading.

(b) If the initial test indicates that the test reading is outside of the control range of the installed device, the calibration of the installed device shall be checked and adjusted as required. The deficient device shall be re-tested and the results recorded on the Functional Performance Test form.

b. If deficiencies are identified during Functional Performance Testing, the General Contractor will be notified, and action taken to remedy the deficiency. The final Functional Test Procedure forms will be reviewed by the CxP to determine if testing is complete and the system is functioning in accordance with the contract documents.

4. Documentation and reporting requirements

a. All measured data, data sheets, and a comprehensive summary, describing the operation of the mechanical systems at the time of testing shall be submitted to the CxP.

b. A preliminary Functional Performance Test report shall be prepared by the CxP and submitted to the Design Team for review. Any identified deficiencies need to be evaluated by the Design Team and General Contractor to determine if they are part of the contractor's or sub-contractor's contractual obligations. Construction deficiencies shall be corrected by the responsible contractor(s), and the specific Functional Performance Test repeated.

c. If it is determined that the mechanical systems are constructed in accordance with the contract documents, and the performance deficiencies are not part of the contract documents, the Owner, design team and GC must decide whether any required modifications needed to bring the performance of the mechanical systems up to the finalized design intent shall be implemented, or if the test shall be accepted as submitted. If corrective work is performed, the owner shall determine if a portion or all required Functional Performance Tests should be repeated, and a revised report submitted and additional costs will be incurred by all those involved.

3.8 SYSTEMS TRAINING:

A. The Mechanical Contractor, and appropriate sub-contractors, shall provide comprehensive systems instruction on building systems prior to delivery. The instruction shall include classroom instruction delivered by competent instructors based upon the contents of the Systems Manual. Emphasis shall be placed upon overall systems diagrams and descriptions, and how system components interact. The classroom instruction shall also include detailed equipment instruction by qualified manufacturer's representatives for which operating instructions are provided. The manufacturer's

representative training shall emphasize operating instructions and preventive maintenance as described in the Systems Manual. At a minimum, the training sessions shall cover the following items:

1. Types of installed systems
2. Theory of operation
    a. Design intent
    b. Occupied vs. unoccupied or partial occupancy
    c. Seasonal modes of operation
    d. Emergency conditions and procedures
    e. Comfort conditions
    f. Indoor air quality
    g. Energy efficiency
    h. Other issues important to facility operation
3. System operations
4. Use of control system
    a. Sequence of operation
    b. Problem indicators
    c. Diagnostics
    d. Corrective actions
5. Service, maintenance, diagnostics and repair
6. Use of reports and logs
7. Troubleshooting, investigation of malfunctions, and determining reasons for the problem

B. Each classroom training period shall be followed by an in the field walk through, inspection, explanation, and demonstration of the system by the instructors. The applicable equipment shall be demonstrated including system startup and shutdown, as deemed appropriate.

C. The CxP shall participate in all training.

D. See Division 019113 and other disciple specific specification sections for complete training requirements and the duration of training required.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 23\23 0800-Commissioning of Mechanical Systems.docx

SECTION 23 0903
TEMPERATURE CONTROL CONDUIT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Conduit

B. Connectors

C. Junction Boxes

1.2 SCOPE

A. This section includes conduit requirements for use with wire, cable and pneumatic polyethylene tubing.

1.3 SUBMITTALS

Not Applicable

PART 2 - PRODUCTS

2.1 CONDUIT

A. All wiring shall be installed in a complete conduit raceway system of a minimum trade size of ½". Conduit shall be installed continuous from terminal to terminal and shall be mechanically and electrically connected. The entire system shall be grounded.

1. Exception: With permission of Owner, metallic surface raceway may be used in finished areas on masonry walls. All surface raceway in finished areas must be color matched to the existing finish within the limitations of standard manufactured colors. Receive authorization from Owner before using surface raceway.

2. Exception: The conduit system shall be complete except that up to 12" of exposed Class 2, 3, or communications wiring may be used from the conduit system to an actuator. Wiring extending beyond the conduit system shall be protected by a plastic bushing at the end of the conduit.

B. Conduit installed outside or exposed to moisture shall be rigid aluminum. Conduit in other areas shall be electric metallic tubing (EMT).

C. Conduits installed in dry locations requiring flexible connections for adjustment or vibration isolation shall be provided with a 14" maximum length of flexible galvanized steel (Greenfield) conduit. Flexible conduit installed in wet locations and exterior locations shall be liquid-tight type.

D. Deductive Alternate DA1

1. Under Deductive Alternate DA1, an incomplete raceway system may be provided. The following additional exceptions may be taken only to paragraph 2.1.A. above.

a. All low voltage wiring and pneumatic tubing in the following areas above ceilings may be plenum rated cable and polyethylene tubing without raceway, if allowed by local code. All cables and tubing shall be neatly bundled and strapped to structural members and not laid on ceilings.

b. All low voltage wiring and pneumatic tubing in non-finished areas (mechanical equipment rooms, storage rooms, etc.) over 8'-0" above finished floor may be plenum rated cable and

polyethylene tubing without raceway, if allowed by local code. All cables and tubing shall be neatly bundled and run parallel to or at right angles to the building structure.

c. Contractor shall provide a complete raceway system for the above areas if such wiring and/or pneumatic tubing may be damaged due to normal operations of the Owner, maintenance, access, etc.

2.2 CONNECTORS

A. Couplings and connectors for use with rigid aluminum shall be the threaded type. Terminations shall be with double locknut and insulated bushings. Fittings installed outdoors shall be water tight.

B. Couplings and connectors for electrical metallic tubing (EMT) shall be gland compression.

2.3 JUNCTION BOXES AND PULL BOXES

A. Provide junction boxes and pull boxes of the proper size and shape.

B. Junction and pull boxes shall be supported independently of the conduit system.

C. Junction and pull boxes shall be of galvanized steel construction.

D. Paint each junction box cover per specification Division 26 Section 26 0505, “Basic Electrical Materials and Methods.” Mark cover using permanent marker to indicate that wiring enclosed is associated with the controls system.

PART 3 - EXECUTION

3.1 CONDUIT INSTALLATION

A. Conduit shall not be smaller than the sizes indicated or specified, and where no size is indicated, the Contractor shall size the conduit in accordance with the requirements of the local/state Electrical Code for the number, size and type of wires indicated and specified for application, except that no conduit shall be less than ½” trade size.

B. Where conduit enters panel boxes, pull boxes, outlet boxes or wireways, it shall be secured in place by galvanized locknut on the outside and galvanized locknut and bushing on the inside. Bushing shall be insulated throat type with ground lug. Care shall be taken to see that all conduit runs from a permanent and continuous ground return back to the panel ground connection point. All bushings shall be bonded to the junction box, outlet box, cabinet, etc. Where required, bonding jumpers shall be installed between conduit and boxes.

C. Conduits for branch circuits shall be installed continuous between connections to outlets, boxes and cabinets and shall have a minimum possible number of bends or fittings. Bends shall be made with an approved hickey or conduit-bending machine and shall be smooth and even without flattening or flaking.

D. Exposed conduit runs shall be run neatly and shall be parallel to the walls of the building.

E. The actual installation of conduit shall be made in the field to clear all piping, ductwork, equipment fixtures, ceiling inserts, access doors, etc. Bends, turns, and pull boxes, as required, shall be provided in accordance with field conditions.

F. Conduit ends shall be reamed and shall be thoroughly cleaned before installation. Conduit openings and boxes shall be plugged or covered as required to keep conduit clean during construction. All conduit shall be swabbed clear of obstructions before the pulling of wires.

G. All threaded joints in rigid aluminum conduit shall be sealed with Thomas & Betts “Alum-Shield” compound on the male thread only.

H. Conduit runs shall be securely fastened in place with approved straps, and hangers and supports from inserts set in the construction above. Vertical conduit shall be securely clamped to steel members and unistruts, and attached to the structure.

I. Conduit shall not pierce or interfere with waterproofing, vapor barriers, damp-proofing, etc.

J. Raceways run through foundation walls, basement slabs, or through any walls for floors that have vapor barriers, waterproofing, or any type of damp-proofing, shall be sealed by use of special wall and floor entrance seals designed for the purpose. Drawings of the proposed seals and clamping arrangements shall be submitted for approval.

K. Conduits passing from the building exterior to interior or passing between conditioned and non-conditioned spaces shall be sealed to prevent condensation in the conduit.

L. Conduits crossing building expansion joints shall be provided with expansion fittings and flexible grounded bonds bypassing the fittings to insure ground continuity.

M. All conduit shall be supported with fasteners designed for the application and must be attached to the building structure and shall not be supported from other conduit, pipes, ductwork, ceiling suspension members or equipment. Existing pipe hangers for multiple conduits with spare capacity may be used.

1. Exception: When conduit is required to terminate at a sensor or control point on ductwork, the conduit may be fastened to the ductwork. This is the only condition in which conduit is allowed to be fastened to ductwork.

2. Note: Perforated metal strap and tie wire are prohibited.

N. Existing conduit which is in place and has additional wire carrying capacity due to existing wiring being removed or due to original spare capacity may be used for new wiring if the conduit installation meets this Temperature Control conduit specification.

O. All openings for conduit passing through masonry walls or floor shall be core drilled by this Contractor. Core holes shall be sealed as follows:

1. For the conduits penetrating floor or fire walls, the Contractor shall provide fire stopping equivalent to the construction penetrated.

2. Where conduit passes through floor or exterior walls, caulk at both sides to insure waterproofing around conduit.

3. Where conduit penetrates walls separating quiet areas such as offices from noisy areas such as equipment rooms, the opening around the conduit shall be filled with fiberglass insulation and sealed.

3.2 JUNCTION BOX INSTALLATION

A. All outlets shall be installed in accessible locations and none shall be installed above ducts, behind furring or in other similar locations. Any outlet designated as providing power for particular piece of equipment shall be accessible for disconnection with said unit in place.

END OF SECTION

SECTION 23 0904
TEMPERATURE CONTROL WIRING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Wire

B. Cable

1.2 SCOPE

A. Power wiring, Class 1, 2, or 3 wiring, and communications wiring required for satisfactory installation and operation of all equipment specified under temperature control shall be furnished and installed by this contractor.

B. Wiring shall be installed in accordance to wiring specification found in this section.

C. All wiring shall be UL listed and installed in accordance with applicable electrical codes and shall comply with equipment manufacturer's recommendations.

Note: When specified materials or installation methods exceed applicable electrical codes and equipment manufacturer's recommendations, this specification shall govern.

1.3 SUBMITTALS

A. Submit data and samples of the following:

1. Analog Cable
2. Other low voltage signal cable

PART 2 - PRODUCTS

2.1 WIRE AND CABLE

A. All wires shall be copper and shall meet the minimum wire size and insulation class listed.

WIRE CLASS	MINIMUM WIRE SIZE	MINIMUM INSULATION CLASS
Power	12 Gauge	600 Volt
Class 1	14 Gauge Stranded	600 Volt
Class 2	18 Gauge Stranded	300 Volt
Class 3	18 Gauge Stranded	300 Volt
Communications	Per Manufacturer	Per Manufacturer

B. 120V power circuit wiring shall be #12 AWG. Home runs longer than 100 feet shall be #10 AWG.

C. 24V control power circuit wiring and all wiring to flow switches and relays shall be #14 AWG. Runs greater than 200 feet in length shall be #12 AWG.

D. Use twisted shielded pair, insulated and jacketed cable, #18 AWG minimum, for wiring to sensors (temperature, humidity, etc.). All sensor wiring shall have a 100% grounded shield.

E. Network communications wiring shall be in accordance with manufacturer's specifications.

F. Use THHN wires for power circuit wiring and all control wiring in dry locations; use THWN wires for wet locations.

G. Conductors shall be continuous from outlet to outlet and no splices or connections shall be made, except within outlet boxes, junction boxes or cabinets.

H. Permanent wiring shall not be pulled into conduits or raceways until permission is granted by Owner.

I. Where the space above a ceiling is a supply or return air plenum, the wiring therein shall be plenum rated.

PART 3 - EXECUTION

3.1 WIRING

A. All sensor wiring shall use crimped or soldered connections; wire nuts are not allowed.

B. Sensor wiring shall be continuous containing no splices between the digital controller and the field sensor.

C. Identify all control/signal wires with labeling tape using either words, letters or numbers that can be exactly cross-referenced with as-built drawings.

3.2 INSTALLATION

A. Wires shall be kept a minimum of 3" from hot water piping, steam piping, condensate piping or any other hot surfaces.

B. The Contractor shall provide a separate insulated green ground wire inside each power branch circuit conduit. Connect one end of the ground wire to the ground bus or ground terminal in the panel board. Connect the other end of the ground wire to the grounding lug in equipment being served. Provide and install a grounding lug in equipment being served if no grounding lug exists.

C. Identify all temperature control raceways with labels stating "Control System Wiring." Typed (not handwritten) labels shall be affixed to the covers of all junction boxes and pull boxes.

3.3 RACEWAY SYSTEM

A. Power and Class 1 wiring may be run in the same conduit. Class 2 and 3 wiring and communications wiring may be run in the same conduit. Power and Class 1 may not be run together with Class 2, Class 3, or communications wiring.

B. No sensor wiring shall be run in the same conduit with power or Class 1 wiring.

C. Where different wiring classes terminate within the same enclosures, maintain clearances and install barriers per National Electric Code.

D. Pneumatic tubing may not be run in wiring conduit.

E. Wiring within air handling units shall be in a complete conduit system.

END OF SECTION

SECTION 23 0911
CONTROL VALVES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Globe style hydronic control valves

B. Characterized ball style hydronic control valves

C. Full port ball style hydronic control valves

D. Critical application characterized ball style control valves

E. Critical application butterfly style control valves

F. Pressure Independent Control Valves

G. Globe style steam control valves

H. Valve actuators

1.2 DEFINITIONS

A. Cv: Design valve coefficient

B. DDC: Direct digital control

C. I/O: Input/output

D. NBR: Nitrile butadiene rubber

E. PICV: Pressure independent control valve

F. PTFE: Polytetrafluoroethylene

G. Rangeability: The ratio of the maximum to minimum controllable flow through a valve

H. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

1.3 CODES AND STANDARDS (USE LATEST EDITION)

A. American Society of Mechanical Engineers (ASME)

1. ASME B1.20.1: Pipe Threads, General Purpose, Inch
2. ASME B16.1: Cast Iron Pipe Flanges and Flanged Fittings
3. ASME B16.4: Cast Iron Threaded Fittings
4. ASME B16.5: Pipe Flanges and Flanged Fittings, NPS1/2 to NPS24
5. ASME B16.10: Face-to-Face and End-to-End Dimensions of Valves
6. ASME B16.15: Cast Bronze Threaded Fittings.
7. ASME B16.18: Cast Copper Alloy Solder Joint Pressure Fittings.
8. ASME B16.21: Nonmetallic Flat Gaskets for Pipes Flanges
9. ASME B16.22: Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

10. ASME B16.24: Bronze Flanges and Flanged Fittings.
11. ASME B16.34: Valves – Flanged, Threaded and Welding End
12. ASME B18.2.1: Square and Hex Bolts and Screws - Inch Series

B. American Society for Testing Materials (ASTM)
1. ASTM A 126: Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
2. ASTM B 61: Specification for Steam or Valve Bronze Castings

C. American Water Works Association (AWWA)
1. AWWA C606: Grooved and Shouldered Joints

D. Brazing Handbook.

E. Copper Tube Handbook.

F. Manufacturers Standardization Society (MSS)
1. MSS SP-67: Butterfly Valves
2. MSS SP-68: High Pressure Butterfly Valves with Offset Design
3. MSS SP-72: Ball Valves with Flanged of Butt-Welding Ends for General Service
4. MSS SP-80: Bronze Gate, Globe, Angle and Check Valves
5. MSS SP-85: Gray Iron Globe and Angle Valves, Flanged and Threaded Ends
6. MSS SP-110: Ball Valves, Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

1.4 QUALITY ASSURANCE

A. This Section establishes a minimum quality of hardware and installation and establishes standard equipment or equipment configurations.

B. Work installed by the Contractor shall be done in a neat and workmanlike manner, as determined by Owner and in keeping with acceptable standards for this type of work.

C. Unless indicated in this specification, all materials used shall be new. Where items have been indicated to be reused, it is the Contractor's responsibility to ensure that the reused items are operating properly and are in good condition. Contractor must make Owner aware of defective items designated for reuse. Owner will be responsible for repairs.

D. Valves and Actuators shall be supplied by the valve manufacturer as a single source.

1.5 SUBMITTALS

A. Preconstruction – Prior to construction provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:
1. Product data:
a. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
b. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical

power requirements, and limitations of ambient operating environment, including temperature and humidity.

c. Product description with complete technical data, performance curves, and product specification sheets.

d. Installation, operation, and maintenance instructions, including factors affecting performance.

e. Submit manufacturer's technical literature for each control device listed below. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions, and bill of materials indicating quantity of each device, and model number:

f. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

g. Include diagrams for power, signal, and control wiring.

h. Include diagrams for pneumatic signal and main air tubing.

2. Control valve schedule: Control valve selections shall be based on equipment flow rates shown in the approved equipment shop drawings. The contractor shall size the control valves and create a valve schedule that includes, at a minimum, the following:

a. Valve tag

b. Location (e.g. first-floor mechanical room)

c. Service (e.g. chilled water, hot water)

d. Valve type (e.g. globe, ball, butterfly)

e. Flow characteristics

f. Valve size

g. Pipe size

h. Flow at project design and minimum flow conditions.

i. Valve CV

j. Rangeability

k. Pressure drop at design flow

l. Close-off pressure

m. Fail position

n. Actuator type

o. Valve and actuator model numbers

3. Manufacturer’s installation and operating manuals.

B. Contract closeout – At contract closeout provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Operating and maintenance data including:

a. Product data

b. Installation instructions

c. Assembly drawings

d. Replacement parts list

e. Maintenance and operation instructions

2. Test Reports
   a. Acceptance Test
3. Warranties

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver products to site under provisions of Division 1.

B. Deliver products to site in containers with manufacturer's stamp affixed.

C. Protect products against dirt, water, chemical and mechanical damage before, during and after installation. Damage to products prior to final acceptance of the Work shall be repaired or replaced at no additional cost to the Owner.

1.7 SPARE PARTS

Not Applicable

1.8 WARRANTY

A. One year warranty on products and complete installation commencing at the time of Substantial Completion.

1.9 MAINTENANCE

Not Applicable

PART 2 - PRODUCTS

2.1 GLOBE STYLE HYDRONIC CONTROL VALVES

A. Acceptable Manufacturers
   1. Belimo (G2/G3/G6/G7)
   2. Honeywell (V5011/V5013/VGF)
   3. Johnson Controls
   4. Siemens (Powermite MT/Flowrite VF)

B. Construction
   1. 2" and smaller: ANSI Class 250 bronze body, stainless steel stem, brass plug, bronze seat, TFE packing, renewable composition disc, and screwed ends.
   2. 2½" and greater: ANSI Class 125 cast iron body, stainless steel stem, bronze plug, bronze seat, TFE packing, and flanged ends.

C. Two-way operation
   1. Flow characteristic
      a. 2" and smaller: Equal percentage.
      b. 2½" and greater: Modified equal percentage or equal percentage.
   2. Leakage: ANSI Class III
   3. Rangeability: Minimum 50:1

D. Three-way operation

1. Flow characteristic: Linear
2. Leakage: ANSI Class III
3. Rangeability: Minimum 50:1

2.2 CHARACTERIZED BALL STYLE HYDRONIC CONTROL VALVES

A. Acceptable manufacturers

1. Belimo (B2/B3/B6)
2. Honeywell (VBN/VGF)
3. Johnson Controls (VG1000)
4. Siemens (599 Series)

B. Construction

1. 2" and smaller: 400 psi rated nickel-plated forged brass body, stainless steel ball, stainless steel stem, PTFE seats, EPDM O-ring packing, ETFE or stainless steel flow characterizing disc, and screwed ends.
2. 2½" and greater: ANSI Class 125 cast iron body, stainless steel ball, stainless steel stem, PTFE seats, EPDM O-ring packing, stainless steel flow characterizing disc, and flanged ends.

C. Two-way operation

1. Flow characteristic: Equal percentage
2. Leakage: 0%
3. Rangeability: Minimum 250:1

D. Three-way operation

1. Flow characteristic: Equal percentage for the port serving the device
2. Leakage: 0% for the port serving the device
3. Rangeability: Minimum 250:1

2.3 FULL PORT BALL STYLE HYDRONIC CONTROL VALVES

A. Acceptable manufacturers

1. Belimo (VS/VB)
2. Honeywell (VBN/VBF)
3. Johnson Controls (VG1000)
4. Siemens (599 Series)

B. Construction

1. 2½" and smaller: bronze body, stainless steel ball, stainless steel stem, PTFE seats, PTFE stem packing and bearing, stainless steel retainer, brass gland, stainless steel jam nut, PTFE body seal, and screwed ends.

2. 3” and greater: carbon steel body, stainless steel ball, stainless steel stem, Teflon seats, Teflon packing, and flanged ends.

C. Two-way operation

1. Flow Characteristic: Equal percentage or modified equal percentage

2. Leakage: 0%

2.4 PRESSURE INDEPENDENT CONTROL VALVES

A. Acceptable manufacturers

1. Flow Control

2. Belimo

3. Siemens

4. Danfoss

5. Honeywell

6. Bray

7. Johnson Controls

B. Valves 1½” and smaller shall have screwed end connections and be constructed of brass

C. 2” valves shall have screwed end connections and be constructed of ductile iron.

D. Valves 2½” and larger shall have flanged end connections and be constructed of ductile iron.

E. Construction

1. The control valve shall be suitable for operation with water or glycol solutions up to 50% with operating temperatures between 35°F and 250°F.

2. Control valve bodies shall meet requirements of ANSI 125 or ANSI 250 pressure classes.

3. Inlets and outlets shall be clearly marked on the valve bodies.

4. Valves shall contain a mechanical, spring-loaded pressure independent regulator to maintain a consistent differential pressure across the control port of the valve.

5. Valves shall contain an actuated flow control portion that responds to the modulating signal from the controller. This control valve portion shall have a linear flow characteristic.

6. Valves shall contain a field adjustable flow limiter. The flow limiter shall be easily adjustable in the field without the use of special tools. The adjustment dial shall be set for and indicate maximum flow. It shall be possible to manually limit the flow to the required value with the flow limiter and then modulate the flow with the control valve and actuator.

    a. A table shall be attached to each valve indicating GPM corresponding to each setting on the dial.

    b. No mechanical devices besides the valve and actuator shall be permitted to adjust the maximum flow setting. Flow limiting port shall be integrated into the valve body.

    c. The valve shall always maintain full nominal stroke regardless of the maximum flow setting of the flow limiter.

    d. The flow limiter shall be lockable and tamper resistant when the actuator is installed correctly.

e. Valve shall include pressure ports to provide a means for a balancer to test the differential pressure across the valve control port to ensure the PICV is operating within the pressure independent range.

F. Operation

1. Accuracy: At any given actuator setting the flow accuracy across the entire pressure independent operating range of the automatic differential pressure regulator shall be ±10% or less.
2. Differential pressure range: Valve shall require no more than 5 PSID to operate as pressure independent
3. Flow characteristic: Linear or equal percentage.
4. Leakage: Valves shall meet or exceed ANSI Class IV (0 to 0.01% of nominal maximum) leakage rating at 100 psi close off.
5. Rangeability: Minimum 50:1

G. Actuators

1. Valves shall be provided with an actuator by the same manufacturer, factory installed.
2. All actuators shall have visual position indication.
3. No external programming device shall be required.
4. Actuator shall be electric motor driving, microprocessor signal controlled.
5. Valves shall be positive positioning, responding to a 0-10VDC, 2-10VDC or 4-20mA signal. There shall be a visual valve position indicator and position feedback.
6. Power: All actuators shall be 24VAC power and less than 100VA draw. Power shall be via Class 2 wiring. Actuators requiring more than 100VA shall have a dedicated conduit for power wiring, not mixed with the signal wiring.
7. Fail safe: Valves actuators shall position the valve in a fail-safe position when the power supply is disrupted, or the signal goes to 0. Fail-safe according to the following guidelines unless otherwise stated in the sequence of operations
   a. AHU heating coil valves shall fail open
   b. AHU cooling coil valves shall fail in-place
   c. Terminal unit valves shall fail-in-place
8. Fail in safe valves shall have a means to manually open the valve when power is not available, such as a hand wheel or a geared crank with a clutch.
9. The actuator shall be designed with a current limiting motor protection. A release button (clutch) or handle on the actuator shall be provided to allow for manual override (except when actuator is spring return type).
10. Actuator shall provide minimum torque required for proper valve close-off. The close-off differential pressure rating of the valve shall exceed the highest possible head pressure available at the pump plus 10%, and still be rated for a Class IV leakage.
11. The actuator shall have the capability of adding auxiliary switches or feedback potentiometer if specified.

12. All automatic control valves installed in locations exposed to the elements shall be provided with weather resistant housings and heaters for climates that reach below freezing.
13. Actuators shall be UL and CSA listed.

H. Basis of Design: Delta P Valve manufactured by Flow Design.

2.5 VALVE ACTUATORS

A. Electronic actuators

1. Acceptable manufacturers
    a. Belimo
    b. Johnson Controls
    c. Siemens
    d. Honeywell
2. Electric type with reversing switch and gear disengagement button on cover.
3. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
4. Size for torque required to close valve against pump shutoff head.
5. Microprocessor-controlled brushless DC motor.
6. Overload protection
    a. Provide against overload throughout the entire operating range in both directions.
    b. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.
7. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of -20°F - 150°F.
8. Humidity: Suitable for humidity range encountered by application with minimum operating range of 5% - 95% relative humidity, non-condensing.
9. Enclosure
    a. Suitable for ambient conditions encountered by application
    b. NEMA 250 Type 2/IP54 enclosure for indoor and protected applications.
    c. NEMA Type 4/IP66 enclosure for outdoor and unprotected applications.
    d. Provide actuator enclosure with heater, controller, and self-contained thermostat where required by application.
10. Power supply
    a. 24V or 120V.
    b. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
    c. Actuator shall function properly within a range of 85%-120% of nameplate voltage.
11. Rotation limitation: Provide angle of rotation limiter capable of setting the valve position to less than 100% open or 100% closed.

12. Stroke time
    a. Except where indicated otherwise on drawings, operate the valve from fully closed to fully open and vice versa within 90 seconds.
    b. For spring return actuators move valve to failed position within 25 seconds.
13. Spring return electronic actuators
    a. Modulating
        (1) Capable of stopping at all points across full range and starting in either direction from any point in range.
        (2) Proportional Control: 4-20mA or 0-10Vdc input signal to modulate the actuator proportionally throughout its angle of rotation.
    b. Two position
        (1) Single direction, spring return type
        (2) Digital input signal to modulate the actuator to its open or closed position.
    c. Fail safe
        (1) Spring-return mechanical fail safe mechanism to drive controlled devices to an end position upon loss of power.
        (2) External manual gear release.
        (3) Field adjustable from fail open to fail closed without replacement.
    d. Position feedback
        (1) Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.
        (2) Provide auxiliary switches for positive means of position indication signal for remote monitoring of open and closed position.
        (3) Provide a 4-20mA or 0-10Vdc position feedback signal for remote monitoring of modulating actuators.
14. Non-spring return electronic actuators
    a. Modulating
        (1) Capable of stopping at all points across full range and starting in either direction from any point in range.
        (2) Floating point: Coordinated digital input signals to modulate the actuator throughout its angle of rotation.
    b. Two position
        (1) On/off type.
        (2) Digital input signal to modulate the actuator to its open or closed position.
    c. Position feedback
        (1) Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.
        (2) Provide auxiliary switches for positive means of position indication signal for remote monitoring of open and closed position.
        (3) Provide a 4-20mA or 0-10Vdc position feedback signal for remote monitoring of modulating actuators.

d. Fail safe
    (1) Actuators shall be configured to fail at the “last position”.
    (2) External manual gear release.

B. Industrial electronic actuators
1. Acceptable manufacturers
    a. Bray (Series 70)
    b. Keystone (EPI-2)
2. Size for torque required to close valve against pump shutoff head.
3. Single phase permanent split-capacitor reversible motor with Class F or better insulation, and built-in thermal overload protector with automatic reset.
4. Provide against overload throughout the entire operating range in both directions.
5. Actuator shall be continuous duty rated for 100% modulating operation at 104°F ambient temperature.
6. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of -20°F - 150°F.
7. Humidity: Suitable for humidity range encountered by application with minimum operating range of 5%-95% relative humidity, non-condensing.
8. Enclosure: NEMA Type 4/IP65 enclosure with visual position status indicator and internal heater with controller and self-contained thermostat.
9. Power supply
    a. 24V or 120V.
    b. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
    c. Actuator shall function properly within a range of 85% - 120% of nameplate voltage.
10. Rotation limitation: Provide angle of rotation limiter capable of setting the valve position to less than 100% open or 100% closed.
11. Stroke time
    a. Except where indicated otherwise on drawings, operate the valve from fully closed to fully open and vice versa within 90 seconds.
    b. For spring return actuators move valve to failed position within 25 seconds.
12. Control type
    a. Modulating
        (1) Capable of stopping at all points across full range and starting in either direction from any point in range.
        (2) Control Signal: Proportional Control: 4-20mA or 0-10Vdc input signal to modulate the actuator proportionally throughout its angle of rotation.
    b. Two position
        (1) On/off type.
        (2) Control signal: Digital input signal to modulate the actuator to its open or closed position.

13. Position feedback
    a. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.
    b. Provide auxiliary switches for positive means of position indication signal for remote monitoring of open and closed position.
14. Fail safe
    a. External manual gear release.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for valves installed in piping to verify actual locations of piping connections before installation.

C. Prepare written report listing conditions detrimental to performance.

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

3.2 APPLICATION

A. Install control valves per the following table:

PIPING SYSTEM AND LOCATION	VALVE TYPE	ACTUATOR TYPE
Chilled water and hot water valves at air-handling unit coils	Globe or characterized ball or PICV	Electronic
Steam valves at air-handling unit coils	Globe	Electronic
Hot water valves at terminal reheat coils	Globe or characterized ball or PICV	Electronic
Steam valves at humidifiers	Globe	Electronic

B. Refer to drawings for identification of requirements for modulating or two-position actuators.

C. Refer to drawings for identification of spring return (normally open/normally closed) or floating actuators (fail last position).

3.3 SIZING

A. Control valves shall be sized to provide a pressure drop:

1. As indicated in equipment schedules.
2. Two-position: Line size or size using a pressure differential of 1 psi.
3. Two-way modulating: Twice the device pressure drop or 2 psi, whichever is more.
4. Three-way modulating: Twice the device pressure drop, but not more than 4 psi.

B. PICVs shall be sized for flow and available differential pressure in accordance with manufacturer's recommendations.

C. Hydronic valve actuators shall be sized for torque required to close valve against pump shutoff head.

D. Steam valve actuators shall be sized for torque required to close valve against 1½ times the steam design pressure.

3.4 INSTALLATION

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduits to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

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

E. Corrosive environments:

1. Use products that are suitable for environment to which they will be subjected.

2. Where control devices are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

F. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.

G. Install flanges or unions to allow drop-in and -out valve installation.

H. Valve orientation:

1. Where possible, install globe and ball valves installed in horizontal piping with stems upright and not more than 15° off of vertical, not inverted.

2. Install valves in a position to allow full stem movement.

3. Where possible, install butterfly valves that are installed in horizontal piping with stems in horizontal position and with low point of disc opening with direction of flow.

I. Clearance:

1. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.

2. Install valves with at least 12 inches (300 mm) of clear space around valve and between valves and adjacent surfaces.

J. Threaded valves:

1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.

2. Align threads at point of assembly.

3. Apply thread compound to external pipe threads, except where dry seal threading is specified.

4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.

K. Flanged valves:

1. Align flange surfaces parallel.

2. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

L. Electrical power:

1. Furnish and install electrical power to products requiring electrical connections.

2. Furnish and install circuit breakers where required. Comply with requirements in Division 26 Specifications.

3. Furnish and install wiring and raceways.

4. Connect electrical devices and components to electrical grounding system. Comply with requirements in Division 26 Specifications.

M. Provide individual valve tagging of up to 30 characters (location/service/unit, etc.).

N. Valve tags shall be documented on the approved valve schedule.

O. Cleaning: Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces. Polish glossy surfaces to a clean shine.

3.5 CHECKOUT PROCEDURES

A. Check installed products before continuity tests, leak tests, and calibration.

B. Check valves for proper location and accessibility.

C. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D. For pneumatic products, verify air supply for each product is properly installed.

E. For pneumatic valves, verify that pressure gauges are provided in each air line to valve actuator and positioner.

F. Verify that control valves are installed correctly for flow direction.

G. Verify that valve body attachment is properly secured and sealed.

H. Verify that valve actuator and linkage attachment are secure.

I. Verify that actuator wiring is complete, enclosed, and connected to correct power source.

J. Verify that valve ball, disc, and plug travel are unobstructed.

K. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

3.6 TESTING

A. Acceptance Test

1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100% open to 100% closed back to 100% open.

2. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100% closed, 50% closed, and 100% open at proper air pressures.

3. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.
4. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.
5. Provide test result report within two weeks of testing indicating completion of the Acceptance Test for each control valve.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 23\23 0911-Control Valves.docx

SECTION 23 0914
FLOW INSTRUMENTS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Thermal airflow stations

B. Duct mounted pitot airflow station

C. Airflow switches.

D. Electromagnetic inline flow meter

E. Electromagnetic insertion flow meter

F. Vortex shedding inline flow meter

G. Ultrasonic clamp-on flow meter

H. Differential pressure flow meter

I. Liquid flow switches

1.2 DEFINITIONS

A. Ethernet: Local area network based on IEEE 802.3 standards.

B. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.

C. NRTL: Nationally Recognized Testing Laboratory

D. PEEK: Polyether Ether Ketone

E. PFA: Perfluoroalkoxy Alkane

F. PTFE: Polytetrafluoroethylene

G. PPS: Polyphenylene Sulfide

H. RS-485: A TIA standard for multipoint communications using two twisted pairs

I. RTD: Resistance Temperature Detector

J. TCP/IP: Transport Control Protocol/Internet Protocol Incorporated into Microsoft Windows.

1.3 CODES AND STANDARDS (UTILIZE LATEST EDITION)

A. Air Movement and Control Associates International (AMCA)

1. AMCA 203: Field Performance Measurement of Fan Systems

2. AMCA 500: Test Methods for Louvers, Dampers and Shutters

3. AMCA 511: Certified Ratings Program for Air Control Devices

4. AMCA 610: Laboratory Methods of Testing Airflow Measurement Stations for Performance Rating

B. American Society of Mechanical Engineers (ASME)

1. ASME B1.20.1: Pipe Threads, General Purpose, Inch
2. ASME B16.1: Cast Iron Pipe Flanges and Flanged Fittings
3. ASME B16.4: Cast Iron Threaded Fittings
4. ASME B16.5: Pipe Flanges and Flanged Fittings, NPS1/2 to NPS24
5. ASME B16.10: Face-to-Face and End-to-End Dimensions of Valves
6. ASME B16.15: Cast Bronze Threaded Fittings.
7. ASME B16.18: Cast Copper Alloy Solder Joint Pressure Fittings.
8. ASME B16.21: Nonmetallic Flat Gaskets for Pipes Flanges
9. ASME B16.22: Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
10. ASME B16.24: Bronze Flanges and Flanged Fittings.
11. ASME B16.34: Valves – Flanged, Threaded and Welding End
12. ASME B18.2.1: Square and Hex Bolts and Screws - Inch Series

C. ASHRAE

1. ASHRAE Standard 111: Measurement, Testing, Adjusting, And Balancing of Building HVAC Systems

D. American Society for Testing Materials (ASTM)

1. ASTM A 126: Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
2. ASTM B 61: Specification for Steam or Valve Bronze Castings

E. American Water Works Association (AWWA)

1. AWWA C606: Grooved and Shouldered Joints

F. Brazing Handbook

G. Copper Tube Handbook

H. National Fire Protection Association (NFPA)

1. NFPA 90A: Installation of Air Conditioning and Ventilating Systems

I. National Electrical Manufacturers Association (NEMA)

1. NEMA 250: Enclosures for Electrical Equipment (1,000 volts maximum)

J. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)

1. SMACNA: HVAC Duct Construction Standards-Metal and Flexible

1.4 QUALITY ASSURANCE

A. This Section establishes a minimum quality of hardware and installation and establishes standard equipment or equipment configurations.

B. Work installed by the Contractor shall be done in a neat and workmanlike manner, as determined by Owner and in keeping with acceptable standards for this type of work.

C. Unless indicated in this specification, all materials used shall be new. Where items have been indicated to be reused, it is the Contractor's responsibility to ensure that the reused items are operating properly and are in good condition. Contractor must make Owner aware of defective items designated for reuse. Owner will be responsible for repairs.

D. Airflow station source limitations: All airflow stations for this project shall be obtained from a single manufacturer.

E. Flow meter source limitations: All flow meters for this project shall be obtained from a single manufacturer.

F. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

1.5 SUBMITTALS

A. Preconstruction – Prior to construction provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Product data: For each type of product, including the following:
    a. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
    b. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
    c. Product description with complete technical data, performance curves, and product specification sheets.
    d. Installation instructions, including factors affecting performance.
2. Shop drawings
    a. Include plans, elevations, sections, and mounting details.
    b. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
    c. Include diagrams for power, signal, and control wiring.
    d. Include diagrams for air and process signal tubing.
    e. Number-coded identification system for unique identification of wiring, cable, and tubing ends.
3. Manufacturer's installation and operating manuals

B. Contract Closeout – At contract closeout provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Operating and maintenance data including:
    a. Product data
    b. Installation instructions
    c. Assembly drawings

d. Replacement parts list

e. Maintenance and operation instructions

2. Test Reports

a. Manufacturer Installation Inspection Report - Provide report prepared by manufacturer's representative indicating the final configuration of the meter and stating that systems installed and services provided under this Section are in accordance with manufacturer's recommendations, are properly operating, and have been field verified for device linearity and repeatability. A report shall be provided for each meter installed.

3. Warranties

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver products to site under provisions of Division 1.

B. Deliver products to site in containers with manufacturer's stamp affixed.

C. Protect products against dirt, water, chemical and mechanical damage before, during and after installation. Damage to products prior to final acceptance of the Work shall be repaired or replaced at no additional cost to the Owner.

1.7 SPARE PARTS

Not Applicable

1.8 WARRANTY

A. Two year warranty on products and complete installation commencing at the time of Substantial Completion.

1.9 MAINTENANCE

Not Applicable

PART 2 - PRODUCTS

2.1 THERMAL AIRFLOW STATIONS

A. Acceptable manufacturers

1. Ebtron, Inc.

B. Air sensors and transmitters shall have an extended range of 10% above scheduled design flow and 10% below minimum scheduled design flow to signal abnormal flow conditions and to provide flexibility for changes in operation.

C. Airflow measurement shall be field configurable to determine the average Actual or Standard mass airflow rate.

D. Temperature measurement shall be field configurable with velocity weighted average as the default, or manual selection of arithmetic average temperature.

E. Listed and labeled by an NRTL as successfully tested as an assembly according to UL 873, "Temperature-Indicating and Regulating Equipment."

F. Sensor assemblies

1. Each sensor probe shall contain one or more independently wired sensing nodes.

2. Probe internal wiring between the connecting cable and sensor nodes shall be Kynar coated copper sealed and protected from the elements.
3. Probe internal wiring connections shall consist of solder joints and spot welds.
4. Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/CL2P, UL®/cUL® Listed cable with a connector plug with gold plated pins for connection to the transmitter.
5. Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy with sensor housings constructed of glass-filled polypropylene. Mount thermistors in sensor using a marine-grade, waterproof epoxy.
6. Each thermistor shall be individually calibrated at a minimum of three temperatures to NIST-traceable temperature standards.
7. Each sensor node shall be individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard and have an accuracy of ±2% of reading over the entire calibrated airflow range of 0 to 5,000 FPM.
8. Sensor node airflow and temperature calibration data shall be stored in a serial memory chip in the cable-connecting plug and not require matching or adjustments to the transmitter in the field.
9. Each sensor node shall independently determine airflow rate and temperature.
10. Sensor ambient operating temperature range: -20°F to 160°F.
11. Sensor ambient operating humidity range: 0 to 100% RH, non-condensing.

G. Transmitter

1. Integral digital display capable of simultaneously displaying total airflow and average temperature, individual airflow, and temperature readings of each independent sensor assembly.
2. The transmitter shall be capable of determining the airflow rate and temperature average of all connected sensor nodes in an array for a single location.
3. The transmitter shall be capable of independently processing up to 16 independently wired sensor assemblies.
4. The transmitter shall be capable of providing a high and/or low airflow alarm with user-defined set point and % of set point tolerance. Alarm shall be capable of being manually or automatically reset and low-limit cutoff value may be selected to disable the alarm. An alarm delay function shall also be field defined.
5. The transmitter shall be capable of identifying an AMD malfunction via the system status alarm and ignore any sensor node that is in a fault condition.
6. The transmitter shall be capable of field configuration, diagnostics and allow for a one or two point field adjustment to factory calibration for installations that require adjustment.
7. Include an integral power switch to operate on 24-V ac (isolation not required) and include the following:
    a. Integral protection from transients and power surges.
    b. Circuitry to ensure reset after power disruption, transients, and brownouts.

c. Integral transformer to convert field power source to operating voltage required by instrument.

8. Remote signal interface
   a. The transmitter shall be provided with one of the following output options:
      (1) Two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over-current protected analog output signals and one RS-485 BACnet/Modbus connection.
      (2) Two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over-current protected analog output signals and one Ethernet BACnet/Modbus connection, or one isolated RS-485 BACnet MS/TP or Modbus RTU connection.
      (3) One RS 485 BACnet/Modbus network connection and one Ethernet BACnet/Modbus.
      (4) One Lonworks Free Topology network connection.
   b. The analog signal capability shall include two output terminals. One shall provide the total airflow rate and the second output shall be field configurable to provide one of the following:
      (1) Temperature
      (2) Low and/or high airflow user-defined set point alarm, or
      (3) System status alarm
   c. The network communications RS-485 (BACnet MS/TP or Modbus RTU) or Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) shall provide the average airflow rate, temperature, hi and/or low airflow set point alarm, system status alarm, individual sensor node airflow rates and individual sensor node temperatures.
9. Transmitter ambient operating temperature range: -20°F to 120°F.
10. Transmitter ambient operating humidity range: 5% to 95% RH.

H. Performance
   1. Accuracy shall include the combined uncertainty of the sensor nodes and transmitter.
   2. Airflow rate of each sensor assembly shall be equally weighted and averaged by transmitter prior to output.
   3. Temperature of each sensor assembly shall be velocity weighted and averaged by transmitter prior to output.
   4. Instrument shall compensate for changes in air temperature and density throughout calibrated velocity range.
   5. Airflow accuracy: ±2% of reading over the entire operating range.
   6. Temperature accuracy: ±0.20°F over entire operating range.
   7. Pressure drop: 0.05” w.g. at 2000 fpm across a 24”x24” area.
   8. A NIST traceable calibration certificate shall be provided with each airflow station.

I. Plenum or duct mounted thermal airflow station
   1. Plenum or duct mounted airflow and temperature measurement where the measurement device operates on the principal of thermal dispersion utilizing a directly heated thermistor.

2. The number of independent sensor nodes provided shall be as follows:

DUCT AREA (FT2)	QUANTITY OF SENSOR NODES
Area ≤ 0.5	1
0.5 < Area ≤ 1.0	2
1.0 < Area ≤ 2.0	4
2.0 < Area ≤ 4.0	6
4.0 < Area ≤ 8.0	8
8.0 < Area ≤ 12.0	12
12.0 < Area ≤ 14.0	14
Area > 14.0	16

3. Sensor probe material: Gold anodized, extruded 6063 aluminum tube.
4. Probe assembly mounting brackets material: Type 304 stainless steel.
5. Basis of Design: Ebtron, Inc. Model GTx116e-P

J. Fan inlet mounted thermal airflow station

1. Fan inlet mounted airflow and temperature measurement where the measurement device operates on the principal of thermal dispersion utilizing a directly heated thermistor.
2. Sensor assemblies shall be as specified above, with the following variations for fan inlet mounted airflow stations:
   a. Sensor probes shall consist of one sensor node mounted on a 304 stainless steel block with two adjustable zinc plated steel rods connected to 304 stainless steel pivoting mounting feet.
   b. The number of independent sensor nodes provided shall be as follows:
      (1) SWSI and DWDI fans: two probes x one sensor node/per probe in each fan inlet.
      (2) Fan Arrays (one to eight fans): one probe x one sensor node probe in each fan inlet.
   c. Sensor ambient operating temperature range: -20°F to 160°F.
   d. Sensor ambient operating humidity range: 0 to 100% RH, non-condensing.
3. Transmitter shall be as specified above, with the following variations for fan inlet mounted airflow stations:
   a. The transmitter shall be capable of determining the airflow rate and temperature of each fan.
   b. The transmitter shall be capable of providing a high and/or low airflow alarm.
   c. The transmitter shall be capable of providing individual fan alarming on fan array configurations.
   d. Basis of Design: Ebtron, Inc. Model GTCx108e-F

K. Damper mounted thermal airflow station

1. Duct and plenum mounted airflow and temperature measurement devices with integral control damper and sleeve assembly where the measurement device operates on the principal of thermal dispersion utilizing a directly heated thermistor.

2. Sensor assemblies: The number of independent sensor nodes provided shall be as specified above for plenum and duct mounted airflow stations.

3. Damper

   a. Provide one or more damper sections for each location indicated on the plans. Damper sections shall be integral to sleeve assembly.

   b. Frame

      (1) Material: ASTM B 211, Alloy 6063-T5 extruded aluminum, minimum 0.07 inch thick.

      (2) Hat-shaped channel with integral flange reinforced at corners. Mating face shall be minimum of 1 inch.

      (3) Width not less than 5 inches

   c. Blades

      (1) Material: ASTM B211, Alloy 6063-T5 aluminum, minimum 0.07 inch thick.

      (2) Standard duty dampers shall be hollow extruded aluminum airfoil profile with press fitted aluminum blade end caps.

   d. Seals

      (1) Blade: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.

      (2) Frame: Stainless steel compression or replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.

   e. Axles: Minimum $^{7}/_{16}$" adjustable hex-shaped plated steel, mechanically attached to the damper blades.

   f. Bearings

      (1) Molded synthetic or stainless-steel sleeve mounted in frame.

      (2) Where blade axles are installed in vertical position, provide thrust bearings.

   g. Linkage

      (1) Concealed in frame.

      (2) Constructed of aluminum, galvanized steel or stainless steel.

      (3) Hardware: Stainless steel

   h. Performance

      (1) Leakage: 1 inch w.g.: AMCA 500, Class 1A. Leakage shall not exceed 3 cfm/ft^2.

4. Damper ambient operating temperature range: -72°F to 212°F.

5. Basis of Design: Ebtron, Inc. Model GTx116

2.2 DUCT MOUNTED PITOT AIRFLOW STATION

A. Acceptable manufacturers

   1. Air Monitor Volu-Probe VS

   2. Paragon Controls FE Series

B. General

   1. Sensing element material: 6063-T5 anodized aluminum or Type 316L stainless steel.

2. Each airflow traverse probe mounted within the station shall contain multiple total and static pressure sensors located along its exterior surface, and internally connected to their respective averaging manifolds. The flow sensors shall not protrude beyond the surface of the probe(s) and shall be the offset (Fechheimer) type for static pressure and the chamfered impact type for total pressure measurement. The airflow station's measured accuracy shall not be affected by directional flow having yaw and/or pitch angles up to 30°.

3. The airflow measuring station(s) shall have a 14 ga. galvanized steel, 6" deep welding casing with 90° connecting flanges. Total and static pressure sensors shall be located at the centers of equal areas (for rectangular ducts) or at equal concentric area centers (for circular ducts) across the station's face area.

4. Stations shall be AMCA certified and designed and built to comply with and provide results according to accepted practice for duct system traversing defined in ASHRAE Handbook of Fundamentals, AMCA 203, AMCA 610, and the Industrial Ventilation Handbook. Number of sensing ports on each element, and quantity of elements utilized at each installation, shall comply with ASHRAE 111 for equal area duct traversing.

5. Capable of measuring the airflow rates within an accuracy of ±2% without the use of correction factors for operating velocities as low as 400 fpm. The maximum allowable unrecovered pressure drop caused by the station shall not exceed .025" w.c. at 2000 FPM, or .085" w.c. at 4000 FPM.

C. Transmitter

1. The transmitter shall be capable of receiving flow signals (total and static pressure) from an airflow station or probe array and produce dual outputs linear and scaled for air volume, velocity, differential pressure, etc.

2. The transmitter shall contain an integral multi-line digital display for use during the configuration and calibration process, and to display one transmitter output during normal operating mode. All Transmitter configuration, parameter setting, zero and span calibration, plus display formatting and scaling will be performed digitally in the on-board microprocessor via input pushbuttons.

3. The transmitter will be available in multiple natural spans covering the range of 0.05 in. w.c. to 10.0 in. w.c. with an accuracy of 0.1% of natural span. The Transmitter shall be furnished with a transducer automatic zeroing circuit and be capable of maintaining linear output signals on applications requiring 10 to 1 velocity (100 to 1 pressure) turndown.

4. Transmitter shall be capable of having its operating span electronically selected without having to perform recalibration involving an external pressure source.

2.3 AIRFLOW SWITCHES

A. Polymer film sail switch

1. Acceptable manufacturers

a. Honeywell S688

(1) Performance:

(a) Suitable for applications operating at velocities up to 400 fpm.

(b) Suitable for mounting with air direction in horizontal, vertical up or down.

(c) Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

(d) Voltage: 24-, 120-, 240-V ac.

(e) Normally open full load current: 2 A at 120-V ac.

(f) Normally closed full load current: 1 A at 120-V ac.

(g) Normally open switch actuates at 250 fpm and opens at 75 fpm.

(h) Normally closed switch actuates at 75 fpm and closes at 250 fpm.

(i) Maximum process temperature: 170°F.

(j) Maximum ambient temperature: 125°F.

(2) Construction:

(a) Polyester film sail encasing a wire frame.

(b) Sail actuates a SPDT snap switch.

(c) Enclosure material: Zinc-plated steel.

(d) Enclosure with removable cover.

(e) NEMA 250, Type 1 enclosure.

(f) Removable spring counterbalances sail to allow mounting in either vertical (up or down) or horizontal airflow.

(g) Electrical connections: Screw terminals.

(h) Conduit connections: ½" trade size conduit knockouts on top and bottom.

B. Stainless-steel single vane switch

1. Acceptable manufacturers

a. Johnson Controls F262

b. Dwyer 530

(1) Description

(a) Velocities up to 2000 fpm.

(b) Suitable for mounting with air direction in horizontal.

(2) Performance

(a) Voltage: 125-, 240-, and 480-V ac.

(b) Full load current: 9.8 A at 125-V ac.

(c) Field-adjustable velocity set point: 400 to 1600 fpm.

(d) Maximum process temperature: 180°F.

(e) Maximum ambient temperature: 125°F.

(3) Construction

(a) Stainless-steel vane.

(b) Vane actuates a SPDT snap switch.

(c) Enclosure material: Die-cast metal.

(d) Enclosure with removable cover.

(e) NEMA 250, Type 1 enclosure.

(f) Screw set-point adjustment.

(g) Electrical connections: Screw terminals.

C. Conduit connections: 1" trade size conduit knockouts on top and bottom.

2.4 ELECTROMAGNETIC INLINE FLOW METER

A. Acceptable manufacturers

1. Rosemount
2. ABB
3. Badger
4. Onicon

B. General

1. Provide inline electromagnetic type flow meters per mechanical equipment schedule on drawings. Locate as noted on drawings.
2. The magnetic flowmeter shall consist of a flow sensor and a transmitter. The flow sensor shall utilize Faraday's Law of Electromagnetic Induction, to produce an electrical voltage that is proportional to the velocity of the liquid through the sensor. The transmitter shall be micro-processor based.

C. Sensor assemblies

1. Each flow sensor shall be provided with a flanged end flow tube, welded and sealed coil housing, grounding straps, and a non-conductive liner.
2. The field coils of the flow sensor shall be supplied with a precisely adjusted bi-polar direct current. Coil drive power shall be supplied by the transmitter. The output signal from the flow sensor shall be fed through cable to the transmitter. There shall be no electronic components in the flow sensor.
3. Flow sensors installed indoors shall be NEMA 250 Type 4X construction.
4. Flow sensors installed in a below grade vault shall be NEMA 250 Type 6P construction. Interconnecting cables between the sensor and remote mounted transmitter shall be installed at the factory. The sensor cable termination box shall be filled with non-setting, transparent potting material.
5. The flow sensor shall be provided with two sensing electrodes to accurately measure mean velocity.
6. The flow senor shall incorporate an empty pipe detection feature, which shall cause the meter to register zero flow when the sensor is not full.
7. Flow tube material: Carbon Steel
8. Flow tube connections: ANSI Class 150 flanged
9. Liner material and operating temperature range:
    a. Polyurethane for systems temperatures of 0F to 140F
    b. PFA for system temperatures of 140F to 350F
    c. Alternate liner types offered by the manufacturer shall be submitted for Engineer review and approval.
10. Sensing electrode material: Type 316 Stainless Steel
11. Sensor maximum pressure rating: 150 psig.
12. Sensor ambient operating temperature range: -4F to 122F.

D. Transmitter

1. The transmitter shall be remote mounted from the flow sensor. Provide with required interconnecting cable.
2. The transmitter shall have an alphanumeric, three-line, 16-character minimum, backlit display indicating flow rate in gallons per minute, totalized values, settings, and faults. Programming shall be accomplished through an integral keypad or touch screen operation and all programming shall be protected by a user-defined password. The transmitter shall be provided with a fault and status log.
3. The transmitter shall be NEMA 250 Type 4X construction.
4. The transmitter shall be coordinated with the flow sensor selection for accurate measurement of the system fluid type.
5. The transmitter shall operate on 120V, 60 Hz supply power.
6. The transmitter shall be provided with a positive zero circuit to register zero flow when pumping units are not operating. A closed external dry contact (generated by pump "off" or other similar equipment control signal) input to the signal converter/transmitter shall drive the meter output to zero.
7. The transmitter shall be capable of verifying the performance of the measuring system in the field without removing the meter tube from the process. The field verification feature shall be integral to the transmitter and shall be capable of continuously monitoring electronic parameters within the flow meter and transmitter. If any value deviates from an acceptable range, the transmitter shall acknowledge the event and a relay shall be activated.
8. Local service communication with the transmitter shall be capable via supplied device communicator.
9. Remote signal interface
    a. Provide two discrete binary input/output channels for the following. Refer to control diagrams for points used.
        (1) Positive zero return (BI)
        (2) Net total reset (BI)
        (3) Reverse flow (BO)
        (4) Zero flow (BO)
        (5) Empty pipe (BO)
    b. The transmitter shall output a 4-20mA analog flow signal.
10. Transmitter ambient operating temperature range: -4F to 140F.
11. Transmitter ambient operating humidity range: 0% to 95% RH, non-condensing.

E. Performance

1. Accuracy: ±0.25% of rate.
2. Turndown: 40:1
3. A NIST traceable calibration certificate shall be provided with each flowmeter.

F. Basis of Design: Rosemount 8705 with 8712E remote transmitter

2.5 ELECTROMAGNETIC INSERTION FLOW METER

A. Acceptable manufacturers

1. Onicon

B. General

1. Provide insertion electromagnetic type flow meters per mechanical equipment schedule on drawings. Locate as noted on drawings.
2. The magnetic flowmeter shall consist of a flow sensor and a transmitter. The flow sensor shall utilize Faraday's Law of Electromagnetic Induction, to produce an electrical voltage that is proportional to the velocity of the flow of liquid through the sensor. The transmitter shall be micro-processor based.

C. Sensor assemblies

1. Each flow sensor shall be provided with a sensor head mounted on an insertion shaft that is connected to the transmitter.
2. The sensor shall be designed to be inserted into the pipe with a hot tap that allows for removal of the meter without a system shutdown.
3. Flow sensors installed indoors shall be NEMA 250 Type 4X construction.
4. The flow sensor shall be provided with two sensing electrodes to accurately measure mean velocity.
5. Sensor head material: XAREC
6. Sensor wetted metal material: Type 316 Stainless Steel
7. Sensor maximum pressure rating: 400 psig.
8. Sensor Liquid operating temperature range: 15°F to 250°F.
9. Sensor ambient operating temperature range: -20°F to 150°F.

D. Transmitter

1. The transmitter shall be mounted on the flow sensor.
2. The transmitter shall be NEMA 250 Type 4X construction.
3. The transmitter shall be coordinated with the flow sensor selection for accurate measurement of the system fluid type.
4. The transmitter shall operate on 24V, 60 Hz supply power.
5. Remote signal interface
    a. The transmitter shall output a 4-20mA analog flow signal.
    b. Solid state dry contact indicating flow direction.
6. Transmitter ambient operating temperature range: -5°F to 150°F.
7. Transmitter ambient operating humidity range: 0% to 95% RH, non-condensing.

E. Performance

1. Accuracy: ±1.0% of rate.
2. Turndown: 100:1

3. A NIST traceable calibration certificate shall be provided with each flowmeter.

F. Basis of Design: Onicon F-3500

2.6 LIQUID FLOW SWITCHES

A. Bellows type liquid flow switch

1. Acceptable manufacturers
    a. Johnson Controls
    b. Dwyer
    c. McDonnell & Miller
    d. Siemens
2. Description
    a. Field-adjustable four-vane combinations.
    b. Field-adjustable set-point adjustment screw.
    c. Switch mounted vertically in horizontal pipe.
3. Performance
    a. Flow rate actuation and de-actuation: Varies with vane combination and set-point adjustment.
    b. Pressure limit: 145 psig.
    c. Temperature limit: 230°F.
    d. Electrical rating: 10A resistive, 3A conductive at 250VAC.
    e. Switch type: SPDT snap switch.
4. Wetted parts construction
    a. Bellows: Tin-bronze.
    b. Vanes: Stainless steel.
    c. Body: Forged brass.
5. Enclosure
    a. Die-cast aluminum alloy.
    b. NEMA 250, Type 4X.
    c. Electrical connection: Cable gland with attached wire leads.

B. Magnetic type liquid flow switch

1. Acceptable manufacturers
    a. Dwyer
    b. McDonnell & Miller
2. Description
    a. Field-adjustable five-vane combinations.
    b. Mounting suitable for application: Switch vertically mounted in horizontal pipe or switch horizontally mounted in vertical pipe with flow up.
    c. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous-environment Class I, Groups C and D; Class II, Groups E, F, and G.

3. Performance
    a. Flow rate actuation and de-actuation: Varies with vane combination.
    b. Pressure limit: 300 psig.
    c. Liquid temperature range: 32°F to 300°F
    d. Ambient temperature range: 32°F to 120°F
    e. Electrical rating: 7.4A at 120VAC.
    f. Switch type: SPDT snap switch.
4. Wetted parts construction
    a. Vanes: Type 301 stainless steel.
    b. Body: Brass.
5. Enclosure
    a. Die-cast aluminum alloy.
    b. Threaded cover.
    c. NEMA 250, Type 4X.
    d. Electrical connection: Terminal block.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the complete set of plans, the process fluids, pressures, and temperatures and furnish instruments that are compatible with installed process condition.

B. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

C. Examine roughing-in for instruments installed in piping to verify actual locations and connections before installation.

D. Examine roughing-in for instruments installed in duct systems to verify actual locations and connections before installation.

E. Prepare a written report listing conditions detrimental to performance.

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

3.2 INSTALLATION

A. Installation of flow instruments and transmitters shall be in accordance with the manufacturer's written instructions.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

D. Provide ceiling, floor, roof, wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Fastening hardware

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.

2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.

3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

F. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks.

G. Wiring between flow sensors and remote mounted transmitters shall be supplied by the meter manufacturer.

H. Straight duct requirements: Install airflow sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.

I. Airflow sensors shall be accessible for visual inspection and service. Install 24" x 24" access doors in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.

J. Coil and secure neatly any extra wire between airflow sensor and transmitter.

K. Clearly record airflow sensor information including cross sectional area used for airflow (cfm) calculations and the cross sectional area factor (as programmed) on the inside cover of the transmitter. Coordinate with the testing and balance contractor.

L. Adjust LCD display for airflow sensors to indicate airflow (in cfm) and temperature (in °F).

M. Straight pipe run requirements: Comply with manufacturer's recommended straight pipe run requirements. The following data is minimum straight run required, increase if necessary to meet manufacturer's recommendations.

1. Electromagnetic inline flow meter: Provide five pipe diameters straight run upstream and two pipe diameters downstream of the meter.

2. Electromagnetic insertion flow meter

a. For unidirectional flow applications provide five pipe diameters straight run downstream of the meter and the following upstream:

UPSTREAM OBSTRUCTION	MINIMUM STRAIGHT RUN REQUIRED (PIPE DIAMETERS)
Single bend preceded by ≥ 9 diameters straight pipe	10
Pipe size reduction/expansion in straight pipe	10
Single bend preceded by < 9 diameters straight pipe	15
Outflowing tee or pump outflow	20
Multiple bends out of plane	30
Inflowing tee	30
Control valve	30

b. For bidirectional flow applications provide the following straight run upstream and downstream of the meter:

UPSTREAM OBSTRUCTION	MINIMUM STRAIGHT RUN REQUIRED (PIPE DIAMETERS)
Single bend preceded by ≥ 9 diameters straight pipe	10

UPSTREAM OBSTRUCTION	MINIMUM STRAIGHT RUN REQUIRED (PIPE DIAMETERS)
Pipe size reduction/expansion in straight pipe	10
Single bend preceded by < 9 diameters straight pipe	15
Outflowing tee or pump outflow	20
Multiple bends out of plane	30
Inflowing tee	30
Control valve	30

3. Vortex inline flow meter
   a. Provide 10 pipe diameters straight run upstream and five pipe diameters downstream of the meter.
   b. Locate the associated pressure transmitter four straight pipe diameters downstream of the meter.
4. Ultrasonic clamp-on flow meter: Provide 10 pipe diameters straight run upstream and five pipe diameters downstream of the meter.
5. Differential pressure flow meter: Provide three pipe diameters straight run upstream and one pipe diameter downstream of the meter.

N. Install pipe reducers for in-line liquid flow meters smaller than line size. Install reducers at distance from meter to avoid interference and impact on accuracy.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 20 0553 “Identification for Mechanical, Plumbing, and Fire Suppression Systems."

B. Install engraved phenolic nameplate identification at instrument.

3.4 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install raceways. Comply with requirements in Division 26 Electrical Specifications.

C. Connect electrical devices and components to electrical grounding system. Comply with requirements in Division 26 Electrical Specifications.

3.5 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.6 CHECKOUT PROCEDURES

A. Inspection

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check instruments for proper location and accessibility.
3. Check instruments for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
5. Check that instrument attachment is properly secured and sealed.
6. Check that required upstream and downstream distances have been maintained.

B. Validation

1. Verify that instrument wiring is complete, enclosed, and connected to correct power source.
2. Verify that insertion type flow meter travel is unobstructed.
3. Verify instrument tag against approved submittal.
4. After duct systems have been tested and put into service, but before insulation and balancing, inspect airflow station for leaks. Seal any leaks prior to balancing and calibration.
5. After piping systems have been tested and put into service, but before insulating and balancing, inspect flow meter for leaks. Adjust to stop leaks. Replace the flow meter if leaks persist.

3.7 CALIBRATION

A. General

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer's recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1% shall be checked by an instrument with an accuracy of 0.5%.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, “Field Testing of HVAC Control Components,” in the absence of specific requirements and to supplement requirements indicated.

B. Calibration of analog signals

1. Check analog voltage signals using a precision voltage meter at 0%, 50%, and 100%.
2. Check analog current signals using a precision current meter at 0%, 50%, and 100%.
3. Check resistance signals for temperature sensors at 0%, 50%, and 100% of operating span using a precision-resistant source.

C. Calibration of digital signals

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Calibration of sensors: Check sensors at 0%, 50%, and 100% of Project design values.

E. Calibration of switches: Calibrate switches to make or break contact at set points indicated.

F. Calibration of transmitters

1. Check and calibrate transmitters at 0%, 50%, and 100% of project design values.
2. Calibrate resistance temperature transmitters at 0%, 50%, and 100% of span using a precision-resistance source.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 23\23 0914-Flow Instruments.docx

SECTION 23 0919
MOISTURE INSTRUMENTS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Outside air relative humidity and temperature sensor/transmitter

B. Duct relative humidity and temperature sensor/transmitter

C. Space relative humidity and temperature sensor/transmitter

1.2 DEFINITIONS

A. NIST: National Institute of Standards and Technology

B. RTD: Resistance temperature detector

1.3 CODES AND STANDARDS (UTILIZE LATEST EDITION)

A. National Fire Protection Association (NFPA)

1. NFPA 90A: Installation of Air Conditioning and Ventilating Systems

B. National Electrical Manufacturers Association (NEMA)

1. NEMA 250: Enclosures for Electrical Equipment (1,000 volts maximum)

C. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)

1. SMACNA: HVAC Duct Construction Standards-Metal and Flexible

1.4 QUALITY ASSURANCE

A. This Section establishes a minimum quality of hardware and installation and establishes standard equipment or equipment configurations.

B. Work installed by the Contractor shall be done in a neat and workmanlike manner, as determined by Owner and in keeping with acceptable standards for this type of work.

C. Unless indicated in this specification, all materials used shall be new. Where items have been indicated to be reused, it is the Contractor's responsibility to insure that the reused items are operating properly and are in good condition. Contractor must make Owner aware of defective items designated for reuse. Owner will be responsible for repairs.

1.5 SUBMITTALS

A. Preconstruction – Prior to construction provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Product data: For each type of product, including the following:

a. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.

b. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical

power requirements, and limitations of ambient operating environment, including temperature and humidity.

c. Product description with complete technical data, performance curves, and product specification sheets.

d. Installation instructions, including factors affecting performance.

2. Manufacturer's installation and operating manuals.

B. Contract closeout – At contract closeout provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Operating and maintenance data including:

a. Product data

b. Installation instructions

c. Assembly drawings

d. Replacement parts list

e. Maintenance and operation instructions

2. NIST Calibration Certificates

3. Test Reports

a. Manufacturer Installation Inspection Report

4. Warranties

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver products to site under provisions of Division 1.

B. Deliver products to site in containers with manufacturer's stamp affixed.

C. Protect products against dirt, water, chemical and mechanical damage before, during and after installation. Damage to products prior to final acceptance of the Work shall be repaired or replaced at no additional cost to the Owner.

1.7 SPARE PARTS

Not Applicable

1.8 WARRANTY

A. One year warranty on products and complete installation commencing at the time of Substantial Completion

1.9 MAINTENANCE

Not Applicable

PART 2 - PRODUCTS

2.1 OUTSIDE AIR RELATIVE HUMIDITY AND TEMPERATURE SENSOR/TRANSMITTER

A. Acceptable manufacturers

1. Vaisala

B. Performance

1. Humidity
    a. Range: 0% - 100% RH, non-condensing
    b. Accuracy: ±2% RH at 77°F from 10%-90% RH
    c. Operating temperatures: -40°F - 140°F
    d. Hysteresis: ≤1%
    e. Drift: ≤0.5% per year
    f. Output resolution: 0.1% RH
    g. Three-point NIST traceable calibration with certificate
2. Temperature
    a. Dry bulb temperature accuracy: ±0.5°F at 68°F
    b. Dew point accuracy: ±1.2°F
    c. Wet bulb temperature accuracy: ±0.9°F
    d. Enthalpy accuracy: ±0.7 BTU/lb
    e. Operating temperatures: -40°F - 140°F
    f. Temperature dependence: ±0.01°C/°C
    g. Output resolution: 0.1°F
    h. Linearity: <0.1°C
    i. Three-point NIST traceable calibration with certificate

C. Construction

1. Humidity sensing element: Capacitive polymer integrated circuit.
2. Temperature sensing element: 1000Ω platinum RTD.
3. Probe: Stainless steel or plastic probe with replaceable sensor tip and filter.
4. Enclosure: IP65 class polycarbonate with glass fiber enclosure, UL-V0 approved, with radiation shield.

D. Output signal

1. 4-20 mA or 0-10 VDC output humidity and dry bulb temperature signals
2. 4-20 mA or 0-10 VDC output dew point temperature signal
3. 4-20 mA or 0-10 VDC output wet bulb temperature signal
4. 4-20 mA or 0-10 VDC output enthalpy signal
5. Non-interacting zero and span adjustments.

E. Accessories

1. Calibration tool

F. Basis of Design: Vaisala Model HMS110

2.2 HIGH ACCURACY DUCT RELATIVE HUMIDITY AND TEMPERATURE SENSOR/TRANSMITTER

A. Acceptable Maufacturers

1. Vaisala

2. Minco
3. Automation Components

B. Performance
1. Humidity
a. Range: 0% - 100% RH, non-condensing
b. Accuracy: ±2% RH at 77°F from 10% - 90% RH
c. Operating temperatures: -40°F - 140°F
d. Hysteresis: ≤1%
e. Drift: ≤0.5% per year
f. Output resolution: 0.1% RH
g. Three-point NIST traceable calibration with certificate
2. Temperature
a. Dry bulb temperature accuracy: ±0.5°F at 68°F
b. Operating temperatures: -40°F - 140°F
c. Temperature dependence: ±0.01°C/°C
d. Output resolution: 0.1°F
e. Linearity: <0.1°C
f. Three-point NIST traceable calibration with certificate

C. Construction
1. Humidity sensing element: Capacitive polymer integrated circuit.
2. Temperature sensing element: 1000Ω platinum RTD.
3. Probe: Stainless steel or plastic probe with replaceable sensor tip and filter.
4. Enclosure: IP65 class polycarbonate with glass fiber enclosure, UL-V0 approved.

D. Output Signal
1. 4-20 mA or 0-10 VDC output humidity and dry bulb temperature signals
2. Non-interacting zero and span adjustments.

E. Basis of Design: Vaisala Model HMD110

2.3 HIGH ACCURACY ROOM RELATIVE HUMIDITY AND TEMPERATURE SENSOR/TRANSMITTER

A. Acceptable manufacturers
1. Vaisala

B. Performance
1. Humidity
a. Range: 0% - 100% RH, non-condensing
b. Accuracy: ±2% RH at 77°F from 10% - 90% RH
c. Operating temperatures: -40°F - 140°F
d. Hysteresis: ≤1%
e. Drift: ≤0.5% per year

f. Output resolution: 0.1% RH
g. Three-point NIST traceable calibration with certificate

2. Temperature
a. Dry bulb temperature accuracy: ±0.5°F at 68°F
b. Dew point accuracy: ±1.2°F
c. Wet bulb temperature accuracy: ±0.9°F
d. Enthalpy accuracy: ±0.7 BTU/lb
e. Operating temperatures: -40°F - 140°F
f. Temperature dependence: ±0.01°C/°C
g. Output resolution: 0.1°F
h. Linearity: <0.1°C
i. Three-point NIST traceable calibration with certificate

C. Construction
1. Humidity sensing element: Capacitive polymer integrated circuit.
2. Temperature sensing element: 1000Ω platinum RTD.
3. Probe: Stainless steel or plastic probe with replaceable sensor tip and filter.
4. Enclosure: IP65 class polycarbonate with glass fiber enclosure, UL-V0 approved.

D. Output signal
1. 4-20 mA or 0-10 VDC output humidity and dry bulb temperature signals
2. 4-20 mA or 0-10 VDC output dew point temperature signal
3. 4-20 mA or 0-10 VDC output wet bulb temperature signal
4. 4-20 mA or 0-10 VDC output enthalpy signal
5. Non-interacting zero and span adjustments.

E. Accessories
1. Calibration tool

F. Basis of Design: Vaisala Model HMW110

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the complete set of plans, the required temperature and humidity and furnish instruments that are compatible with installed process condition.

B. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations and connections before installation.

D. Prepare a written report listing conditions detrimental to performance.

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

3.2 INSTALLATION

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

C. Provide ceiling, floor, roof, wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Fastening hardware

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.

2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.

3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

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

F. Corrosive environments

1. Use products that are suitable for environment to which they are subjected.

2. If possible, avoid or limit use of materials in corrosive environments.

3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.

4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

G. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 20 0553 “Identification for Mechanical, Plumbing, and Fire Suppression Systems."

B. Install engraved phenolic nameplate identification at instrument.

3.4 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install raceways. Comply with requirements in Section 26 0533 "Raceways and Boxes for Electrical Systems."

C. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 26 0526 "Grounding and Bonding for Electrical Systems."

3.5 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.6 CHECKOUT PROCEDURES

A. Inspection

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check instruments for proper location and accessibility.
3. Check flow instruments for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
5. Check that instrument attachment is properly secured and sealed.

B. Validation

1. Verify that instrument wiring is complete, enclosed, and connected to correct power source.
2. Verify sensing element type and proper material.
3. Verify instrument tag against approved submittal.

3.7 CALIBRATION

A. General

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer’s written instructions.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements and to supplement requirements indicated.

B. Calibration of analog signals

1. Check analog voltage signals using a precision voltage meter at zero, 50%, and 100%.

2. Check analog current signals using a precision current meter at zero, 50%, and 100%.

C. Calibration of digital signals

1. Check digital signals using a jumper wire.

2. Check digital signals using an ohmmeter to test for contact.

D. Calibration of sensors: Check sensors at zero, 50%, and 100% of the design values.

E. Calibration of switches: Calibrate switches to make or break contact at set points indicated.

F. Calibration of transmitters

1. Check and calibrate transmitters at zero, 50%, and 100% of Project design values.

2. Calibrate resistance temperature transmitters at zero, 50%, and 100% of span using a precision-resistance source.

3.8 ADJUSTING

A. Occupancy adjustments: When requested with 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions.

3.9 TESTING

A. Manufacturer Installation Inspection Report - Provide report prepared by manufacturer's representative, stating that systems installed and services provided under this Section are in accordance with manufacturer's recommendations and are properly operating.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 23\23 0919-Moisture Instruments.docx

SECTION 23 0923
PRESSURE INSTRUMENTS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Air pressure sensor/transmitters

B. Air pressure switches

C. Liquid pressure sensor/transmitters

D. Liquid pressure switches

1.2 DEFINITIONS

Not Applicable

1.3 CODES AND STANDARDS (UTILIZE LATEST EDITION)

A. National Fire Protection Association (NFPA)

1. NFPA 90A: Installation of Air Conditioning and Ventilating Systems

B. National Electrical Manufacturers Association (NEMA)

1. NEMA 250: Enclosures for Electrical Equipment (1,000 volts maximum)

C. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)

1. SMACNA: HVAC Duct Construction Standards-Metal and Flexible

D. IEC Publication 60529: Classification of Degrees of Protection Provided by Enclosures

E. NEMA 250-2014: Enclosures for Electrical Equipment

F. UL® 94: Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.4 QUALITY ASSURANCE

A. This Section establishes a minimum quality of hardware and installation and establishes standard equipment or equipment configurations.

B. Work installed by the Contractor shall be done in a neat and workmanlike manner, as determined by Owner and in keeping with acceptable standards for this type of work.

C. Unless indicated in this specification, all materials used shall be new. Where items have been indicated to be reused, it is the Contractor's responsibility to insure that the reused items are operating properly and are in good condition. Contractor must make Owner aware of defective items designated for reuse. Owner will be responsible for repairs.

D. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

E. Device ratings and enclosures shall be as required by ambient conditions where product is to be installed.

F. Factory tests: Test and inspect assembled pressure instruments, as indicated by instrument requirements. Affix standards organization's certification and label.

1.5 SUBMITTALS

A. Preconstruction – Prior to construction provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Product data: For each type of product, including the following:
    a. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
    b. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
    c. Product description with complete technical data, performance curves, and product specification sheets.
    d. Installation instructions, including factors affecting performance.
2. Manufacturer's installation and operating manuals.

B. Contract closeout – At contract closeout provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Operating and maintenance data including:
    a. Product data
    b. Installation instructions
    c. Assembly drawings
    d. Replacement parts list
    e. Maintenance and operation instructions
2. NIST Calibration Certificates
3. Test Reports
    a. Manufacturer Installation Inspection Report
4. Warranties

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver products to site under provisions of Division 1.

B. Deliver products to site in containers with manufacturer's stamp affixed.

C. Protect products against dirt, water, chemical and mechanical damage before, during and after installation. Damage to products prior to final acceptance of the Work shall be repaired or replaced at no additional cost to the Owner.

1.7 SPARE PARTS

Not Applicable

1.8 WARRANTY

A. Two year warranty on products and complete installation commencing at the time of Substantial Completion.

1.9 MAINTENANCE

Not Applicable

PART 2 - PRODUCTS

2.1 AIR PRESSURE SENSOR/TRANSMITTERS

A. The assembly shall consist of a pressure transducer with a solid state, two wire, 4-20 MA transmitter mounted in one housing.

B. The transmitter shall be matched to the respective sensing element.

C. The transmitter shall have non-interactive zero and span adjustments, adjustable from the outside cover.

D. Single range duct mounted static pressure sensor/transmitter

1. Acceptable manufacturers
    a. Dwyer
    b. Setra
2. Description
    a. Single range duct mounted pressure sensor/transmitter with duct probe.
3. Construction
    a. IP65/NEMA 4 plastic glass-filled polycarbonate UL94V-0 case.
    b. LCD display of reading.
    c. Zero and span adjustment.
    d. Provided with static duct probe.
4. Performance
    a. Range: unidirectional, select for approximately 2 times set point.
    b. Accuracy: ±1.0% of full scale with calibration certificate
    c. Maximum overpressure: 1.0 psi operation, 10 psi burst
    d. Linearity: ±0.98% of full scale
    e. Hysteresis: ±0.10% of full scale
    f. Repeatability: ±0.05% of full scale
    g. Operating temperature: 20°F - 120°F
5. Remote signal interface: The transmitter shall output a 4-20mA analog signal.
6. Basis of Design: Setra Model 267

E. Multi-range duct mounted static pressure sensor/transmitter

1. Acceptable manufacturers
    a. Dwyer
    b. Setra
2. Description
    a. Multi-range duct mounted pressure sensor/transmitter with duct probe.

3. Construction
    a. IP66/NEMA 4 plastic glass-filled polycarbonate UL94V-0 case.
    b. LCD display of reading.
    c. Zero and span adjustment.
    d. Provided with static duct probe.
    e. Multi-range capability with field selectable ranges via switches.
4. Performance
    a. Range: unidirectional, selectable from:
        (1) 0.0 – 0.5 in. W.C.
        (2) 0.0 – 1.0 in. W.C.
        (3) 0.0 – 2.5 in. W.C.
        (4) 0.0 – 5.0 in. W.C.
    b. Accuracy: ±1.0% of full scale with calibration certificate
    c. Maximum overpressure: 1.0 psi operation, 10 psi burst
    d. Linearity: ±0.98% of full scale
    e. Hysteresis: ±0.10% of full scale
    f. Repeatability: ±0.05% of full scale
    g. Operating temperature: 32°F - 122°F
5. Remote signal interface: The output signal shall be field selectable from the following output options:
    a. 4 – 20 mA
    b. 0 – 5 VDC
    c. 0 – 10 VDC
6. Basis of Design: Setra Model MRG

F. Space static pressure sensor/transmitter
1. Acceptable manufacturers
    a. Dwyer
    b. Setra
2. Description
    a. Wall mounted pressure pickup port with single range low pressure transmitter.
3. Pressure pickup port
    a. Wall mounted: Single gang electrical box mounted concealed pressure pickup port with 1/8” tubing connection, 60 micron filter, and white wall plate.
    b. Ceiling mounted: Concealed pressure pickup designed to rest on ceiling with 1/8” tubing connection and 60 micron filter.
    c. Provide with silicone rubber tubing with surge damper.
4. Transmitter
    a. Construction
        (1) IP65/NEMA 4 plastic glass-filled polycarbonate UL94V-0 case.

(2) Zero and span adjustment.

b. Performance

(1) Range: bidirectional, -0.10 to 0.10 in. W.C.

(2) Accuracy: ±0.25% of range with calibration certificate

(3) Maximum overpressure: 1.0 psi operation, 10 psi burst

(4) Linearity: ±0.22% of full scale

(5) Hysteresis: ±0.10% of full scale

(6) Repeatability: ±0.05% of full scale

(7) Operating temperature: 0°F - 175°F

5. Remote signal interface: The transmitter shall output a 4-20mA analog signal.

6. Basis of Design: Setra Model 264

2.2 AIR PRESSURE SWITCHES

A. Air pressure differential switch with manual reset

1. Acceptable Manufacturers

a. Automation Components

b. Cleveland Controls

c. Dwyer

d. Penn

e. Siemens

2. Field adjustable differential pressure switch with manual reset switch that detects excessively high positive pressures or low negative pressures and turns off a fan before damage occurs.

3. Construction

a. Diaphragm operated to actuate a SPDT snap switch with manual reset.

b. User Interface: Screw-type set-point adjustment located inside removable enclosure cover.

c. Enclosure

(1) Dry indoor installations: NEMA 250, Type 1.

(2) Outdoor and wet indoor installations: NEMA 250, Type 4.

(3) Hazardous environments: Explosion proof.

d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

4. Performance

a. Electrical rating: 15A at 120 - 480VAC.

b. Maximum overpressure: 0.5 psi

c. Temperature limits: -30°F - 180°F.

d. Operating range: Approximately 2 times set point.

e. Repeatability: Within 3%.

5. Provide complete installation kit including: static pressure tips, tubing, fittings and air filters.

6. Basis of Design: Dwyer Model 1831

B. Air pressure differential switch with automatic reset

1. Acceptable manufacturers
    a. Automation Components
    b. Cleveland Controls
    c. Dwyer
    d. Penn
    e. Siemens
2. Field adjustable differential pressure switches with automatic reset used to monitor air filter status.
3. Construction
    a. Diaphragm operated to actuate a SPDT snap switch with automatic reset.
    b. User Interface: Screw-type set-point adjustment with enclosed set-point indicator and scale.
    c. Enclosure
        (1) Dry indoor installations: NEMA 250, Type 1.
        (2) Outdoor and wet indoor installations: NEMA 250, Type 4.
        (3) Hazardous environments: Explosion proof.
    d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Performance
    a. Electrical rating: 15A at 120 - 480VAC.
    b. Maximum overpressure: 0.5 psi
    c. Temperature limits: -30°F - 110°F.
    d. Operating range: Approximately 2 times set point.
    e. Repeatability: Within 1%.
5. Provide complete installation kit including: static pressure tips, tubing, fittings and air filters.
6. Basis of Design: Dwyer Model EDPS

2.3 LIQUID PRESSURE SENSOR/TRANSMITTERS

A. Multi-range liquid pressure sensor/transmitter

1. Acceptable manufacturers
    a. Dwyer
    b. Setra
2. Description
    a. Multi-range liquid pressure sensor/transmitter.
3. Construction
    a. IP56/NEMA 4 powder coated aluminum case.
    b. LCD display of reading.
    c. Auto zero adjustment.

d. Provided with static duct probe.

e. Multi-range capability with field selectable ranges via switches.

f. Provide transmitter with three-valve manifold. Construct manifold of brass, bronze, or stainless steel. Manifold shall have threaded, NPS 1/4 process connections.

4. Performance

a. Range: unidirectional, selectable from:

(1) 5 psid

(2) 10 psid

(3) 20 psid

(4) 50 psid

b. Accuracy: ±1.0% of full scale with calibration certificate

c. Stability: ±0.5% per year

d. Operating temperature: -4°F - 185°F

5. Remote signal interface

a. The output signal shall be field selectable from the following output options:

(1) 4 – 20 mA

(2) 0 – 5 VDC

(3) 0 – 10 VDC

(4) 1 – 5 VDC

6. Basis of Design: Setra Model 231

2.4 LIQUID PRESSURE SWITCHES

A. Liquid pressure switch – diaphragm operated

1. Acceptable manufacturers

a. Dwyer/Mercoid

2. Construction

a. Diaphragm operated to actuate a SPDT snap switch.

b. Electrical Connections: Screw terminal.

c. Enclosure Conduit Connection: Knock out or threaded connection.

d. User interface: Internal hex nut set-point adjustment with enclosed set-point indicator and scale.

e. Process connection: Threaded, NPS 1/4 or NPS 1/2.

f. Enclosure

(1) Dry indoor installations: NEMA 250, Type 1, 12.

(2) Outdoor and wet indoor installations: NEMA 250, Type 4X with drain.

(3) Hazardous environments: Explosion proof.

g. Pressure chamber material: Aluminum or brass or stainless steel.

h. Diaphragm material: Buna-N or fluorocarbon.

3. Performance

a. Electrical rating: 15A at 120, 240, and 480VAC.

b. Pressure limits: 500 psig.

c. Ambient temperature limits: -40°F - 175°F.

d. Adjustable operating range: 2 - 15 psig, 4 - 75 psig, 8 – 225 psig, or 16 - 450 psig. Select for approximately two times set point, but not less than system design pressure rating.

e. Deadband: Adjustable.

4. Basis of Design: Mercoid by Dwyer Model A1F

B. Liquid pressure switch – Bourdon tube operated

1. Acceptable manufacturers

a. Dwyer/Mercoid

2. Construction

a. Bourdon tube operated to actuate a SPDT or DPDT snap switch.

b. Provide switches used in safety limiting applications with reset.

c. Wetted materials: Brass or Type 403 stainless steel or Type 316 stainless steel.

d. Electrical connections: Screw terminal.

e. Enclosure conduit connection: Knock out or threaded connection.

f. User interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.

g. Process connection: Threaded, NPS 1/4.

h. Enclosure

(1) Dry indoor installations: NEMA 250, Type 1.

(2) Outdoor and wet indoor installations: NEMA 250, Type 4.

(3) Hazardous environments: Explosion proof.

i. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. Performance

a. Electrical rating: 5 or 10A at 120VAC.

b. Pressure limits: Equal to maximum pressure in full-scale range, but not less than system design pressure rating.

c. Temperature limits: 180°F.

d. Operating range: Select for approximately 2 times set point, but not less than system design pressure rating.

e. Deadband: Adjustable or fixed as required by application.

4. Basis of Design: Mercoid by Dwyer Model DA

C. Liquid pressure differential switch

1. Acceptable manufacturers

a. Mercoid

2. Field adjustable differential pressure switch to prove flow or monitor filter status.

3. Construction

a. Diaphragm operated to actuate an SPDT snap switch.

b. Electrical connections: Screw terminal.

c. Enclosure conduit connection: Knock out or threaded connection.

d. User interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.

e. High and low process connections: Threaded, NPS 1/8.

f. Enclosure

(1) Dry indoor installations: NEMA 250, Type 1.

(2) Outdoor and wet indoor installations: NEMA 250, Type 4.

g. Pressure chamber material: Brass.

h. Diaphragm material: Fluoroelastomer.

4. Performance

a. Electrical rating: 5A at 120 to 240VAC.

b. Pressure limits: At least 1.25 times full-scale range, but not less than system design pressure rating.

c. Temperature limits: 30°F - 140°F.

d. Operating range: Select for approximately 2 times set point.

e. Deadband: Adjustable or fixed as required by application.

5. Basis of Design: Mercoid by Dwyer Model DX

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the complete set of plans, the process fluids, pressures, and temperatures and furnish instruments that are compatible with installed process condition.

B. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

C. Examine roughing-in for instruments installed in piping to verify actual locations and connections before installation.

D. Examine roughing-in for instruments installed in duct systems to verify actual locations and connections before installation.

E. Prepare a written report listing conditions detrimental to performance.

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

3.2 INSTALLATION

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Install products in accordance with manufacturer's instructions.

C. Do not mount switches on rotating equipment.

D. Do not mount sensor/transmitters on equipment.

E. Install products in a location free from vibration, heat, moistures, or adverse effects which damage the products and hinder accurate operation.

F. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

G. Provide ceiling, floor, roof, wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

H. Fastening hardware

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.

2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.

3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

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

J. Corrosive environments

1. Use products that are suitable for environment to which they are subjected.

2. If possible, avoid or limit use of materials in corrosive environments.

3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.

4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

K. Mounting location

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.

2. Install switches and sensor/transmitters for air and liquid pressure associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.

3. Install liquid pressure switches and sensor/transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on drawings.

4. Install air pressure switches and sensor/transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on drawings.

5. Mount switches and sensor/transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

6. Install instruments (except pressure gages) in liquid and liquid-sealed piped services below their process connection point. Slope tubing down to instrument with a slope of 2%.

L. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

M. Unless indicated on drawings, locate duct pressure sensor/transmitters approximately 75% of the distance of the longest hydraulic run. Location of sensors shall be submitted and approved before installation.

N. System process tubing connections for liquid pressure switches and sensor/transmitters shall be full size of device connection, but not less than 1/2 inch. Install stainless-steel bushing if required to mate device to system connection.

O. Install isolation valves in process tubing for liquid pressure switches and sensor/transmitters as close to system connection as practical.

P. Install dirt leg and drain valve at each liquid pressure switch and sensor/transmitter connection.

Q. Provide shielded static pressure probe at each end of building differential pressure sensors. Probe shall have multiple sensing ports, impulse suppression chamber and airflow shielding. Provide suitable probes for indoor and outdoor locations.

3.3 identification

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 20 0553 “Identification for Mechanical, Plumbing, and Fire Suppression Systems."

B. Install engraved phenolic nameplate identification at instrument.

3.4 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install raceways. Comply with requirements in Section 26 0533 "Raceways and Boxes for Electrical Systems."

C. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.6 CHECK-OUT PROCEDURES

A. Inspection

1. Check installed products before continuity tests, leak tests, and calibration.

2. Check instruments for proper location and accessibility.

3. Check flow instruments for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
5. Check that instrument attachment is properly secured and sealed.

B. Validation

1. Verify that instrument wiring is complete, enclosed, and connected to correct power source.
2. Verify sensing element type and proper material.
3. Verify instrument tag against approved submittal.

3.7 CALIBRATION

A. General

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer's written instructions.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements and to supplement requirements indicated.

B. Calibration of analog signals

1. Check analog voltage signals using a precision voltage meter at zero, 50%, and 100%.
2. Check analog current signals using a precision current meter at zero, 50%, and 100%.

C. Calibration of digital signals

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Calibration of sensor/transmitters: Check sensor/transmitters at zero, 50%, and 100% of the design values.

E. Calibration of switches: Calibrate switches to make or break contact at set points indicated.

3.8 ADJUSTING

A. Occupancy adjustments: When requested with 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions.

3.9 TESTING

A. Manufacturer Installation Inspection Report - Provide report prepared by manufacturer's representative, stating that systems installed and services provided under this Section are in accordance with manufacturer's recommendations and are properly operating.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 23\23 0923-Pressure Instruments.docx

SECTION 23 0927
TEMPERATURE INSTRUMENTS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Freezestats

B. Air temperature sensor/transmitters

C. Liquid temperature sensor/transmitters

1.2 DEFINITIONS

A. NIST: National Institute of Standards and Technology

B. RTD: Resistance temperature detector.

1.3 CODES AND STANDARDS (UTILIZE LATEST EDITION)

A. National Fire Protection Association (NFPA)

1. NFPA 90A: Installation of Air Conditioning and Ventilating Systems

B. National Electrical Manufacturers Association (NEMA)

1. NEMA 250: Enclosures for Electrical Equipment (1,000 volts maximum)

C. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)

1. SMACNA: HVAC Duct Construction Standards-Metal and Flexible

1.4 QUALITY ASSURANCE

A. This Section establishes a minimum quality of hardware and installation and establishes standard equipment or equipment configurations.

B. Work installed by the Contractor shall be done in a neat and workmanlike manner, as determined by Owner and in keeping with acceptable standards for this type of work.

C. Unless indicated in this specification, all materials used shall be new. Where items have been indicated to be reused, it is the Contractor's responsibility to insure that the reused items are operating properly and are in good condition. Contractor must make Owner aware of defective items designated for reuse. Owner will be responsible for repairs.

D. Device ratings and enclosures shall be as required by ambient conditions where product is to be installed.

1.5 SUBMITTALS

A. Preconstruction – Prior to construction provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Product data: For each type of product, including the following:

a. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.

b. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control

signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.

c. Product description with complete technical data, performance curves, and product specification sheets.

d. Installation instructions, including factors affecting performance.

2. Manufacturer's installation and operating manuals.

B. Contract closeout – At contract closeout provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Operating and maintenance data including:

a. Product data

b. Installation instructions

c. Assembly drawings

d. Replacement parts list

e. Maintenance and operation instructions

2. NIST Calibration Certificates

3. Test Reports

a. Manufacturer Installation Inspection Report

4. Warranties

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver products to site under provisions of Division 1.

B. Deliver products to site in containers with manufacturer's stamp affixed.

C. Protect products against dirt, water, chemical and mechanical damage before, during and after installation. Damage to products prior to final acceptance of the Work shall be repaired or replaced at no additional cost to the Owner.

1.7 SPARE PARTS

Not Applicable

1.8 WARRANTY

A. One year warranty on products and complete installation commencing at the time of Substantial Completion

1.9 MAINTENANCE

Not Applicable

PART 2 - PRODUCTS

2.1 FREEZESTATS

A. Acceptable manufacturers

1. Siemens

2. Automation Components
3. Johnson Controls
4. Honeywell

B. Low temperature cutout control with sensing element that closes control contacts when a section of the element falls below the device setpoint.

C. Construction

1. Sensing element: ⅛" x 20'-0" vapor-charged copper tube sensing element.
2. Sensing length: 12"-16"
3. Control contact: Single-pull, single-throw contact
4. Reset: Manual

D. Temperature range: Field adjustable setpoint between 35°F-45°F

E. Installation: Refer to details on drawings for freezestat installation requirements.

F. Basis of Design: Johnson Controls A11A

2.2 AIR TEMPERATURE

A. Temperature sensing shall be RTDs with matched transmitters. Thermistors, nickel and silver elements, thermocouples or pneumatic transmitters shall not be allowed.

B. Match sensor with temperature transmitter and factory calibrate together. Each matched sensor and transmitter set shall include factory calibration data traceable to NIST.

C. Obtain temperature-measuring sensors and transmitters single manufacturer.

D. The transmitter shall be compatible with the temperature element and the DDC panel. The assembly shall be factory calibrated over the entire operating span.

E. Duct averaging temperature sensor/transmitter

1. Acceptable manufacturers
   a. Minco
   b. Automation Components
   c. Johnson Controls (Flexible only)
   d. Siemens
   e. Building Automation Products
2. Rigid averaging
   a. Averaging sensor for installation in duct with multiple RTD sensors in a rigid sheath to provide average temperature across the entire length of the sensor.
   b. Construction
      (1) Sensor: Multiple 1000Ω platinum RTD in a brass sheath.
      (2) Length: As required to cover the widest dimension of the duct.
      (3) Enclosure: Galvanized steel junction box with removable cover and gasket for attachment to duct to seal penetration airtight. NEMA 250, Type 1 for indoor applications. NEMA 250, Type 4 for outdoor applications.
      (4) Temperature coefficient of resistance: 0.00375 Ω/Ω/°C or 0.00385 Ω/Ω/°C

c. Performance
(1) Temperature range: 20F-120°F
(2) RTD resistance accuracy: ±0.25% at 32°F
(3) Drift: ±0.14°C
d. Transmitter
(1) Output: 4 to 20 mA over the specified range, linear with temperature.
(2) Adjustments: Zero and span, ±5% of span.
(3) Ambient temperature: 32F-122°F
(4) Range: 40-120°F
(5) NIST traceable match calibrated to 0.75% total system accuracy through the range of operation.
(6) Calibration accuracy: ±0.2% of span.
(7) Linearity: ±0.1% of span
e. Basis of Design: Minco S493PF.

3. Flexible averaging
a. Averaging sensor for installation in duct or equipment with multiple RTD sensors in a flexible sheath to provide average temperature across the entire length of the sensor.
b. Construction
(1) Sensor: Multiple 1000Ω platinum RTD in a copper or aluminum sheath.
(2) Length: As required to cover the entire cross section of the air tunnel.
(3) Enclosure: Galvanized steel junction box with removable cover and gasket for attachment to duct to seal penetration airtight. NEMA 250, Type 1 for indoor applications. NEMA 250, Type 4 for outdoor applications.
(4) Temperature coefficient of resistance: 0.00375 Ω/Ω/°C or 0.00385 Ω/Ω/°C
c. Performance
(1) Temperature range: 20F-120°F.
(2) RTD resistance accuracy: ±0.25% at 32°F
(3) Drift: ±0.14°C
d. Transmitter
(1) Output: 4 to 20 mA over the specified range, linear with temperature.
(2) Adjustments: Zero and span, ±5% of span.
(3) Ambient temperature: 32°F-122°F
(4) Range: 40-120°F
(5) NIST traceable match calibrated to 0.75% total system accuracy through the range of operation.
(6) Calibration accuracy: ±0.2% of span.
(7) Linearity: ±0.1% of span
e. Basis of Design: Minco S475PF.

F. Single point temperature sensor/transmitter
1. Acceptable manufacturers
a. Minco

b. Automation Components
c. Johnson Controls
d. Siemens
e. Building Automation Products

2. Single point sensor for installation in duct or equipment with one sensor in a rigid sheath to provide temperature reading at the midpoint of the air tunnel.
3. Construction
   a. Sensor: Single 1000Ω platinum RTD in a stainless steel sheath.
   b. Length: As required to position the sensor tip at the midpoint of the air tunnel.
   c. Enclosure: Galvanized steel junction box with removable cover and gasket for attachment to duct to seal penetration airtight. NEMA 250, Type 1 for indoor applications. NEMA 250, Type 4 for outdoor applications.
   d. Temperature coefficient of resistance: 0.00375 Ω/Ω/°C or 0.00385 Ω/Ω/°C
4. Performance
   a. Temperature range: 20F -120°F
   b. RTD resistance accuracy: ±0.25% at 32°F
   c. Drift: ±0.14°C
5. Transmitter
   a. Output: 4 to 20 mA over the specified range, linear with temperature.
   b. Adjustments: Zero and span, ±5% of span.
   c. Ambient temperature: 32F-122°F for indoor transmitters
   d. Range:
      (1) Duct: 40°F -120°F
      (2) Outdoor air: -30F–120°F
      (3) Space: 50°F-90°F
   e. NIST traceable match calibrated to 0.75% total system accuracy through the range of operation.
   f. Calibration accuracy: ±0.2% of span.
   g. Linearity: ±0.1% of span
6. Space temperature sensor
   a. Provide sensor/transmitter as specified above.
   b. The assembly shall consist of a decorative ventilated enclosure acceptable to Owner.
   c. In addition, provide the following for space sensors used with terminal equipment ASC controllers:
      (1) Digital temperature display
      (2) Set point adjustment
7. Basis of Design: Duct - Minco S451PF, Outdoor air – Minco S455PF with sun shield.

2.3 LIQUID TEMPERATURE

A. Temperature sensing shall be RTDs with matched transmitters. Thermistors, nickel and silver elements, thermocouples or pneumatic transmitters shall not be allowed.

B. Match sensor with temperature transmitter and factory calibrate together. Each matched sensor and transmitter set shall include factory calibration data traceable to NIST.

C. Obtain temperature-measuring sensors and transmitters single manufacturer.

D. The transmitter shall be compatible with the temperature element and the DDC panel. The assembly shall be factory calibrated over the entire operating span.

E. Immersion temperature sensor

1. Acceptable manufacturers
    a. Minco
    b. Automation Components
    c. Johnson Controls
    d. Siemens
    e. Building Automation Products
2. Single point sensor for installation in pipe with one sensor in a thermowell to provide temperature reading at the midpoint of the pipe.
3. Construction
    a. Sensor: Single 1000Ω platinum RTD in a stainless steel thermowell.
    b. Length: As required to position the sensor tip at the midpoint of the air tunnel.
    c. Enclosure: NEMA 250, Type 3R galvanized steel connection head with removable cover. NEMA 250, Type 4 for outdoor applications.
    d. Temperature coefficient of resistance: 0.00375 Ω/Ω/°C or 0.00385 Ω/Ω/°C
4. Performance
    a. Temperature range: -40°F-212°F.
    b. RTD resistance accuracy: ±0.25% at 32°F
    c. Drift: ±0.14°C
5. Transmitter
    a. Location: Sensor mounted
    b. Output: 4 to 20 mA over the specified range, linear with temperature.
    c. Adjustments: Zero and span, ±5% of span.
    d. Ambient temperature: 32°F-122°F
    e. Range:
        (1) Chilled water: 40°F-70°F
        (2) Heating water: 70°F-250°F
    f. NIST traceable match calibrated to 0.75% total system accuracy through the range of operation for heating water.
    g. NIST traceable match calibrated to 0.2% total system accuracy through the range of operation for chilled, condenser and dual temperature water.
    h. Calibration accuracy: ±0.2% of span.

i. Linearity: ±0.1% of span

6. Basis of Design: Minco S480P/S490PW

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the complete set of plans, the process fluids, pressures, and temperatures and furnish instruments that are compatible with installed process condition.

B. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

C. Examine roughing-in for instruments installed in piping to verify actual locations and connections before installation.

D. Examine roughing-in for instruments installed in duct systems to verify actual locations and connections before installation.

E. Prepare a written report listing conditions detrimental to performance. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install products level, plumbing, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.

C. Fastening hardware

1. Wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.

2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.

3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks.

E. Space sensors on exterior walls shall be mounted on an insulated backplate and the hole into the wall completely sealed. If conduit is used up to the device, the conduit shall be plugged with insulation to prevent cold air from entering the device.

F. Coordinate exact mounting height and location of space sensors with architectural plans and elevations. Mounting height shall comply with codes and accessibility requirements. Space sensors shall be mounted 4’0” above the finished floor line or in line with existing devices unless otherwise noted.

G. Protect products installed outdoors from solar radiation, building and wind effect with stand-offs and shields

H. Liquid temperature sensor installation

1. Assembly shall include sensor, thermowell and connection head.

2. For pipe 4" and larger, install sensor and thermowell length to extend into pipe between 50 to 75% of pipe cross section.

3. For pipe smaller than 4":

   a. Install reducers to increase pipe size to 4" at point of thermowell installation.

   b. For pipe sizes 2½" and 3", thermowell and sensor may be installed at pipe elbow or tee to achieve manufacturer-recommended immersion depth in lieu of increasing pipe size.

   c. Minimum insertion depth shall be 2½".

4. Install matching thermowell.

5. Fill thermowell with heat-transfer fluid before inserting sensor.

6. For insulated piping, install thermowells with extension neck to extend beyond face of insulation.

7. Install thermowell in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.

I. Averaging duct temperature sensor installation

1. Install averaging-type air temperature sensor for temperature sensors located within air-handling units, and large ducts with air tunnel cross-sectional area of 20 ft^2 and larger or where indicated on the drawings.

2. Install sensor length to maintain coverage over entire cross-sectional area. Install multiple sensors where required to maintain the minimum coverage.

3. Fasten and support sensor with manufacturer-furnished clips to keep sensor taut throughout entire length.

J. Low-limit air temperature switch installation

1. Install multiple low-limit switches to maintain coverage over entire cross-sectional area of air tunnel.

2. Fasten and support sensing element with manufacturer-furnished clips to keep element taut throughout entire length.

3. Mount switches outside of airstream at a location and mounting height to provide easy access for switch set-point adjustment and manual reset.

4. Install on entering side of cooling coil unless otherwise indicated on drawings.

K. Corrosive environments

1. Use products that are suitable for environment to which they are subjected.

2. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.

3. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

L. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

M. Where instruments are installed on insulated ductwork, install such that the insulation and vapor barrier are not cut or interrupted.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 20 0553 “Identification for Mechanical, Plumbing, and Fire Suppression Systems."

B. Install engraved phenolic nameplate identification at instrument.

3.4 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install raceways. Comply with requirements in Division 26 specifications.

C. Connect electrical devices and components to electrical grounding system. Comply with requirements in Division 26 specifications.

3.5 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.6 CHECK-OUT PROCEDURES

A. Inspection

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check instruments for proper location and accessibility.
3. Check flow instruments for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
5. Check that instrument attachment is properly secured and sealed.

B. Validation

1. Verify that instrument wiring is complete, enclosed, and connected to correct power source.
2. Verify sensing element type and proper material.
3. Verify instrument tag against approved submittal.

3.7 CALIBRATION

A. General

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.

4. Equipment and procedures used for calibration shall meet instrument manufacturer's written instructions.

5. Provide diagnostic and test equipment for calibration and adjustment.

6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated.

7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements and to supplement requirements indicated.

B. Calibration of analog signals

1. Check analog voltage signals using a precision voltage meter at zero, 50%, and 100%.

2. Check analog current signals using a precision current meter at zero, 50%, and 100%.

C. Calibration of digital signals

1. Check digital signals using a jumper wire.

2. Check digital signals using an ohmmeter to test for contact.

D. Calibration of sensors: Check sensors at zero, 50%, and 100% of the design values.

E. Calibration of switches: Calibrate switches to make or break contact at set points indicated.

F. Calibration of transmitters

1. Check and calibrate transmitters at zero, 50%, and 100% of Project design values.

2. Calibrate resistance temperature transmitters at zero, 50%, and 100% of span using a precision-resistance source.

3.8 TESTING

A. Manufacturer Installation Inspection Report - Provide report prepared by manufacturer's representative, stating that systems installed and services provided under this Section are in accordance with manufacturer's recommendations and are properly operating.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 23\23 0927-Temperature Instruments.docx

SECTION 23 2113
HYDRONIC PIPING AND SPECIALTIES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Hydronic pipe and fitting materials, joining methods, valves, and specialties in this section include:

1. Heating water piping
2. Chilled water piping
3. Dual temperature heating and cooling water piping
4. Condenser water piping
5. Glycol water piping
6. Domestic water make-up piping
7. Cooling coil condensate drain piping
8. Equipment drain piping
9. Refrigerant vent piping
10. Valves
11. Air control devices
12. Pressurized make-up water system
13. Glycol specialties.

B. Services provided:

1. Pipe pressure testing

1.2 DEFINITIONS

A. CWP: Cold working pressure

B. EPDM: Ethylene propylene copolymer rubber

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber

D. NRS: Non-rising stem

E. OS&Y: Outside screw and yoke

F. PTFE: Polytetrafluoroethylene

G. RS: Rising stem

H. SWP: Steam working pressure

1.3 CODES AND STANDARDS (USE LATEST EDITIONS)

A. American Welding Society (AWS)

1. AWS A5.8: Specification for Filler Metals for Brazing and Braze Welding
2. AWS D1.1/D1.1M: Structural Welding Code - Steel

3. AWS D10.12/D10.12M: Guide for Welding Mild Steel Pipe

B. American Society of Mechanical Engineers (ASME)

1. ASME B1.20.1: Pipe Threads, General Purpose, Inch
2. ASME B16.1: Cast Iron Pipe Flanges and Flanged Fittings
3. ASME B16.3: Malleable Iron Threaded Fittings
4. ASME B16.4: Cast Iron Threaded Fittings
5. ASME B16.5: Pipe Flanges and Flanged Fittings, NPS1/2 to NPS24
6. ASME B16.10: Face-to-Face and End-to-End Dimensions of Valves
7. ASME B16.15: Cast Bronze Threaded Fittings.
8. ASME B16.18: Cast Copper Alloy Solder Joint Pressure Fittings.
9. ASME B16.21: Nonmetallic Flat Gaskets for Pipes Flanges
10. ASME B16.22: Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
11. ASME B16.23: Cast Copper Alloy Solder Joint Drainage Fittings DWV.
12. ASME B16.24: Bronze Flanges and Flanged Fittings.
13. ASME B16.29: Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings DWV.
14. ASME B16.34: Valves – Flanged, Threaded and Welding End
15. ASME B16.39: Malleable Iron Threaded Pipe Unions
16. ASME B18.2.1: Square and Hex Bolts and Screws - Inch Series
17. ASME B31 Series: Code for Pressure Piping
18. ASME B31.1: Power Piping
19. ASME B31.9: Building Services Piping
20. ASME Boiler and Pressure Vessel Code: Section IV, “Heating Boilers”; Section VIII, “Pressure Vessels,” Division 1; Section IX, “Welding and Brazing Qualifications”

C. American Society for Testing Materials (ASTM)

1. ASTM A 47/A 47M: Specification for Ferritic Malleable Iron Castings
2. ASTM A48/A 48M: Specification for Gray Iron Castings
3. ASTM A 53/A 53M: Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
4. ASTM A 106: Specification for Seamless Carbon Steel Pipe for High-Temperature Service
5. ASTM A 126: Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
6. ASTM A 234/A 234M: Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Services
7. ASTM A 307: Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
8. ASTM A 395/A 395M: Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures

9. ASTM A 536: Specification for Ductile Iron Castings
10. ASTM A 733: Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
11. ASTM B 32: Specification for Solder Metal
12. ASTM B 61: Specification for Steam or Valve Bronze Castings
13. ASTM B 62: Specification for Composition Bronze of Ounce Metal Castings
14. ASTM B 75: Specification for Seamless Copper Tube
15. ASTM B 88: Specification for Seamless Copper Water Tube
16. ASTM B 306: Standard Specification for Copper Drainage Tube (DWV)
17. ASTM B 584: Specification for Copper Alloy Sand Castings for General Applications
18. ASTM B 813: Specification for Liquid and Paste Fluxes for Soldering Applications of Copper and Copper Alloy Tube
19. ASTM B 828: Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
20. ASTM D 1785: Specification for PolyVinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120
21. ASTM D 2466: Specification for PolyVinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 40
22. ASTM D 2467: Specification for PolyVinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 80
23. ASTM D 2564: Specification for Solvent Cements for PolyVinyl Chloride (PVC) Plastic Piping Systems
24. ASTM D 2672: Specification for Joints for IPS PVC Pipe Using Solvent Cement
25. ASTM D 2846/D 2846M: Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems
26. ASTM D 2855: Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
27. ASTM F 402: Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermostatic Pipe and Fittings
28. ASTM F 438: Specification for Socket-Type Chlorinated PolyVinyl Chloride (CPVC) Plastic Pipe Fittings, Schedule 40
29. ASTM F 439: Specification for Socket-Type Chlorinated PolyVinyl Chloride (CPVC) Plastic Pipe Fittings, Schedule 80
30. ASTM F 441/F 441M: Specification for Chlorinated PolyVinyl Chloride (CPVC) Plastic Pipe, Schedules 40 and 80
31. ASTM F 493: Specification for Solvent Cements for Chlorinated PolyVinyl Chloride (CPVC) Plastic Pipe and Fittings
32. ASTM F 656: Specification for Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
33. ASTM F 1545: Standard Specification for Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges

D. American Water Works Association (AWWA)

1. AWWA C606: Grooved and Shouldered Joints

E. Brazing Handbook.

F. Copper Tube Handbook.

G. Manufacturers Standardization Society (MSS)

1. MSS SP-45: Bypass and Drain Connections
2. MSS SP-58: Pipe Hangers and Supports - Materials, Design and Manufacture
3. MSS SP-67: Butterfly Valves
4. MSS SP-68: High Pressure Butterfly Valves with Offset Design
5. MSS SP-70: Cast Iron Gate Valves, Flanged and Threaded Ends
6. MSS SP-71: Gray Iron Swing Check Valves, Flanged and Threaded Ends
7. MSS SP-72: Ball Valves with Flanged of Butt-Welding Ends for General Service
8. MSS SP-78: Cast Iron Plug Valves, Flanged and Threaded Ends
9. MSS SP-80: Bronze Gate, Globe, Angle and Check Valves
10. MSS SP-85: Gray Iron Globe and Angle Valves, Flanged and Threaded Ends
11. MSS SP-107: Transition Union Fittings for Joining Metal and Plastic Products
12. MSS SP-108: Resilient-Seated Cast Iron-Eccentric Plug Valves
13. MSS SP-110: Ball Valves, Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends
14. MSS SP-122: Plastic Industrial Ball Valves
15. MSS SP-125: Gray Iron and Ductile Iron In-Line, Spring-Loaded, Center-Guided Check Valves

1.4 QUALITY ASSURANCE

A. Pipe: Each length of pipe shall be legibly identified at mill by paint, stenciling, or raised symbols identifying manufacturer and class type or schedule of pipe. Copper pipe shall be identified at 3 foot intervals.

B. Fittings: To be identified by the manufacturer by permanently attached tags, imprints, or other approved means, indicating the class of wall thickness and material.

C. Valves: Manufacturer's name and pressure rating marked on valve body.

D. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label.

E. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.

F. Welding materials and procedures: Conform to ANSI/ASME SEC 9 and applicable state labor regulations.

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

G. Steel support welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

H. Qualifications for Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP shall be certified by the manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.

I. All grooved piping products shall be supplied by a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components. Grooving procedures shall be in accordance with the manufacturer's current listed standards conforming to ANSI/AWWA C606.

1.5 SUBMITTALS

A. Preconstruction – Prior to construction provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Product data: Submit product data for each type of the products listed in Part 2 including:
    a. Product description
    b. Model
    c. Dimensions
    d. Rough in requirements
    e. Service sizes
    f. Finishes
2. Shop drawings: For all new piping systems submit layout drawings at ¼" – 1'-0" scale in both hard-copy and AutoCAD compatible format. Shop drawings shall include, but not be limited to:
    a. Piping layout indicating sizes and locations
    b. Elevations of piping
    c. Slopes of horizontal piping
    d. Wall and floor penetrations
    e. Pressure rating for each service
    f. Penetrations through fire-rated and other partitions, floors, etc.
    g. Equipment installation and connections based on the equipment being used on the Project
    h. Hangers and supports including multiple pipe hangers
    i. Location of alignment guides, expansion joints, and anchors, including attachment to building structure
    j. Shop drawings shall show other building and building system components for coordination purposes. Input from other installers shall be obtained. Any proposed changes to piping layout required for coordination purposed shall be indicated. Coordination items shown shall include but no be limited to:
        (1) Any pipe (e.g. sprinkler, plumbing pipes, roof drains, etc.) in vicinity of hydronic piping
        (2) Electrical equipment, duct banks, and conduit
        (3) Structural members, including structural members to which piping supports and anchors will be attached
        (4) Ceiling access panels required for hydronic piping and accessories
3. Manufacturer's installation and operating manuals.
4. Welding certificates.

5. Inspection certificates for pressure vessels.

B. During construction – During construction provide and maintain the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Site record drawings - Maintain a set of drawings on site during construction showing the exact routing and location of piping systems being installed. The drawing shall be updated neatly by hand on a daily basis and account for routing modifications made in the field. Contractor shall use these drawing as a basis for generating the project as-built drawings.

C. Contract closeout – At contract closeout provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Operation and maintenance data including:
   a. Product data
   b. Installation instructions
   c. Assembly views
   d. Replacement parts list
   e. Maintenance and operation instructions
2. As-built drawings
   a. Upon completion of project, Contractor shall furnish as-built drawings showing in scale the exact routing and locations of all newly installed piping systems. Submit in both hard-copy and electronic AutoCAD format.
3. Test Reports
   a. Pipe pressure test
   b. Glycol concentration test
4. Warranties

1.6 DELIVERY, STORAGE AND HANDLING

A. Protect new pipe interiors from moisture, construction debris and dust, and other foreign materials with the use of plastic end caps/plugs on each end of pipe. Maintain end-caps/plugs in place until piping is installed. Open end of pipes should be capped/plugged throughout construction.

B. Store materials indoors, protected from the weather. Where exterior storage is necessary, elevate piping above grade and enclose with waterproof wrapping or cover.

C. Deliver and store valves in shipping containers with labeling in place.

D. Replace any piping or devices which are damaged during shipping or storage.

1.7 SPARE PARTS

Not Applicable

1.8 WARRANTY

A. One year warranty on products and complete installation commencing at the time of Substantial Completion

1.9 MAINTENANCE

Not Applicable

PART 2 - PRODUCTS

2.1 HEATING WATER PIPING, ABOVE GROUND

A. Steel pipe: ASTM A53/A53M, Grade B, Type E or S, Schedule 40, black steel with plain ends. Pipe 12" and over shall be standard weight, 0.375" wall thickness.

1. Fittings and joints
    a. 2" and smaller: ANSI/ASTM B16.3 Class 150 malleable iron or ANSI/ASTM B16.4 Class 125 cast iron fittings. Threaded joints.
    b. 2½" and larger: ASTM A234, wrought steel welding type fittings. ANSI/AWS D1.1 welded joints.
2. Flanges and flanged fittings
    a. ANSI/ASME B16.1, Class 125 raised face cast iron flanges
    b. ANSI/ASME B16.5, Class 150 forged steel, raised face, welding neck flanges
    c. Flanges to match those on valves and equipment
    d. Slip-on steel flanges not allowed.

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

1. Fittings and joints
    a. ANSI/ASME B16.22 solder wrought copper fittings, ASTM B32, soldered joints, Grade 95TA
    b. ANSI/ASME B16.15 screwed fittings and joints may be used at valves and equipment connections where required.

2.2 CHILLED WATER PIPING, ABOVE GRADE

A. Steel pipe: ASTM A53/A53M, Grade B, Type E or S, Schedule 40, black steel with plain ends. Pipe 12" and over shall be standard weight, 0.375" wall thickness.

1. Fittings and joints
    a. 2" and smaller: ANSI/ASTM B16.3 Class 150 malleable iron or ANSI/ASTM B16.4 Class 125 cast iron fittings. Threaded joints.
    b. 2½" and larger: ASTM A234, wrought steel welding type fittings. ANSI/AWS D1.1 welded joints.
2. Flanges and flanged fittings
    a. ANSI/ASME B16.1, Class 125 raised face cast iron flanges
    b. ANSI/ASME B16.5, Class 150 forged steel, raised face, welding neck flanges
    c. Flanges to match those on valves and equipment
    d. Slip-on steel flanges not allowed.

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

1. Fittings and joints
    a. ANSI/ASME B16.22 solder wrought copper fittings, ASTM B32, soldered joints, Grade 95TA
    b. ANSI/ASME B16.15 screwed fittings and joints may be used at valves and equipment connections where required.

2.3 DUAL TEMPERATURE HEATING AND COOLING PIPING

A. Steel pipe: ASTM A53/A53M, Grade B, Type E or S, Schedule 40, black steel with plain ends. Pipe 12" and over shall be standard weight, 0.375" wall thickness.

1. Fittings and joints
    a. 2" and smaller: ANSI/ASTM B16.3 Class 150 malleable iron or ANSI/ASTM B16.4 Class 125 cast iron fittings. Threaded joints.
    b. 2½" and larger: ASTM A234, wrought steel welding type fittings. ANSI/AWS D1.1 welded joints.
2. Flanges and flanged fittings
    a. ANSI/ASME B16.1, Class 125 raised face cast iron flanges
    b. ANSI/ASME B16.5, Class 150 forged steel, raised face, welding neck flanges
    c. Flanges to match those on valves and equipment
    d. Slip-on steel flanges not allowed

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

1. Fittings and joints
    a. ANSI/ASME B16.22 solder wrought copper fittings, ASTM B32, soldered joints, Grade 95TA
    b. ANSI/ASME B16.15 screwed fittings and joints may be used at valves and equipment connections where required.

2.4 COOLING COIL CONDENSATE DRAIN PIPING

A. Galvanized steel pipe: ASTM A53, Schedule 40

1. Fittings and joints: Class 125 galvanized steel or cast iron.
2. Joints: Screwed.

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

1. Fittings and joints
    a. ANSI/ASME B16.22 solder wrought copper fittings, ASTM B32, soldered joints, Grade 95TA. ANSI/ASME B16.29 solder wrought copper (DWV) fittings may be used for condensate drain piping 1¼" and larger.
    b. ANSI/ASME B16.15 screwed fittings and joints may be used at equipment connections where required.

2.5 EQUIPMENT DRAIN PIPING

A. Same materials and joining methods as for piping specified for the service in which the equipment drain is located.

2.6 FLANGES, UNIONS AND COUPLINGS

A. Steel pipe

1. Unions 2" and smaller: ANSI/ASME B16.39 malleable iron unions for threaded pipe, ground joint, screwed bronze or brass to iron. Pressure class and joint type of union shall be equal to that specified for fittings of respective piping service.

2. Flanges 2½" and larger: ANSI/ASME B16.5, forged steel, raised face, welding neck flanges. Pressure class and joint type of flange shall be equal to that specified for fittings of respective piping service.

3. Slip on flanges are **not** allowed.

B. Copper pipe

1. Unions 2" and smaller: ANSI/ASME B16.15 bronze unions, soldered joints. Pressure class and joint type of union shall be equal to that specified for fittings of respective piping service.

2. Flanges 2½" and larger: ANSI/ASME B16.24 bronze flanges, soldered joints. Pressure class and joint type of flange shall be equal to that specified for fittings of respective piping service.

C. Flanges to match those on valves and equipment.

D. Flange bolts and nuts: ASME B18.2.1, carbon steel, unless otherwise indicated

E. Pipe-flange gasket materials

1. Suitable for chemical and thermal conditions of piping system contents.

2. ASME B16.21, nonmetallic, flat, asbestos free, 1/8" maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.

b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2.7 DIELECTRIC FITTINGS

A. Dielectric nipples 4" and smaller

1. Acceptable manufacturers: Flow Design Inc., Perfection Corporation, Victaulic.

2. Electroplated steel nipple with inert and non-corrosive thermoplastic lining; threaded or grooved ends, 300-psig minimum working pressure at 225°F meeting the requirements of ASTM F-1545. Clearflow dielectric waterway fittings as manufactured by Perfection Corporation.

2.8 GROOVED FITTINGS AND COUPLINGS FOR STEEL PIPE

A. Acceptable manufacturers

1. Anvil/Gruvlok

2. Victaulic

B. Steel Pipe grooved couplings 2" through 12": ASTM A536 ductile iron; housing clamps to engage and lock, designed to permit some angular deflection, contraction and expansion; C-shape elastomer EPDM pressure responsive composition sealing gasket for operating temperature range from -30F to 230F; ASTM A183 steel bolts, nuts and washers. Use galvanized couplings for galvanized pipe.

1. Rigid type couplings: Housings shall be cast with offsetting, angle-pattern bolt pads or tongue and groove design to provide system rigidity and support and hanging in accordance with ANSI B31.1 and B31.9. Victaulic Style 107 or Gruvlok 7401, 7402.

2. Flexible type couplings: Use in locations where vibration attenuation and stress relief are required. Must use three couplings in close proximity. Victaulic Style 177 or Gruvlok 7001.

C. Grooved end fittings 2" through 12": ASTM A536 ductile iron, ASTM A234 forged steel, or ASTM A53 fabricated carbon steel with grooves designed to accept couplings. Use galvanized fittings for galvanized pipe.

D. Grooved end flange adapter: For use with grooved end pipe and fittings, flat face, for direct connection to ASTM A 234, or fabricated from carbon steel conforming to ASTM A53, galvanized for galvanized pipe, with grooves designed to accept grooved joint couplings of the same manufacturer.

E. Grooved couplings 14" through 24": Couplings shall consist of two ductile iron housing segments and flat bolt pads for metal to metal contact. Gaskets shall be pressure responsive synthetic rubber Grade EPDM, secured together with carbon steel bots and nuts.

1. Rigid type: Provide a rigid joint that corresponds with support spacing as defined by ASME B31.1 and B31.9. Victaulic style W07 or Gruvlok 7401-2.

2. Flexible type: Use in locations where vibration attenuation and stress relief are required. Allow for linear and angular movement, vibration attenuation and stress relief. Victaulic Style W77 or Gruvlok 7001-2.

3. Couplings shall be installed with metal to metal contact at the required torque, follow manufacturer' installation instructions.

F. Grooved end fittings 14" through 24": ASTM A536 ductile iron, ASTM A234 forged steel, or ASTM A53 fabricated carbon steel with grooves designed to accept grooved joint couplings of the same manufacturer.

2.9 GROOVED FITTINGS AND COUPLINGS FOR COPPER PIPE

A. Acceptable manufacturers

1. Anvil/Gruvlok

2. Victaulic

B. Copper pipe grooved couplings 2" through 8": ASTM A-536 Grade 65-45- ductile iron housing clamps to engage and lock cast with offsetting, angle-pattern bolt pads or tongue and grooves to provide system rigidity, copper colored enamel coated; C-shape or flush gap pressure responsive, elastomer EPDM composition sealing gasket for operating temperature range from -30°F to 230°F; ASTM 449 steel bolts, nuts, and washers. Couplings shall be manufactured to connect copper tubing sized tube and fittings. Victaulic Style 607 or Gruvlok 6400 or 6402.

C. Grooved end fittings 2" through 8": Wrought copper conforming to ANSI B16.22, or bronze sand castings conforming to ANSI B16.18. Fittings shall be manufactured to copper tubing sizes, with grooves designed to accept grooved joint couplings of the same manufacturer.

D. Flange adapters: ASTM A536 ductile iron housing coated with copper-colored enamel, for engaging directly roll grooved copper tube and fittings or a flange by groove adaptor made of epoxy coated steel flange with copper tube insert and bolting directly to ANSI Class 125 and Class 150 flanges. Victaulic Style 641, Gruvlok 6074.

2.10 PRESSURE SEAL JOINTS FOR COPPER TUBING

A. Acceptable manufacturers

1. Viega "Pro-Press"

2. Nibco "Press System"

3. Apollo “Xpress”
4. No substitutions

B. Pipe sizes ½” through 4”: For use on ASTM B88, type L hard drawn piping
1. Copper press fittings shall conform to the material and sizing requirements of ASME B16.18 or ASME B16.22 and performance criteria of IAPMO PS 117.
2. O-rings for copper press fitting shall be EPDM and shall be factory installed in fittings.
3. Fittings to incorporate Smart Connect “SC” feature that includes a leakage path that will not pass a pressure test unless properly pressed.
4. “Pro-press” as manufactured by Viega.

2.11 GLOBE VALVES

A. Acceptable manufacturers
1. Crane
2. Hammond
3. Milwaukee
4. Nibco

B. Up to 2”: Class 150, 300 psig CWP rated, manufactured in accordance with MSS-SP-80. ASTM B62 bronze body, union bonnet, bronze trim, rising bronze stem, malleable iron handwheel, asbestos free packing, renewable composition PTFE of TFE disc, screwed ends. Model 590T manufactured by Milwaukee.

C. 2½” and greater: Class 125, 200 psig CWP rated manufactured in accordance with MSS-SP-85. ASTM A126 iron body, bolted bonnet, bronze trim, rising stem, cast iron handwheel, asbestos free packing OS&Y, solid disc, flanged end. Model F-2981-M manufactured by Milwaukee.

2.12 BALL VALVES

A. Acceptable manufacturers
1. Apollo
2. Crane
3. Hammond
4. Milwaukee
5. Nibco
6. Watts Regulator

B. Up to 2½”: 600 psi CWP rated, manufactured in accordance with MSS-SP-110. Two-piece bronze body, stainless steel full port vented ball, PTFE or TFE seats, lever handle and threaded ends. Model T-585-70-66 manufactured by Nibco.

C. Ball valves mounted in insulated pipes shall have 2” extended stems of non-thermal conductive material to clear pipe covering, and a protective sleeve that allows operation of the valve without breaking the vapor seal or disturbing insulation.

2.13 BUTTERFLY VALVES – RESILIENT SEATED

A. Acceptable manufacturers

1. Bray
2. DeZurik
3. Keystone/Tyco
4. Milwaukee (Standard Pressure only)
5. Nibco

B. Standard pressure butterfly valves

1. 2½" – 20": 250 psi CWP rated at temperatures up to 225°F, manufactured in accordance with MSS-SP-67, suitable for bi-directional bubble-tight and dead-end service at rated pressure without use of downstream flange. Cast iron or ductile iron body with lug ends, aluminum bronze or Nylon 11 coated ductile iron disc, blowout proof stainless steel stem, cured EPDM seat bonded or vulcanized to the body for service to 250°F, extended neck for insulating, 10 position lever handle for valves up to 6" in size. Series 31H manufactured by Bray.
2. Valves 8" and larger shall be furnished with handwheel and gear drive.
3. In addition to the butterfly valves specified above the following valves may be used in a grooved piping system:
    a. Valves up to 12": Victaulic VIC 300 MasterSeal with aluminum bronze disc. Provide handwheel and gear drive for sizes 8" and larger.
    b. Valves 14"-20": Victaulic AGS Vic 300 with EPDM coated disc for service to 230F.

C. High pressure butterfly valves

1. 2½" – 20": 250 psi CWP close-off pressure at temperatures up to 225°F, manufactured in accordance with MSS-SP-67, suitable for bi-directional dead-end service at rated pressure without use of downstream flange. Cast iron or ductile iron body with lug ends, aluminum bronze or Nylon 11 coated ductile iron disc, blowout proof stainless steel stem, cured EPDM seat bonded or vulcanized to the body for service to 250°F, extended neck for insulating, 10 position lever handle for valves up to 6" in size. Series 31H manufactured by Bray.
2. Valves 8" and larger shall be provided with handwheel and gear drive.

D. Provide chain operators for valves 8" and over installed 8'-0" or more above floor in mechanical rooms.

2.14 SWING CHECK VALVES

A. Acceptable manufacturers

1. Crane
2. Hammond
3. Milwaukee
4. Nibco
5. Watts Regulator

B. Up to 2": Class 150, 300 psig CWP rated, manufactured in accordance with MSS-SP-80. ASTM B62 bronze body, horizontal flow body design, PTFE or TFE seat disc, threaded ends. Model 510T manufactured by Milwaukee.

C. 2½" and greater: Class 125, 200 psig CWP rated, manufactured in accordance with MSS-SP-71. ASTM A126 iron body with clear or full waterway, bronze trim, cast iron disc, non-asbestos gasket, flanged ends. Model F-2974-M manufactured by Milwaukee.

2.15 SPRING LOADED CHECK VALVES

A. Acceptable manufacturers

1. Apco
2. Hammond
3. Metraflex
4. Milwaukee
5. Mueller
6. Nibco
7. Watts Regulator
8. Victaulic

B. Up to 2": Class 125, 250 psi CWP rated, manufactured in accordance with MSS-SP-80. ASTM B584 bronze body, wafer style, bronze seat, stainless steel spring, threaded ends. Model BSN manufactured by Metraflex.

C. Over 2": Class 125, 200 psi CWP rated, manufactured in accordance with MSS-SP-125. ASTM A126 cast iron body, globe style, stainless steel seat and plug, stainless steel spring, flanged ends. Series 900 manufactured by Metraflex.

2.16 STRAINERS

A. Acceptable manufacturers

1. Armstrong International
2. Keckley
3. Metraflex
4. Spirax Sarco
5. Titan Flow Control
6. Victaulic

B. Up to 2", bronze body: Class 125, rated for 200 psi @ 150F, ASTM B-584 bronze body, Y-pattern type with 20 mesh Type 304 stainless steel perforated screen, threaded cover for screen access and blow-off plug, threaded ends. Model F-150 manufactured by Keckley.

C. Up to 2", iron body: Class 125, rated for 400 psi @150F, ASTM A126 cast iron body, Y pattern type with 20 mesh Type 304 stainless steel perforated screen, threaded cover for screen access and blow-off plug, threaded ends. Model TS manufactured by Metraflex.

D. Size 2½" to 16": Class 125, rated for 175 psi @ 150F, ASTM A126 cast iron body, Y pattern type with $^{1}/_{16}$" (sizes 2½" to 4") or ⅛" (sizes larger than 4") perforated Type 304 stainless steel screen, bolted cover for screen access and blow-off plug, flanged ends. Model YS58-CI manufactured by Titan Flow Control.

E. Size 5" to 12": Class 125, rated for 175 psi @ 150°F, ASTM A126 cast iron body, basket strainer with 0.125" perforated Type 304 stainless steel screen provided with integral handle, bolted cover and bottom drain, flanged ends. Model B-1 manufactured by Metraflex.

F. All Y pattern strainers shall be provided with a ball valve and capped nipple on the blow-off connection.

2.17 AUTOMATIC FLOW CONTROL VALVES

A. Acceptable manufacturers

1. Bell & Gossett
2. Griswold Controls
3. Hays Fluid Controls
4. IMI Flow Design
5. Nexus Valve

B. Sizes up to 3": Forged brass or iron body, CWP rated for 175 psig @ 250°F with threaded ends, union on outlet, temperature and pressure test plug on inlet and outlet. Valves shall be the same size as the piping in which installed.

C. Provide extended neck test ports to clear insulation for valves installed in insulated piping.

D. Strainer: Provide either an integral in line 20 mesh stainless steel strainer or a field installed strainer at valve inlet.

E. Valves shall flow within 5% of selected rating, over the operating pressure range. Manufacturer shall be able to provide independent laboratory tests verifying accuracy of performance.

F. Control mechanism

1. Elastomeric diaphragm and orifice or stainless steel piston and spring assembly.
2. Control mechanism shall be self-cleaning and fully removable without disturbing piping.

G. Identification tag: Each valve shall be marked with system identification, valve number and flow rate.

H. Pump Head Requirement: The permanent pressure loss added to the pump head shall not exceed 8 feet for operating pressure range of 2-32 psi.

I. Basis of Design: Measureflo as manufactured by Hays Fluid Controls. Provide Y-ball style valve for sizes where available.

J. Valve assemblies which include an integral bronze or brass ball valve may be used. Provide extended handle ball valves to clear insulation for valves installed in insulated piping.

2.18 MANUAL BALANCING VALVES

A. Venturi style

1. Acceptable manufacturers
    a. Bell & Gossett (all sizes)

b. Griswold Controls (all sizes)
c. IMI Flow Design (all sizes)
d. Hays Fluid Controls (only up to 2")
e. Nexus Valve (only up to 2")

2. Venturi flow measurement device with integral ball valve or butterfly valve furnished by the venturi manufacturer for flow adjustment.
3. Sizes up to 2": Brass or bronze body rated for 300 psi at 250°F, isolation ball valve with equal percentage port, Teflon seats and memory stop; venturi measurement device, dual temperature and pressure test ports, threaded connections with union on inlet. Model QuickSet as manufactured by Griswold.
4. Sizes 2½" to 14": Steel body rated for 175 psi at 250°F, isolation butterfly valve with EPDM seat and memory stop, lever handle for valves up to 6" in size, gear drive and handwheel for valves 8" and larger; venturi measurement device, dual temperature and pressure test ports, flanged or grooved connections to match piping. Model QuickSet as manufactured by Griswold.
5. Provide extended neck test ports and extended handle valves to clear insulation for valves installed in insulated piping.
6. Valves shall be the same size as the piping in which installed.
7. Venturi measurement device shall have a precision machined throat and shall have a guaranteed accuracy of 3% across full operating range.
8. Pump head requirement: Select venturi Cv such that permanent pressure loss added to the pump head with the valve at the full open position does not exceed 2 ft.

B. Globe style

1. Acceptable manufacturers
   a. Anvil/Gruvlok (Red & White)
   b. Armstrong Fluid Technology
   c. Victaulic (Tour & Andersson)
2. Wye pattern, equal percentage, globe-style, fixed orifice design.
3. Sizes up to 2": Brass or bronze body rated for 250 psi at 230F, Model TA-786 (solder) or TA-787 (threaded) as manufactured by Victaulic.
4. Each valve shall have two ¼" metering ports with Nordel check valves and gasketed caps for differential pressure and flow measurement.
5. Valve handwheel shall have memory stop feature to lock the valve position after the system has been balanced. Handwheel shall be multi-turn from fully open to fully closed, quarter turn valves are not allowed.
6. Valve shall provide positive shut-off.
7. Valves shall be the same size as the piping in which installed unless larger valve is required to meet maximum pump head loss requirement specified in this section.
8. Flow measurement device shall have a guaranteed accuracy of 5% across full operating range.
9. Pump head requirement: Select valve Cv such that permanent pressure loss added to the pump head with the valve at the full open position does not exceed 2 ft.

2.19 MULTI-FUNCTION VALVE ASSEMBLIES

A. Acceptable manufacturers

1. Anvil/Gruvlok (Red & White)
2. Flow Design (Autoflow)
3. Griswold Controls
4. Hays Fluid Controls
5. Nexus Valve
6. Victaulic (Tour & Andersson)

B. Manufacturer's packaged valve assemblies that combine multiple components and functions into a single device may be used for coil and equipment connections. Individual components shall be as specified in this Section.

C. Valve assemblies shall include all components and devices shown on the drawings.

2.20 RELIEF VALVES

A. Acceptable manufacturers

1. Amtrol
2. Armstrong International
3. Bell and Gossett
4. Kunkle
5. Spence
6. Taco
7. Watts Regulator

B. Bronze or iron body, non-ferrous seat, diaphragm operated, non corrosive seat and stem designed for maximum working pressure of 125 psi.

C. Valve size, capacity and operating pressure: Comply with ASME Boiler and Pressure Vessel Code – Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

D. Valves to bear ASME stamp, and meet all requirements of authority having jurisdiction.

2.21 PRESSURE REDUCING VALVES

A. Acceptable manufacturers

1. Amtrol
2. Armstrong Fluid Technology
3. Bell and Gossett
4. Spence
5. Taco
6. Watts Regulator

B. Bronze or brass body, PTFE disc, brass seat, low inlet pressure check valve, inlet strainer which is removable without system shutdown.

C. Valve size, capacity and operating pressure shall be selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated piping 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 coordination drawings.

B. Protect new pipe interiors from moisture, construction debris and dust, and other foreign materials with the use of plastic end caps/plugs on each end of pipe. Maintain end-caps/plugs in place until piping is installed. Open end of pipes should be capped/plugged throughout construction.

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 to permit valve servicing.

G. Install piping at indicated slopes. Install piping at a uniform grade of 0.2% upward in direction of flow when no other slope is indicated on the drawings. Piping shall be installed to permit system drainage.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Install groups of pipes at common elevations, parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

M. Install branch connections to mains using tee fittings in main pipe.

1. The use of saddle or “cut-in” connections is NOT allowed.

2. The use of T-drill connections is NOT allowed.

N. The use of bullhead tee connections, where two opposite flows join to a common perpendicular outlet, is NOT allowed.

O. Install ¾” nipple and ball valve in blowdown connection of strainers 2” and larger. Match size of strainer blowoff connection for strainers smaller than 2”.

P. Identify piping as specified in Division 20 Section 20 0553, “Identification for Mechanical, Plumbing, and Fire Suppression Systems.”

Q. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

R. Install pipe wells for temperature controls sensors and instrumentation. Coordinate with temperature controls contractor.

S. Pipe joint construction

1. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
3. Soldered joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's “Copper Tube Handbook,” using lead-free solder alloy complying with ASTM B 32.
4. Brazed joints: Construct joints according to AWS's “Brazing Handbook,” “Pipe and Tube” Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
5. Threaded joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
    a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
    b. 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.
6. Welded joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 “Quality Assurance” Article.
7. Flanged joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
8. Plastic piping solvent-cemented joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
    a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
    b. CPVC piping: Join according to ASTM D 2846/D 2846M Appendix.
    c. PVC pressure piping: Join ASTM D 1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D 2855.
    d. PVC non-pressure piping: Join according to ASTM D 2855.
9. Grooved joints: Grooved joints shall be installed in accordance with the manufacturer’s guidelines and recommendations.
    a. Assemble joints with coupling and gasket, lubricant, and bolts.
    b. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove.
    c. Use grooved-end fittings and rigid, grooved-end-pipe couplings.
    d. The gasket style and elastomeric material shall be verified as suitable for the intended service as specified.

e. A factory trained representative shall provide on-site contractor training and periodic joint inspection

10. Pressure seal joints
    a. Pipe shall be certified for use with the copper pressure seal system.
    b. Pipe shall be square cut, ±0.030", properly deburred and cleaned.
    c. Pipe ends shall be marked at the required location, using a manufacturer-supplied gauge, to ensure full insertion into the coupling or fitting during assembly.
    d. Utilize press tool approved by fitting manufacturer.
    e. Press tool shall leave identification mark such that use of proper tool can be visually verified.

T. Coordination of mechanical work installation and access requirements:

1. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Owner and General Contractor.
2. Where pipes are to be installed in partitions, furred out spaces and chases, obtain information as to their exact location and size and install work so as to be entirely concealed in allotted space.
3. Furnish advance information on locations and sizes of frames, boxes, sleeves and openings needed for work and also furnish information and shop drawings necessary to permit installation of other work without delay.
4. Where there is evidence that parts of Mechanical Work will interfere with other work, assist in working out space conditions and/or structure, and make necessary adjustments to accommodate work.
5. Mechanical Work installed before coordinating with other work so as to cause interference with other work to be changed to correct such condition without additional cost to Owner.
6. Install mechanical work to permit removal (without damage to other parts) of coils, heat exchangers, pumps, fan shafts and wheels, belt guards, sheaves and drives and other parts requiring periodic replacement or maintenance.
7. Arrange pipes, ducts and equipment to permit ready access to valves, cocks, traps, starters, motors, dampers, control components and to clear the openings of swinging and overhead doors and of access panels.
8. Provide access panels in equipment, ducts and like items for inspection of interiors and proper maintenance.

U. Appliances and equipment to be installed and connected with best engineering practices and in accordance with manufacturer's instructions and recommendations. Piping, valves, connections and other like items recommended by manufacturer or as required for proper operation to be provided without additional cost to Owner.

V. In no case will any pipe, conduit or duct be installed where it is supported on or suspended from another pipe, conduit or duct.

W. Follow manufacturers' directions in installation and operation of all equipment and materials.

X. Indirect waste lines, cooling coil drain pan lines, overflow pipes, relief valve discharge pipes, etc. shall have ends beveled at 45° angle to minimize splashing.

Y. After completion or piping installation, clean, flush, and treat systems. Coordinate with chemical treatment requirements; refer to Division 23 Section 23 2500, “Pipe Cleaning, Flushing, and Chemical Treatment.”

Z. Valves

1. Examine valve interior for cleanliness. Clean or replace as required.
2. Remove special packing materials from valves.
3. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by valve operation.
4. Install valves with stems upright or horizontal, not inverted.
5. Install valves in position to allow full movement and operation.
6. Install chainwheels on operators for butterfly and other shut-off valves sizes 8” and over, installed 8’-0” or more above floor in mechanical rooms.
7. Install swing check valves in horizontal position with hinge pin level.

AA. Piping connections to heat transfer coils and terminal equipment

1. Sizes for supply and return piping connections shall be the same as or larger than equipment connections. Provide reducers only at connection to equipment where equipment connection size is smaller than specified line size.
2. Install control valves in accessible locations close to connected equipment.
3. Install ports for pressure gages and thermometers at coil inlet and outlet connections.

3.2 APPLICATIONS

A. Select system components with pressure rating equal to or greater than system operating pressure.

B. The following systems shall be provided with high pressure valves and fittings as specified in Part 2 of these specifications:

1. Pipe sizes through 12”: Systems or portions of systems with operating pressure equal to or greater than 150 psi.
2. Pipe sizes 14” through 24”: Systems or portions of systems with operating pressure equal to or greater than 100 psi.

C. Install unions in piping 2” and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

D. Install flanges in piping 2½” and larger, at final connections of equipment and elsewhere as indicated.

E. Install drains, consisting of a tee fitting, ¾” ball valve, and short threaded nipple with cap, at main shut off valves, low points of piping, bases of vertical risers, at equipment and elsewhere as required for system drainage.

F. Provide manual air vents where shown on drawings and all high point of water systems, at heat transfer coils and elsewhere as required for air venting. Where large air quantities can accumulate in piping systems, provide enlarged air collection chambers.

G. Install automatic air vents at high points of system piping in mechanical equipment rooms only and where indicated on the drawings. Provide vent tubing to nearest drain.

H. Provide non conducting dielectric fittings wherever joining dissimilar metals.

I. Piping to equipment shall be installed full size as indicated on the plans. If equipment connections differ from piping shown on the drawings, provide reducers/increasers at all valves, devices, and equipment as required.

J. Install brass male adapters each side of valves in copper piped system. Sweat solder adapters to pipe.

K. Multi-function valve assemblies may be used at coil and equipment connections at the contractor's option to reduce the number of joints which must be made in the field. These valve assemblies shall include all components and devices shown on the drawings.

L. For new hydronic systems, make final connections to make-up water pipes provided by either plumbing or mechanical contractor as called for on the drawings.

M. Grooved joints and couplings

1. Use grooved mechanical couplings and fasteners only in mechanical rooms and accessible locations.

2. Use flexible couplings only where specifically called for in the drawings or specifications to reduce vibration and provide stress relief in piping.

N. Use of pressure seal joints is subject to the Owner's approval of voluntary alternate pricing.

3.3 WELDING

A. All welding shall be performed by experienced welders in a neat and workmanlike manner. Welding done on piping, pressure vessels and structural steel under this section shall be performed only by persons who are currently qualified in accordance with ANSI Standard Code for Pressure Piping, Section I, Power Piping, Bulletin ANSI B31.1.0-1980; applicable portions of ASME Boiler and Pressure Vessel Code, Section I, Power Boilers, and Section IX, Welding Qualifications. Submit for approval and record certified copies of Procedure Specification for Welding, Welding Procedure Qualification Tests and Welder Performance Qualification Tests. Welding specifications and qualification tests shall be recorded on Forms Q 1 as recommended in Appendix II of Section IX of the ASME Boiler and Pressure Vessel Code. Records shall be certified by Contractor and shall be accessible to authorized inspector.

B. Bevel piping on both ends before welding as required and defined in Code.

C. Use following weld spacing on all butt-welds:

NOMINAL PIPE WALL THICKNESS	SPACE
¼" or less	⅛"
Over ¼" or less than ¾"	$^{3}/_{16}$"
¾" and over	$^{3}/_{16}$"

D. Use backing rings on welds in all piping 10" and larger.

E. Where welding branches or connections are taken from a branch or main and the branch or connection pipe size is the same diameter as the main, a welding tee must be installed in the main for the branch or connection. Saddle or cut-in connections are NOT allowed.

F. Where branches or connections are made to a welded main and the branch or connection is a minimum of two pipe sizes less than the diameter of the main, and the branch is 2½" and larger, install a Bonney-Forge weldolet at the branch connection to the main. Where the branch or connection is 2" and smaller, install a Bonney-Forge threadolet at the branch connection to the main.

Screwed couplings, half couplings or screwed nipples welded to mains for screwed branches will not be permitted.

G. The method of attaching weldolet or threadolet units to the piping shall be in strict accordance with the ANSI Code for Pressure Piping, B31.1.

H. Before start of any welding, remove all corrosion and other foreign material from surface to be welded.

I. Welding shall be performed by either manual shielded metallic arc process or automatic submerged arc process. Use direct current exclusively.

J. Electrodes to be used with manual shielded metallic arc method shall conform to ASTM A-233, Classification E-6010.

K. Size of electrodes, voltages, current, thickness, and number of passes or beads shall be in accordance with provisions of previous paragraph.

L. After deposition, clean each layer of weld metal to remove all slab and scale by wire brushing or grinding, then chip where necessary to prepare for proper deposition of next layer.

M. Weld reinforcement shall be not less than 1/16" or more than ⅛" above normal surface of joined sections. Reinforcement shall be crowned at center and shall taper on each side to surface being joined. Exposed surface of weld shall present workmanlike appearance and shall be free of depressions below surface of joined members.

N. No welding of any kind shall be done when temperature of base metal is lower than 0°F. Material to be welded during freezing temperatures shall be made warm and dry before welding is started. Temperature of metal shall be "warm to hand" – or approximately 60°F.

O. All welders engaged in work performed under this Section shall have been qualified in accordance with test requirements of Section IX of the ASME Boiler and Pressure Vessel Code. Each operator shall identify his production welds by marking his regularly assigned identification number or mark within 1" of weld. Contractor shall submit complete list of individual numbers of identifying marks and operator's name, and a copy of each operator's certificate.

3.4 START UP

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following before operating the system:

1. Open manual valves fully.

2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, and cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

3.5 TESTING

A. Pipe Pressure Test

1. Furnish all labor, material, instruments, supplies and services and bear all costs for the accomplishment of tests herein specified. Correct all defects appearing under test and repeat the tests until no defects are disclosed; leave the equipment clean and ready for use.
2. Field test all piping before start-up of systems. Tests of piping systems shall be conducted before connections to equipment are made and before piping is covered, buried or otherwise concealed.
3. Perform all tests other than herein specified which may be required by legal authorities or by agencies to whose requirements this work is to conform.
4. Furnish all necessary testing apparatus, make all temporary connections and perform all testing operations required, at no additional cost to Owner.
5. No work shall be insulated, painted, backfilled or concealed until authorized by Owner's representative and/or the Engineer representative.
6. Inform Engineer and Owner's representative 48 hours prior to when work is ready for test.
7. Systems found to have leaks shall be subjected to further tests when faulty joints have been repaired or replaced.
8. Contractor shall be responsible for any corrective action required due to a failed pipe pressure test.
9. Perform the following tests on hydronic piping:
    a. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
    b. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
    c. Isolate expansion tanks and determine that hydronic system is full of water.
    d. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure or 100 psi, whichever is greater. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90% of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
    e. Test pressures shall be increased if necessary to comply with applicable codes.

f. After hydrostatic test pressure has been applied for at least 15 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

10. Pipe Pressure Test Report - Submit documentation of pipe pressure testing and submit test result reports within two weeks of testing.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 23\23 2113-Hydronic Piping and Specialties.docx

SECTION 23 3113
METAL AND FLEXIBLE DUCT

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Duct and duct-associated materials and procedures in this section include:

1. Sheet metal materials
2. Single-wall rectangular ducts and fittings
3. Double-wall rectangular ducts and fittings
4. Single-wall round ducts and fittings
5. Double-wall round ducts and fittings
6. Flexible ducts
7. Duct liners
8. Sealants and gaskets
9. Hangers and supports

B. Products/material specified under other Divisions but installed under this section:

1. Duct-mounted smoke detectors

C. Services provided

1. Duct leak testing
2. Removal of existing duct lining
3. Duct cleaning

1.2 DEFINITIONS

A. Duct size: Duct sizes indicated herein or on associated drawings shall be the inside clear dimensions of actual air path for both unlined and lined ducts.

B. Pressure class: A “SMACNA - HVAC Duct Construction Standards, Metal and Flexible” pressure classification system designating static pressure values (in inches w.g.) equal to the maximum operating pressure to which the ductwork can safely be subjected.

1.3 CODES AND STANDARDS (USE LATEST EDITIONS)

A. American Society for Testing Materials (ASTM)

1. ASTM A 36/A 36M: Specification for Carbon Structural Steel
2. ASTM A 366/A 366M: Specification for Steel, Sheet, Carbon, Cold-Rolled, Commercial Quality
3. ASTM A 480/A 480M: Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
4. ASTM A 653/A 653M: Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
5. ASTM B 209: Specification for Aluminum and Aluminum-Alloy Sheet and Plate

6. ASTM C 203: Standard Test Methods for Breaking Load and Flexural Properties of Block-Type Thermal Insulation
7. ASTM C209: Standard Test Methods for Cellulosic Fiber Insulating Board
8. ASTM C 411: Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation
9. ASTM C 534: Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
10. ASTM C 916: Specification for Adhesives for Duct Thermal Insulation
11. ASTM C 920: Specification for Elastomeric Joint Sealants
12. ASTM C 1071: Specification for Thermal and Acoustical Insulation (Glass Fiber, Duct Lining Material)
13. ASTM D 256: Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
14. ASTM D 638: Standard Test Method for Tensile Properties of Plastics
15. ASTM D 790: Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
16. ASTM D 1621: Standard Test Method for Compressive Properties of Rigid Cellular Plastics
17. ASTM E 84: Test Method for Surface Burning Characteristics of Building Materials

B. National Fire Protection Association (NFPA)
1. NFPA 90A: Installation of Air Conditioning and Ventilating Systems
2. NFPA 90B: Installation of Warm Air Heating and Air Conditioning Systems
3. NFPA 96: Ventilation Control and Fire Protection of Commercial Cooking Operations
4. NFPA 255: Standard Method of Test of Surface Burning Characteristics of Building Materials

C. North American Insulation Manufacturers Association (NAIMA)
1. NAIMA AH124: Fibrous Glass Duct Liner Standard

D. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)
1. SMACNA: Duct Cleanliness for New Construction
2. SMACNA: HVAC Air Duct Leakage Test Manual
3. SMACNA: HVAC Duct Construction Standards - Metal and Flexible (excluding all amendments and proposed revisions)
4. SMACNA: IAQ Guidelines for Occupied Buildings Under Construction

E. Underwriters Laboratory
1. UL® 94: Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
2. UL® 181: Factory-Made Air Ducts and Air Connectors
3. UL® 723: Test for Surface Burning Characteristics of Building Materials

1.4 QUALITY ASSURANCE

A. Construct ductwork to NFPA 90A standards.

B. Welding qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, “Structural Welding Code - Steel,” for hangers and supports.

2. AWS D1.2/D1.2M, “Structural Welding Code - Aluminum,” for aluminum supports.

3. AWS D9.1M/D9.1, “Sheet Metal Welding Code,” for duct joint and seam welding.

C. Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall, at a minimum, comply with SMACNA’s “HVAC Duct Construction Standards - Metal and Flexible,” excluding all amendments and proposed revisions, and performance requirements and design criteria indicated.

1. All further references to conformance with the requirements of SMACNA’s “HVAC Duct Construction Standards - Metal and Flexible” shall always mean with the exclusion of all amendments and proposed revisions.

2. Where the requirements of this specification exceed the requirements of the SMACNA’s “HVAC Duct Construction Standards - Metal and Flexible,” the specifications shall govern.

D. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts.

E. Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA’s “HVAC Duct Construction Standards - Metal and Flexible.”

1.5 SUBMITTALS

A. Preconstruction – Prior to construction provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Product data: Submit for each type of the following products:
    a. Liners and adhesives.
    b. Sealants and gaskets: submit manufacturer’s data sheets including performance data, pressure ratings, surface burning characteristic and installation instruction.

2. Shop drawings: For all new duct systems submit layout drawings at ¼” = 1’-0” scale in both hard-copy and AutoCAD compatible format. Shop drawings shall include, but not be limited to:
    a. Metal and flexible ductwork and fittings including both factory- and shop-fabricated
    b. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work
    c. Duct layout indicating sizes, configuration, liner material, and static-pressure classes
    d. Elevation of ducts
    e. Dimensions of main duct runs from building grid lines
    f. Fittings
    g. Reinforcement and spacing
    h. Seam and joint construction
    i. Penetrations through fire-rated and other partitions
    j. Equipment installation based on equipment being used on Project

k. Locations for duct accessories including dampers, turning vanes, and access doors and panels

l. Hangers and supports, including methods for duct and building attachment, and vibration isolation

m. Provide detail or schedule of:

(1) Sheet metal thicknesses

(2) Joint and seam construction and sealing

(3) Reinforcement details and spacing

(4) Materials, fabrication, assembly, and spacing of hangers and supports

n. Indicate all duct mounted equipment including fan coil units, reheat coils, terminal units, and humidifiers and indicate:

(1) Elevations, sections, details of components, manifolds

(2) Support types, locations, and weight on each support

(3) Required clearances

o. Shop drawings shall show other building and building system components for coordination purposes. Input from other installers shall be obtained. Any proposed changes to duct layout required for coordination purposes shall be indicated. Coordination items shown shall include but not be limited to:

(1) Any pipe (e.g., sprinkler, heating hot water, chilled water, plumbing pipes, roof drawings, etc.) in vicinity of duct

(2) Electrical duct banks and conduit

(3) Structural members including structural members to which duct will be attached

(4) Items penetrating finished ceiling including the following:

(a) Lighting fixtures

(b) Air outlets and inlets

(c) Speakers

(d) Sprinklers

(e) Access panels

3. Duct testing plan: Submit duct pressure testing plan with duct shop drawings, including list of ducts to be tested and duct testing schedule. Plan shall be color coded indicating areas to be tested in each phase of testing.

a. Notify engineer and owner of duct leakage testing schedule. Engineer shall be present at first duct leakage test per system.

4. Manufacturer's installation and operating manuals.

5. Welding certificates

B. During construction – During construction provide and maintain the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Site record drawings: Maintain a set of drawings on site during construction showing the exact routing and location of duct systems being installed. The drawing shall be updated neatly by hand on a daily basis and account for routing modifications made in the field. Contractor shall use these drawing as a basis for generating the project as-built drawings.

C. Contract closeout – At contract closeout provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Operation and maintenance data including:
    a. Product data
    b. Installation instructions
    c. Assembly views
    d. Replacement parts list
    e. Maintenance and operation instructions
2. As-built drawings
    a. Upon completion of project, Contractor shall furnish as-built drawings showing in scale the exact routing and locations of all newly installed duct systems. Submit in both hard-copy and electronic AutoCAD format.
3. Test reports
    a. Duct testing reports: Submit documentation of duct performance testing and submit performance testing result reports within two weeks of testing.
        (1) Contractor shall be responsible for any corrective action required due to a failed duct leakage test.
4. Warranties

1.6 DELIVERY, STORAGE AND HANDLING

A. Protect new duct interiors from moisture, construction debris and dust, and other foreign materials. If inside of new duct becomes dirty, Contractor shall clean duct per Duct Cleaning specifications.

B. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Intermediate Level.

1.7 WARRANTY

A. One-year warranty on products and complete installation commencing at the time of Substantial Completion.

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

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

1. Galvanized sheet steel: Comply with ASTM A 653. Lock forming quality with G-90 galvanized coating designation (not less than 1.25 oz. of zinc on each side of each square foot of sheet).
2. Paint grip steel: Mill-phosphatized "Paintgrip" or "Zincgrip" finish suitable for field painting.
3. Minimum ducts gauges shall be in accordance with the following tables. This table shall be used in conjunction with SMACNA table for application of appropriate reinforcement in accordance with proper pressure class.

MINIMUM GALVANIZED AND STAINLESS STEEL RECTANGULAR DUCT GAUGE WITHOUT REINFORCEMENT					
DUCT DIMENSION (IN.)	**1" W.G.**	**2" W.G.**	**3" W.G.**	**4" W.G.**	**6" W.G.**
8 and under	26	26	24	24	24
9 – 10	26	26	24	22	24
11 – 12	26	26	24	22	20
13 – 14	26	24	22	20	20
15 – 16	26	24	22	20	18
17 – 18	24	22	20	18	18
19 – 20	24	20	18	18	16
21 – 22	22	18	18	18	16
23 – 24	22	18	18	18	16
25 – 26	20	18	18	16	
27 – 28	18	18	18	16	
29 – 30	18	18	18	16	
31 – 36	18	16	16		
37 – 42	16				
43 – 48	16				
49 – 54					
55 – 60					
61 – 72					
73 – 84					
85 – 96					
97 – 108					
109 – 120					

REINFORCEMENT REQUIRED
REFER TO SMACNA HVAC DUCT CONSTRUCTION STANDARDS - METAL AND FLEXIBLE

MINIMUM GALVANIZED AND STAINLESS STEEL ROUND DUCT GAUGE WITHOUT REINFORCEMENT								
Duct Diameter (in.)	**+10" w.g. Long Seam**	**+10" w.g. Spiral Seam**	**- 2" w.g. Long. Seam**	**-2" w.g. Spiral Seam**	**-4" w.g. Long Seam**	**-4" w.g. Spiral Seam**	**-6" w.g. Long. Seam**	**-6" w.g. Spiral Seam**
4	28	28	28	28	28	28	28	28
6	28	28	28	28	28	28	28	28
8	28	28	28	28	28	28	26	28
10	28	28	28	28	26	28	24	26
12	28	28	26	28	24	26	24	24
14	28	28	24	28	22	24	22	24
16	26	26	24	26	22	24	20	22
18	26	26	22	24	20	22	20	22
20	24	26	22	24	20	22	18	20
22	24	26	22	22	18	20	18	20
24	24	26	20	22	18	20	18	18
30	22	24	18	20	16	18	16	18
36	22	24	16	18		16		16
42	22	24	16	18		16		
48	20	22		16				

54	20	22	16	
60	20	22		
66	18	22		
72	18	20		
78	18	20		
84	18	20		
90	18	20		
96	18	20		

REINFORCEMENT REQUIRED
REFER TO SMACNA HVAC DUCT
CONSTRUCTION STANDARDS - METAL AND FLEXIBLE

B. PVC-Coated, galvanized sheet steel: Comply with ASTM A 653. Galvanized steel sheet, lock forming quality with G-90 galvanized coating designation. Minimum thickness for factory-applied PVC coating shall be 4 mils (0.10 mm) thick on sheet metal surface of ducts and fittings exposed to corrosive conditions and on opposite surface.

1. Coating materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.

2. Minimum duct gages shall be as per the minimum duct gauges listed under Galvanized Sheet Metal.

C. Carbon-steel sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

D. Stainless-steel sheets: Comply with ASTM A 480 Type 304, 316 or 316L, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet.

1. Ductwork shall have Type 2B mill finish where concealed from view.

2. Ductwork shall have Type 4 polished finish where exposed to view and located in finished building areas. All welds shall be ground and polished.

E. Aluminum sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view and located in finished building areas. Aluminum Connectors and Bar Stock: Alloy 6061-T6 or of equivalent strength. Aluminum: rectangular duct.

1. Minimum duct gauges shall be in accordance with the following table. This table shall be used in conjunction with SMACNA table for application of appropriate reinforcement in accordance with proper pressure class.

MINIMUM RECTANGULAR DUCT ALUMINUM THICKNESS WITHOUT REINFORCEMENT

DUCT DIMENSION (IN.)	1" W.G.	2" W.G.	3" W.G.	4" W.G.	6" W.G.
8 and under	0.027 in.	0.027 in.	0.034 in.	0.034 in.	0.034 in.
9 – 10	0.027 in.	0.027 in.	0.034 in.	0.043 in.	0.034 in.
11 – 12	0.027 in.	0.027 in.	0.034 in.	0.043 in.	0.052 in.
13 – 14	0.027 in.	0.034 in.	0.043 in.	0.052 in.	0.052 in.
15 – 16	0.027 in.	0.034 in.	0.043 in.	0.052 in.	0.067 in.
17 – 18	0.034 in.	0.043 in.	0.052 in.	0.067 in.	0.067 in.
19 – 20	0.034 in.	0.052 in.	0.067 in.	0.067 in.	0.083 in.
21 – 22	0.043 in.	0.067 in.	0.067 in.	0.067 in.	0.083 in.
23 – 24	0.043 in.	0.067 in.	0.067 in.	0.067 in.	0.083 in.

MINIMUM RECTANGULAR DUCT ALUMINUM THICKNESS WITHOUT REINFORCEMENT					
DUCT DIMENSION (IN.)	**1" W.G.**	**2" W.G.**	**3" W.G.**	**4" W.G.**	**6" W.G.**
25 – 26	0.052 in.	0.067 in.	0.067 in.	0.083 in.	
27 – 28	0.067 in.	0.067 in.	0.067 in.	0.083 in.	
29 – 30	0.067 in.	0.067 in.	0.067 in.	0.083 in.	
31 – 36	0.067 in.	0.083 in.	0.083 in.		
37 – 42	0.083 in.				
43 – 48	0.083 in.				
49 – 54					
55 – 60					
61 – 72					
73 – 84					
85 – 96					
97 – 108					
109 – 120					

REINFORCEMENT REQUIRED
REFER TO SMACNA HVAC DUCT CONSTRUCTION STANDARDS - METAL AND FLEXIBLE

MINIMUM ROUND DUCT ALUMINUM THICKNESS WITHOUT REINFORCEMENT				
Duct Diameter (in.)	**+2" w.g. Long Seam**	**+2" w.g. Spiral Seam**	**-2" w.g. Long. Seam**	**-2" w.g. Spiral Seam**
3 – 8	0.032 in.	0.025 in.	0.040 in.	0.025 in.
9 – 14	0.032 in.	0.025 in.	0.040 in.	0.032 in.
15 – 26	0.040 in.	0.032 in.	0.050 in.	0.040 in.
27 – 36	0.050 in.	0.040 in.	0.063 in.	0.050 in.
37 – 50	0.063 in.	0.050 in.	0.071 in.	0.063 in.
51 – 60	0.071 in.	0.063 in.	0.090 in.	
61 – 84	0.090 in.	**REINFORCEMENT REQUIRED**		

F. Concrete ducts: ASTM C14; hub and spigot concrete sewer pipe with ANSI/ASTM C443 joints, rubber gaskets.

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

2.2 SINGLE WALL RECTANGULAR DUCTS AND FITTINGS (SHOP AND FACTORY FABRICATED)

A. Acceptable manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Lindab Inc.
2. McGill AirFlow LLC.
3. SEMCO Inc.
4. Sheet Metal Connectors, Inc.
5. Shop fabricated duct is acceptable for ducts with a pressures class rating of 6" w.g. or less provided compliance with the requirements herein are met.

B. General fabrication requirements

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

2. Comply with SMACNA's "Industrial Duct Construction Standards" where indicated.

C. Transverse joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) 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" except as otherwise noted.

1. No duct shall be constructed to less than 2" w.g.

D. Longitudinal seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," 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," except as otherwise noted:

1. Button punch snap lock is not acceptable.

E. 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 2, "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," except as otherwise noted.

2.3 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS (SHOP AND FACTORY FABRICATED)

A. Acceptable manufacturers

1. McGill AirFlow LLC.

2. Sheet Metal Connectors, Inc.

B. Rectangular ducts: Fabricate ducts with indicated dimensions for the inner duct.

C. All double wall duct must be factory fabricated.

D. Outer duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

1. Transverse joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) 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" except as otherwise noted.

a. No duct shall be constructed to less than 2" w.g.

2. Longitudinal seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," 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" except at otherwise noted:

a. Button punch snap lock is not acceptable.

E. Interstitial insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum thermal conductivity, k-value: 0.27 Btu in/hr ft^2 °F at 75°F mean temperature.
    a. For exterior ducts located outside the building envelope, provide a minimum of R-12 insulation.
    b. For ducts located within the building envelope, in unconditioned spaces such as mechanical rooms, etc., provide a minimum of R-6 (2" thick) insulation.
    c. For ducts located within the building envelope, in conditioned spaces, provide a minimum of R-5 (1.5" thick) insulation.
    d. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.

F. Inner duct: Minimum 24 gauge (0.028") solid sheet steel.

1. Formed-on transverse joints (flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Traverse (Girth) 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."
2. Longitudinal seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 SINGLE-WALL ROUND DUCTS AND FITTINGS (FACTORY AND SHOP-FABRICATED)

A. Acceptable manufacturers

1. Lindab Inc.
2. McGill AirFlow LLC.
3. SEMCO Inc.
4. Sheet Metal Connectors, Inc.
5. Shop fabricated ducts are acceptable for all positive pressure ducts and negative pressure ducts with ratings of -1" w.g. to -4" w.g.

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.

1. All round ducts must utilize spiral lock seam except:
    a. Ducts up to and including 12" diameter with a positive pressure class of 2" w.g. and less may utilize longitudinal lock seam construction.

C. SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, and materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse joints in ducts larger than 60" in diameter shall be flanged.

D. Longitudinal seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 48" in diameter with butt-welded longitudinal seams.

E. Tees and laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.5 DOUBLE-WALL ROUND DUCTS AND FITTINGS (FACTORY FABRICATED)

A. Acceptable manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Lindab Inc.
2. McGill AirFlow LLC.
3. SEMCO Inc.
4. Sheet Metal Connectors, Inc.

B. Outer duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.

C. Transverse joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse joints in ducts larger than 60" in diameter shall be flanged.

D. Longitudinal seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 48" in diameter with butt-welded longitudinal seams.

E. Tees and laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

F. Inner duct: Minimum 24 gauge (0.028") solid sheet steel.

G. Interstitial insulation

1. Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
2. Maximum thermal conductivity, k-value: 0.27 Btu in/hr ft^2 °F at 75°F mean temperature.
    a. For exterior ducts located outside the building envelope, provide a minimum of R-12 insulation.

b. For ducts located within the building envelope, in unconditioned spaces such as mechanical rooms, etc., provide a minimum of R-6 (2" thick) insulation.

c. For ducts located within the building envelope, in conditioned spaces, provide a minimum of R-5 (1.5" thick) insulation.

2.6 FLEXIBLE DUCTS

A. Acceptable manufacturers

1. Buckley Associates, Inc.
2. Flexmaster USA

B. Quality assurance

1. Factory fabricated UL listed under UL-181 as Class 1 duct, meeting requirements of NFPA 90A with a flame spread rating of 25 or less and smoke development rating of 50 or less, unless otherwise noted.
2. Only factory-insulated flexible duct is acceptable. No field-insulated flexible duct is allowed.

C. Noninsulated aluminum laminate flexible duct

1. Tri-laminate of aluminum foil, fiberglass and aluminized polyester supported by helically wound galvanized steel. The fabric shall be mechanically fastened to the helix.
   a. Pressure rating: 12" w.g. positive and 10" w.g. negative through 12" diameter, 5" w.g. negative through 16" diameter.
   b. Maximum 5,500 fpm maximum air velocity.
   c. Temperature range: -20°F to 250°F.
2. Basis of Design: FlexmasterUSA Type 3NI

D. Insulated acoustic CPE flexible duct

1. Core material shall be an acoustical transparent chlorinated polyethylene (CPE) fabric supported by helically wound galvanized steel. The fabric shall be mechanically fastened to the steel helix without the use of adhesive.
   a. Pressure rating: 10" w.g. positive and 5" w.g. negative through 16" diameter.
   b. Maximum 5,500 fpm air velocity.
   c. Temperature range: -20°F to 250°F.
   d. The insertion loss (dB) of a 5-foot length of duct shall be a minimum of:

DIAMETER	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
10 inch	8.7	14.4	24.9	31.6	23.9	12.7
14 inch	8.1	21	20	24.4	14.5	6.8

2. Factory insulate with flexible fiberglass insulation with a minimum R value of 6.0 at a mean temperature of 75°F. Cover the insulation with a reinforced aluminum pigmented vapor barrier jacket having a permeance of not greater than 0.05 perms when tested in accordance with ASTM E 96, procedure A.
3. Basis of Design: FlexmasterUSA Type 1M

E. Insulated corrugated metal flexible duct

1. Construct the duct of 3003-H14 alloy aluminum in accordance with ASTM B 209. The duct wall shall be at least 0.005 inches thick, spiral wound into a tube and spiral corrugated to provide strength and flexibility. Use a mechanical lock to form a continuous secure airtight joint without the use of adhesive.
    a. Pressure rating: 10" w.g. positive and 12" w.g. negative.
    b. Maximum 5,500 fpm air velocity.
    c. Temperature range: -20°F to 250°F.
2. Factory insulate with flexible fiberglass insulation with a minimum R value of 6.0 at a mean temperature of 75°F. Cover the insulation with a reinforced aluminum pigmented vapor barrier jacket having a permeance of not greater than 0.05 perms when tested in accordance with ASTM E 96, procedure A.
3. Basis of Design: FlexmasterUSA Type TL-M

F. Flexible duct connectors

1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a quick-release worm-gear action, to suit duct size. Nylon or other non-metallic draw bands are not acceptable.

2.7 SEALANT AND GASKETS

A. Acceptable manufacturers for duct sealant

1. Hardcast
2. United McGill
3. Ductmate

B. General sealant and gasket requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

C. Duct sealant

1. Water-based non hardening, water resistant, mold and mildew resistant sealant classified compounded specifically for sealing joints and seams in ductwork.
    a. Maximum Static-Pressure Class: 10" w.g., positive and negative.
    b. Service: Indoor or outdoor.
    c. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets for specific applications.
2. Duct tapes are not allowed.

D. Flanged joint sealant: Comply with ASTM C 920. General: Single-component, acid-curing, silicone, electrometric. Type S, Grade NS, Class 25, Use O.

E. Flange gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

1. Gaskets used in chemical, laboratory, or process exhaust duct systems shall be suitable for exposure to substances in the air stream. Contractor shall verify the compatibility with Engineer prior to installation.

2.8 HANGERS AND SUPPORTS

A. Hanger rods for dry or non-corrosive environments: Cadmium-plated steel rods and nuts.

B. Steel cables for galvanized-steel ducts: Galvanized steel complying with ASTM A 603.

C. Steel cables for stainless-steel ducts: Stainless steel complying with ASTM A 492.

D. 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.

E. Trapeze and riser supports

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 APPLICATION

Designer – confirm applicability of the following static pressure classes for your project!!!!!.
If no duct pressure class designations are provided, the 1" w.g. pressure class is the basis of compliance with SMACNA standards, regardless of velocity in the duct, except when the duct is upstream of VAV boxes in a VAV system, in which case the ductwork has a 2" water gauge pressure class basis of compliance. Specify proper pressure class for project system(s).
Review isolation room exhaust system requirements, Pressure Class listed below is most common arrangement.

A. Install duct with duct material for pressure class as per the following table:

DUCT SYSTEM AND LOCATION	MATERIAL	PRESSURE CLASS
VAV supply system: duct from AHU discharge to inlet of air terminal units	Galvanized steel (G90)	+4"
VAV supply system: duct downstream of air terminal units	Galvanized steel (G90)	+2"
Outside air and exhaust plenums	Galvanized steel (G90)	-2"
Return system with air terminal units: duct from air terminal units to inlet of return fan	Galvanized steel (G90)	-4"
Return system with air terminal units: duct from return grille to terminal unit	Galvanized steel (G90)	-2"
Return system with no air terminal units: all duct	Galvanized steel (G90)	-2"
Air relief and transfer	Galvanized steel (G90)	+2"
Toilet and general (non-hazardous) exhaust system: all duct	Galvanized steel (G90)	-2"
Ducts for a minimum of 2' before and 5' after the location of a duct-mounted humidifier	304 stainless steel	To match adjacent duct

B. Utilize the following flexible ducts for the applications as outlined below:

DUCT SYSTEM AND LOCATION	FLEXIBLE DUCT TYPE
VAV supply system: duct from AHU discharge to inlet of air terminal units	Insulated corrugated metal flexible duct
VAV supply duct downstream of air terminal units	Acoustic insulated CPE flexible duct

DUCT SYSTEM AND LOCATION	FLEXIBLE DUCT TYPE
Return system with air terminal units: duct from air terminal units to inlet of return fan	Noninsulated corrugated metal flexible duct
Return system with air terminal units: duct from return grille to terminal unit	Noninsulated aluminum laminate flexible duct
Return system with no air terminal units: all duct	Noninsulated aluminum laminate flexible duct
Air relief and transfer	Noninsulated aluminum laminate flexible duct

3.2 INSTALLATION

A. General

1. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Where interferences develop in field, offset or reroute ductwork as required for clearing such interference.
2. Contractor shall modify specified duct sizes as required to fit. Modified duct size shall have cross-sectional area and pressure drop equivalent to that of the specified duct size.
3. All ducts shall be airtight and free from pulsation and vibration at normal operating conditions.
4. Contractor shall submit sheet metal shop drawings to the Test and Balance Contractor for review, and provide any additional volume dampers that the Test and Balancing Contractor needs to perform final balancing.
5. Install round ducts in maximum practical lengths.
6. Install ducts with fewest possible joints.
7. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
8. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
9. Install ducts with a minimum clearance of 1", plus allowance for insulation thickness.
10. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
11. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
12. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1½".
13. Where ducts pass through fire and smoke rated interior partitions and exterior walls, install fire, smoke, and/or combination fire/smoke dampers. Contractor shall obtain a copy of architectural drawings showing the fire and smoke rated partitions and exterior walls at the time of bid and provide the appropriate damper (at all ducts penetrating fire and smoke rated partitions and walls whether shown on mechanical plans or not). Comply with requirements in Division 23 Section "Ductwork Accessories" for fire and smoke dampers.
14. Provide openings in ducts where required to accommodate thermometers and controllers. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ducts, install insulation material inside a metal ring.

15. Fabricate continuously welded medium and high pressure round duct fittings two gauges heavier than duct gauges indicated in SMACNA Standard. Joints shall be minimum 4" cemented slip joint, brazed or electric welded. Prime coat welded joints.
16. Install duct-mounted smoke detectors.
17. Where ducts of different metals meet, joint shall use a gasket, seal or compound to prevent the two different metals from coming in contact.
18. Galvanized surfaces altered or damaged (including the damage due to welding) shall be painted with a galvanized paint.
19. For paint grip steel ducts, place identification stickers in side ducts off of the surface to be painted.
20. Gaskets shall not protrude into airstream.
21. Elbows:
    a. Rectangular duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
        (1) For supply duct:
            (a) Use Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
            (b) If space does not allow the use of a Radius Type RE1, provide a square-throated elbow with turning vanes. Turning vanes shall comply with the requirements of Division 23 Section "Ductwork Accessories".
        (2) For return and exhaust duct:
            (a) Use Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
            (b) If space does not allow the use of a Radius Type RE1, provide a square-throated elbow with vanes. Turning vanes shall comply with the requirements of Division 23 Section "Duct Accessories."
    b. Round duct, excluding laboratory (fume handling) exhaust duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."
        (1) Use minimum 1.5 radius-to-diameter ratio.
            (a) 12" and Smaller in Diameter: Stamped (pleated not acceptable)
            (b) 14" and Larger in Diameter: Standing seam or welded five-piece 90° turning elbows (three-piece elbows not acceptable for 90° elbow).
            (c) 45° elbows shall meet the requirements for 90° elbows and shall be die stamped up to 12" and three piece construction of sized greater than 12".
22. Branch configurations
    a. Rectangular duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."
        (1) Rectangular main to rectangular branch: 45° entry.
        (2) Rectangular main to round branch: Bellmouth connection. A 45° boot connection is allowed only where the duct main size does not allow the use of a Bellmouth branch connection.
        (3) No straight tap, butt flange or cinch lock is allowed

b. Round duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees."

(1) Provide 45° lateral tap; conical taps are allowed only on supply duct downstream of air terminal units and return ducts upstream of air terminal units.

(2) Saddle taps are permitted only for new connection in existing duct.

(3) No 90° taps are allowed.

23. Offsets and transitions: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-7, "Offsets and Transitions."

a. Transitions

(1) Increase duct sizes gradually, not exceeding 15° on each side for a concentric transition or 30° on one each side for an eccentric transition.

(2) Decrease duct sized not exceeding 22.5° on each side for a concentric transition or 45° on one side for an eccentric transition.

b. Offsets

(1) Provide smooth radius offset with the radius equal to the duct dimension.

(2) Mitered offset Type 2 is acceptable provided the offset angle no greater than 15°.

24. Easements for obstructions

a. Provide easements where ductwork conflicts with piping and structure.

b. Where easements exceed 10% duct area, split into two ducts maintaining original duct area.

25. Seam and joint sealing

a. For **all new ducts**, all transverse joints, longitudinal seams and connections shall be sealed in conformance with SMACNA Class A sealing requirements as defined in the 2005 SMACNA HVAC Duct Construction Standards - Metal and Flexible, Second Edition.

26. Hangers and supports: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

a. Refer to Division Section 20 0529 "Hangers and Supports for Mechanical, Plumbing and Fire Suppression Systems" for additional information.

b. Support ducts using traverse steel and threaded rods or 1" wide straps of 16 gauge galvanized steel. Wire or perforated straps of any kind are not acceptable.

c. No hangers and supports shall be attached to ducts with sheet metal screws that penetrate any part of ducts.

d. Round duct shall be suspended on prefabricated circular single loop or two-piece bands completely encircling ducts.

e. Hanger spacing: Except where requirements herein exceed, 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,"

(1) Provide duct supports at a maximum of 6 foot intervals, within 24" of each elbow, and within 24" of each branch intersection.

(2) Provide vertical ducts supports at a maximum of 10 foot intervals.

27. Flexible duct
    a. Aluminum laminate or acoustic CPE flexible duct (insulated or noninsulated)
        (1) Connect diffusers to low pressure ducts with a maximum of five feet of flexible duct.
        (2) Each connection shall be a single piece of flexible duct. No splicing is allowed.
        (3) Support flexible duct at a maximum of 2 feet on center, with no portion lying on suspended ceiling system or other horizontal surface.
        (4) Flexible ducts shall not pass through any partition, wall, floor or ceiling.
        (5) Connect fabric type flexible ducts to diffuser collars or duct with stainless steel draw bands with quick release. Position draw bands behind collar beads if applicable. Connection shall be airtight; seal if required for airtight connection.
    b. Corrugated metal flexible duct installation
        (1) Terminal units may be connected to medium pressure duct mains directly or with a maximum of one foot of Insulated Corrugated Metal Flexible Duct.
        (2) Do not use corrugated metal flexible duct to change direction.
        (3) Connect corrugated metal flexible duct with sealant and clamps; connection shall be airtight.
    c. For all insulated flexible ducts, pull back insulation and connect internal duct to collar with stainless steel draw band. Then pull insulation and vapor barrier jacket over liner connection and secure with a second draw band. Tape insulation end with three wraps of compatible vapor barrier tape to seal insulation.
    d. For termination of flexible duct at externally insulated duct, secure flexible duct jacket to duct insulation with three wraps of compatible vapor barrier tape.
28. Access panels
    a. Locate access openings on top or sides of duct, whichever is more accessible. Side openings shall be a minimum of 1½" from bottom of duct.
    b. Install fire-rated access panel assemblies within 10 feet of each change in direction and at maximum intervals of 12 feet in horizontal ducts, and at every floor for vertical ducts, or as indicated on drawings.
    c. Install access panels within 3 feet of each side of fan where the fan has ductwork connected to both the inlet and outlet.
    d. Install an access panel within 3 feet of a wall mounted exhaust fan.
    e. Access panels shall be installed liquid tight.
    f. Access panels shall have a gasket or sealant that is rated for 1500F.

3.3 SERVICES

A. Duct system cleaning
    1. Clean ducts and associated accessories:
        a. Supply duct (20 feet downstream of existing AHU's)
        b. Return duct (20 feet upstream of existing AHU's)
        c. Exhaust duct (20 feet downstream of existing return fans)
        d. Air intake plenums

2. Protect equipment which may be harmed by excessive dirt with temporary filters, or bypass during cleaning.

3. Temporary closure: At ends of ducts which are not connected to equipment of air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until such time as connections are to be completed.

4. At the time of the cleaning, take photographs of the system to document the cleaning. Report to Owner any problems found during the course of the work.

5. Ductwork
    a. Clean all ductwork, excluding flexible ductwork, by using skilled workmen to crawl through ducts. Brush, scrape and HEPA-vacuum all surfaces to remove accumulations of dirt, dust, soot and other foreign material.
    b. To clean ductwork too small to crawl through, cut as needed to facilitate accessibility. Reach in with proper tools and clean these ducts.
    c. After cleaning, reseal ducts that have been cut into with new sheet metal plates. Attach plates with sheet metal screws and seal per SMACNA Seal Class A.

6. Existing grilles and vents (which are scheduled to remain and to be reused)
    a. All grilles, diffusers, registers and vents shall be marked, taken down and cleaned by brushing, HEPA-vacuuming and washing.
    b. After cleaning, these grilles will be replaced in their original marked settings to maintain proper airflow.

7. Air intakes and plenums
    a. Clean by brushing, scraping and HEPA-vacuuming to remove dust, dirt, soot, grease and other foreign material.

8. Existing fans and fan housings which are scheduled to remain and to be reused
    a. Scrape and HEPA-vacuum all surfaces, including the inside and outside of the cooling coil drain pan, to remove dust, dirt, soot and all other foreign material.
    b. Thoroughly wash with water applied under pressure.

3.4 TESTING

A. Duct leakage tests

1. The following shall be the scope of the new duct leakage testing:
    a. All new duct with a pressure class of +3" w.g. and greater, or 3" w.g and lower.
    b. All duct of any pressure class that will be located outdoors.
    c. All duct of any pressure class that will be located in an inaccessible area (e.g. in shafts, above plaster ceilings).
    d. All exhaust ductwork.
    e. A sampling of approximately 25% of duct constructed to a pressure class ranging from -2" w.g through +2" w.g. (e.g. duct downstream of supply air terminal units).
        (1) If sample passes tests, remaining ductwork of similar pressure class shall be permitted to proceed without further testing.

(2) If sample fails leak test, the sample duct shall be repaired and the leakage test repeated until test passes. Any other duct of similar pressure class that was installed will be repaired in a similar manner.

2. Ducts shall be tested in accordance with the SMACNA HVAC Air Duct Leakage Test Manual Leak Testing procedure. Leaks or imperfections that are detected shall be properly remedied and the tests repeated until all work is reasonably sound.

3. Notify engineer and owner of duct leakage testing schedule. Engineer shall be present at first duct leakage test per system.

4. Air leakage shall not exceed maximum allowable leakage for specified Leakage Class CL as defined in SMACNA "HVAC Air Duct Leakage Test Manual," most recent edition.

   a. ASHRAE / SMACNA Leakage Class is defined by:

      $F = C_L \times P^{0.65}$

      $Q = F \times A$

      Where:

      F Leakage flow rate (cfm per 100 ft^2 of duct surface area)

      C_L Leakage Class

      P Test static pressure (in. w.g.)

      Q Total leakage rate (cfm)

      A Duct surface area (ft^2)

   b. Leaking rates shall be in conformance with the Leakage Class shown in the table below:

DUCT CONSTRUCTION PRESSURE RATING	SMACNA LEAKAGE CLASS CL
+3" w.g. and greater -3´ w.g. and lower	4
From -2" w.g to +2" w.g	6
Welded ducts	No leakage

5. There shall be no audible leaks.

6. A duct system need not be completed before tests are conducted. Sections may be temporarily blanked off or suitably capped, etc., and such sections individually tested as specified. All equipment, portable blower, instruments, temporary connections, blank-offs, etc., necessary to conduct tests as specified shall be provided by the Contractor, and the costs of which shall be included in the Contractor's original bid for the work, without any additional costs to Owner.

7. Ductwork shall be pressure tested to a pressure equal to the specified duct construction pressure (i.e., a duct built to a 3" standard shall be tested to 3").

8. Air measuring stations used for temperature control purposes are not to be used to measure leakage.

9. Contractor shall be responsible for any corrective action required due to a failed duct leakage test. Ductwork shall be re-tested after corrective actions are taken until the leakage test is passed.

10. Duct leakage test report: Submit documentation of duct leakage testing and submit test result reports within two weeks of testing.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 23\23 3113-Metal and Flexible Duct.docx

SECTION 23 3300
DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Accessories addressed in this section include:

1. Manual volume dampers
2. Automatic balancing dampers
3. Turning vanes
4. Duct access doors
5. Flexible connectors
6. Instrument test holes

B. Products/materials specified under other Divisions but installed under this Section:

1. Smoke detectors for smoke dampers and combination fire and smoke dampers.

1.2 DEFINITIONS

Not Applicable

1.3 CODES AND STANDARDS (UTILIZE LATEST EDITION)

A. Air Movement and Control Associates International (AMCA)

1. AMCA 500: Test Methods for Louvers, Dampers and Shutters
2. AMCA 500-D: Laboratory Methods for Testing Dampers for Ratings.
3. AMCA 511: Certified Ratings Program for Air Control Devices

B. ASTM International

1. ASTM A 480: Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
2. ASTM A 653: Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
3. ASTM B 209: Specification for Aluminum and Aluminum-Alloy Sheet and Plate
4. ASTM B 221: Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
5. ASTM E 84: Test Method for Surface Burning Characteristics of Building Materials
6. ASTM E 477: Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers

C. National Fire Protection Association (NFPA)

1. NFPA 90A: Installation of Air Conditioning and Ventilating Systems

D. National Institute of Standards and Technology (NIST)

E. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)

1. SMACNA: HVAC Duct Construction Standards-Metal and Flexible

F. Underwriters Laboratories (UL®)

1. UL 555: Standard for Safety Fire Dampers
2. UL 555C: Standard for Safety Ceiling Dampers
3. UL 555S: Standard for Safety Smoke Dampers
4. UL 2043: Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces

1.4 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

B. Ductwork specialties shall be designed and manufactured to conform to the same pressure class as the duct in which they are located, unless otherwise indicated to exceed.

1.5 SUBMITTALS

A. Preconstruction – Prior to construction provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Product data: Submit product data for each of the products listed in Part 2 including:
   a. Drawings indicating quantities, dimensions, weights, clearances, configuration and materials used in fabrication.
   b. For automatic balancing dampers, include leakage, pressure drop, and maximum pressure data in accordance with AMCA 500 testing. Submit data for full range of damper sizes.
2. Manufacturer's installation and operating manuals.
3. Coordination drawings: Provide coordination reflected ceiling plans, drawn to scale showing penetrations, ceiling-mounting items, ceiling-mounting access panels and access doors required for access to duct accessories.

B. Contract closeout – At contract closeout provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Operating and maintenance data including:
   a. Product data
   b. Installation instructions
   c. Assembly drawings
   d. Replacement parts list
   e. Maintenance and operation instructions
2. Test reports
   a. Manual Volume Damper Acceptance Test
   b. Fire, Smoke, and Combination Fire/Smoke Damper Acceptance Test
   c. Airflow Measuring Station Manufacturer Installation Inspection
3. Warranties

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver products to site under provisions of Section 01 6000.

B. Deliver products to site in containers with manufacturer's and UL stamp affixed.

C. Protect products against dirt, water, chemical and mechanical damage before, during and after installation. Damage to products prior to final acceptance of the Work shall be repaired or replaced at no additional cost to the Owner.

1.7 SPARE PARTS

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

1. Fusible links: Furnish quantity equal to 10% of amount installed or a minimum of one.

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, except where otherwise indicated to exceed the requirements of the Standard.

B. Galvanized sheet steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation. For uninsulated ducts with surfaces exposed to view, provide paint grip steel; mill-phosphatized "Paintgrip" or "Zincgrip" finish suitable for field painting.

C. Stainless steel: ASTM A 480/A 480M.

D. Aluminum sheets: ASTM B 209 (ASTM B 209M), alloy 3003, temper H14; with mill finish for concealed ducts and 1-side bright finish for exposed ducts.

E. Extruded aluminum: ASTM B 221 (ASTM B 221M), alloy 6063, temper T6.

F. Reinforcement shapes and plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

G. Tie rods: Galvanized steel, ¼" minimum diameter for tie rod lengths of 36" or less; ⅜" minimum diameter for tie rod lengths longer than 36".

2.2 MANUAL VOLUME DAMPERS

A. Acceptable manufacturers

1. Air Balance, Inc.
2. Nailor Industries, Inc.
3. Ruskin Company
4. Vent Products Company, Inc.

B. Quality assurance

1. Include leakage, pressure drop, and maximum pressure data with submittals.
2. Damper pressure drop ratings shall be based on tests and procedures performed in accordance with AMCA500.

3. Field or shop fabricated manual volume dampers are not acceptable.

C. High performance manual volume damper

1. Factory fabricated, rectangular or round damper with required hardware and accessories. Single-blade or multiple-opposed-blade design, with linkage outside airstream, and suitable for horizontal or vertical applications

2. Performance data

a. Capacity: Demonstrate capacity of damper to withstand HVAC operating conditions

(1) Closed position: Maximum pressure of 10" w.g.

(2) Open position: Maximum air velocity of 4,000 fpm.

b. Pressure drop

(1) Rectangular damper: Maximum 0.05" w.g. at 1,500 fpm across a 24" x 24" damper.

(2) Maximum 0.05" w.g. at 1,500 fpm across a 24" diameter damper.

c. Leakage

(1) Rectangular damper: Maximum 2.0 cfm per ft^2 at 1.0" w.g.

(2) Round dampers: Maximum 6.0 cfm per ft^2 at 1.0" w.g.

3. Rectangular damper construction

a. Frame: Hat-shaped, galvanized sheet steel channels, minimum of 16 gauge (0.064" thick), with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.

b. Blades: Minimum 14 gauge (0.078" thick), galvanized steel. For ducts 6" in height and less, single blade damper are acceptable. For ducts over 6"in height, provide multiple blades of 6" maximum width.

c. Blade seals: Neoprene, mechanically attached to damper.

d. Axles: ½" diameter or hex full length plated steel rod

e. Basis of Design: Ruskin Company Model CD-60.

4. Round damper construction

a. Frame: Minimum 20 gauge (0.036" thick) galvanized steel with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.

b. Minimum 14 gauge (0.078" thick) galvanized steel, maximum 24" in diameter.

c. Blade seals: Closed cell polyethylene foam rubber or neoprene.

d. Axles: Minimum ⅜" square full length plated steel rod

e. Basis of Design: Ruskin Company Model CDRS25.

D. Jackshaft: 1" diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.

1. Length and number of mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.

E. Damper hardware

1. Hand-operated damper regulator

a. For all manual dampers provide a locking type hand quadrant operator with lever handle, position indicator and lock nut for all dampers.

b. Provide a minimum of a 2" hand-quadrant stand-off elevated platform where damper is located in insulated ducts.

2.3 TURNING VANES

A. Acceptable manufacturers

1. Aero/Dyne Industries
2. Ductmate Industries, Inc.
3. Carlisle Harcast, Inc.

B. Quality assurance

1. Comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible" for vanes and vane runners or provide Aero/Dyne HEP vanes. Vane runners shall automatically align vanes.
2. Vanes shall be factory fabricated on common base rail. Field fabricated vanes are not acceptable.

C. Construction

1. 2" or 4½" double-vane, curved blades of galvanized sheet steel set ¾" on center; support with bars perpendicular to blades set a maximum of 2" on center; and set into vane runners suitable for duct mounting.
2. Minimum 24 gauge vanes for ducts less than 30" wide.
3. Minimum 22 gauge vanes for ducts 30" wide and greater.

2.4 FLEXIBLE CONNECTORS

A. Acceptable manufacturers

1. Ductmate
2. Duro Dyne Corp.
3. Ventfabrics, Inc.

B. General description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

C. Metal-edged connectors: Factory fabricated with a fabric strip minimum 4" wide attached to two strips of 2¾" wide, 24 gauge (0.028" thick), galvanized sheet steel or 0.032" thick aluminum sheets. Select metal compatible with ducts.

D. Indoor system, flexible connector fabric: Glass fabric double coated with neoprene.

1. Minimum weight: 26 oz/yd^2.
2. Tensile strength: 475 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service temperature: -10°F to +200°F
4. Air pressure rating: ± 10" w.g.

2.5 DUCT ACCESS DOORS

A. Acceptable manufacturers

1. Insulated and uninsulated access doors
    a. FlexmasterUSA
    b. Kees
    c. Ward Industries
2. Uninsulated doors only
    a. Air Balance, Inc.
    b. Greenheck
    c. McGill AirFlow Corporation
    d. Nailor Industries, Inc.

B. Access door construction

1. General: Fabricate doors airtight and suitable for duct pressure class.
    a. Access doors for supply duct to be rated for a minimum of 4.5 in w.g. increase as required by duct pressure class.
2. Doors shall be rectangular, close-fitting doors of galvanized steel with sealing gaskets, edge protection and quick fastening locking devices suitable for duct pressure class. Access doors with sheet metal screw fasteners are not acceptable.
3. Access doors located in insulated ductwork shall be double wall with insulation fill. Provide a minimum thickness of 1½" insulation fill (R-6) or thicker insulation as necessary to match the insulation thickness on duct in which the access door is located.
4. Provide number of hinges and locks as follows:
    a. Up to 18" square: Two hinges and two sash locks.
    b. Up to 24" x 48": Three hinges and two compression latches with outside handles.
    c. Sizes 24" x 48" and larger: One additional hinge.
5. Provide viewing port for all access doors 24" x 48" and larger and where indicated.

2.6 INSTRUMENT TEST HOLES

A. Cut or drill temporary test holes in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist on metal caps.

B. Permanent test holes shall be factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

PART 3 - EXECUTION

3.1 APPLICATION AND INSTALLATION

A. General

1. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible" except where otherwise noted to exceed the requirements of this Standard.

2. Provide duct accessories of materials suited to duct materials; use galvanized steel accessories in galvanized-steel, paint grip steel accessories in paint grip steel ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
3. Install accessories in accordance with manufacturer's instructions.
4. Contractor shall obtain the latest fire and smoke separation documents prior to the initiation of each portion of the project, and provide fire, smoke and/or combination fire and smoke dampers at all such separations.

B. Manual volume dampers

1. Utilize standard volume dampers for:
   a. Supply airflow balancing downstream of terminal units,
   b. Return and exhaust airflow balancing applications further than 30 feet from the return or exhaust fan.
2. Utilize high performance volume dampers for:
   a. Supply airflow upstream of terminal units,
   b. Return and exhaust airflow balancing within 30 feet of the return or exhaust fan.
   c. Locations where tight shut-off is required
3. Provide manual volume dampers for balancing at all points on supply, return and exhaust systems where branch ducts are taken from larger ducts and at duct or flexible take-offs to supply and return diffusers or registers.
4. Install at a minimum of two duct widths from branch takeoff.
5. When installing volume dampers in ducts with liner; avoid damage to and erosion of duct liner.
6. When installing volume dampers in insulated duct, install regulator with elevated platform such that damper is accessible and adjustable without imparting damage to the insulation.
7. Close duct penetrations for damper components to seal duct consistent with pressure class.
8. Provide remote operated volume control dampers regulator(s) for inaccessible volume dampers.

C. Automatic balancing dampers

1. Install dampers in accordance with manufacturer's installation instructions.
2. Do not compress or stretch damper frame into duct or opening.
3. Handle damper using sleeve or frame. Do not lift damper using blades.
4. If dampers are installed in a continuous duct run, a duct access door should be provided for inspection and maintenance. If damper is installed such that it is adjacent to a removable grille, a duct access door is not required

D. Turning vanes

1. Utilize 2" radius double wall airfoil vanes in:
   a. Supply distribution ductwork located downstream of air terminal units that is less than or equal to 18" wide.
   b. Return exhaust distribution ductwork less than or equal to 18" wide.
   c. General exhaust distribution ductwork less than or equal to 18" wide.

2. Utilize 4½" double wall airfoil vanes in:
    a. Supply distribution ductwork located downstream of air terminal units and greater than 18" wide.
    b. All supply ductwork located upstream of air terminal units.
    c. Return distribution ductwork greater than 18" wide.
    d. General exhaust distribution ductwork greater than 18" wide.
3. Install turning vanes for all rectangular square throat elbows, except in transfer air ducts. Install in accordance with SMACNA standards and manufacturer's recommendations.
4. Install tuning vanes tangential to airflow.
5. Inspect turning vanes for proper and secure installation.

E. Flexible connectors
1. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators. Installed width shall be not less than 4".
2. For fans developing static pressures of 5" w.g. and higher, cover flexible connectors with leaded vinyl sheet held in place with metal straps.

F. Duct access doors
1. Review locations prior to fabrication.
2. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows and anywhere that provisions for maintenance or service of duct-mounted equipment is required
    a. Before and after filters.
    b. Before and after coils, including reheat coils. Where a reheat coil is provided integral with a terminal unit, provide an access door after terminal unit coil.
    c. Downstream from, motorized control dampers and turning vanes.
    d. Upstream or downstream of sound attenuators.
    e. Adjacent to fire, smoke, or combination fire and smoke dampers, providing sufficient access to reset or reinstall fusible links.
        (1) Access doors must be a minimum of 12" square. If duct size does not allow this size access door to be installed, a removable duct section much be provided.
        (2) Exterior of access doors for fire damper, smoke damper or combination fire/smoke damper access doors shall be labeled with letters not less than 0.5" in height reading "FIRE DAMPER", "SMOKE DAMPER," or "COMBINATION FIRE/SMOKE DAMPER". Labeling shall be permanently affixed.
    f. Before and after duct-mounted humidifiers. Access door downstream of humidifiers shall be on sides of duct.
    g. At airflow measuring stations.
    h. Any valve or actuator located within a duct or casing.
    i. At duct-mounted smoke detectors.

3. Provide duct access doors sufficient for required inspecting, adjusting and maintenance but not less than the dimension shown below (the duct dimension given is that in which the access door is to be located):
    a. For duct dimension up to 12": 8" x 8"
    b. For duct dimension 14 " to 21": 12" x 12"
    c. For duct dimension 22" to 48": 18" x 18"
    d. For ducts over 48": 2 doors at 18" x 18"
    e. For fire and smoke dampers: Minimum size 12" x 12", provide removable duct section for smaller ducts where required.
    f. For AFMS: 24" x 24"
4. After installation inspect locations of access doors and verify that purpose of access door can be performed.

G. Instrument test holes

1. Provide duct test holes where indicated and required for testing and balancing purposes.
2. Provide only factory fabricated instrument test holes in ductwork with a pressure rating greater than 2" or less than -2".
3. Install visible above insulation.

3.2 TESTING

A. Manual volume damper acceptance test

1. Operate manual control dampers to verify full range of movement is possible. Correct any situation in which dampers cannot travel their full range of movement.
2. Adjust final positioning of manual-volume dampers as specified in Section 23 0593, "Testing, Adjusting, and Balancing for HVAC."
3. Operate remote manual volume damper operators to verify full range of movement of operator and damper.
4. Provide test result report within two weeks of testing indicating completion of the Acceptance Test for each manual volume damper.

B. Airflow measuring station manufacturer installation inspection test: Provide report prepared by manufacturer's representative, stating that systems installed and services provided under this Section are in accordance with manufacturer's recommendations and are properly operating.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 23\23 3300-Ductwork Accessories.docx

SECTION 23 4100
PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Filters

1. Pleated panel filters
2. Rigid cell box filters
3. Non-supported bag filters

B. Filter frames and housings

1. Front and rear access filter frames
2. Side service housings

C. Accessories

1. Static pressure gauges and filter gauges

1.2 DEFINITIONS

A. Not Used

1.3 CODES AND STANDARDS (USE LATEST EDITIONS)

A. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

1. ASHRAE 52.1: Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter (ANSI)
2. ASHRAE 52.2: Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size (ANSI)
3. ASHRAE 62.1: Ventilation for Acceptable Indoor Air Quality

B. American Society of Mechanical Engineers (ASME)

1. ASME N510: Testing of Nuclear Air Treatment Systems

C. Code of Federal Regulations (CFR)

1. 40 CFR 59, Subpart D-2005: National Volatile Organic Compound Emission Standards for Architectural Coatings

D. Institute of Environmental Sciences and Technology (IEST)

1. IEST-RP-CC001.3: HEPA and ULPA Filters
2. IEST-RP-CC007.1: Testing ULPA Filters

E. Military Specification and Standards (MIL-STD)

1. MIL STD 282 Filter Units, Protective Clothing, Gas Mask Components and Related Products: Performance Test Methods

F. National Fire Protection Association (NFPA)

1. NFPA 90A-2002: Standard for the Installation of Air-Conditioning and Ventilating Systems
2. NFPA 90B-2006: Standard for the Installation of Warm Air Heating and Air-Conditioning Systems

G. Underwriters Laboratories Inc. (UL®)

1. UL 900: Standard for Air Filter Units

1.4 QUALITY ASSURANCE

A. ASHRAE compliance

1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
2. Comply with ASHRAE 62.1 for finish of interior surfaces in contact with airstream.
3. Comply with ASHRAE 52.1 for arrestance and ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.
4. Comply with NFPA 90A and NFPA 90B.

B. Filter media shall be ANSI/UL 900 listed.

C. All filters provided shall be the product of one manufacturer.

D. Assemble filter components to form filter banks from products of one manufacturer.

1.5 SUBMITTALS

A. Preconstruction – Prior to construction provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Product data: For each type of product indicated provide:
    a. Dimensions
    b. Operating characteristics
    c. Required clearances and access
    d. Rated airflow capacity, including initial and final pressure drop at rated airflow
    e. Efficiency and test method
    f. Furnished specialties and accessories.
    g. Product test report including all details as prescribed in ASHRAE Standards 52.2, including Appendix J.
    h. Drawings showing filter rack assemblies, dimensions, materials, methods of assembly, and templates for installing anchorages
    i. Wiring diagrams for power, signal, and control wiring
2. Manufacturer’s installation and operating manuals.

B. Contract closeout – At contract closeout provide the following in accordance with Specification 20 0500 – Basic Requirements for Mechanical, Plumbing, and Fire Suppression:

1. Operating and maintenance data including:
    a. Product data
    b. Installation instructions

c. Assembly drawings
d. Replacement parts list
e. Maintenance and operation instructions

2. Test reports
a. Manufacturer installation inspection report

3. Warranties

1.6 DELIVERY, STORAGE AND HANDLING

A. Filters shall be delivered in closed boxes or cartons to protect from physical damage or contamination. Filters shall not be removed from shipping cartons until ready for final assembly and installation.

B. Store and protect filters to avoid damage, contamination and water damage.

1.7 EXTRA MATERIALS

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

1. Provide one complete set of filters for each filter bank.

PART 2 - PRODUCTS

2.1 PLEATED PANEL FILTERS

A. Acceptable manufacturers

1. AAF International
2. Airguard
3. Camfil Farr
4. Filtration Group
5. Flanders-Precisionaire
6. Puralator

B. Description

1. Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters.
2. Media: Cotton and synthetic fibers coated with nonflammable adhesive.
a. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b. Separators shall be bonded to the media to maintain pleat configuration.
c. Welded wire grid shall be on downstream side to maintain pleat.
d. Media shall be bonded to frame to prevent air bypass.
e. Support members on upstream and downstream sides to maintain pleat spacing.
3. Filter-media frame: Cardboard frame with perforated metal retainer sealed or bonded to the media.
4. Manufacturer shall guarantee the integrity of the filter pack to 2.0” w.g.

5. Capacities and characteristics
    a. Thickness or depth: 2”
    b. Maximum rated face velocity: 625 fpm
    c. Initial resistance: 0.30” w.g., or less, at 500 fpm
    d. Recommended final resistance: 1.0” w.g.
    e. Efficiency
        (1) MERV-8 when tested according to ASHRAE 52.2.
        (2) MERV-A of 8 when tested per Appendix J of ASHRAE 52.2.
        (3) Dust spot efficiency of 30-35% when tested according to ASHRAE 52.1.
        (4) The media shall maintain or increase in efficiency over the life of the filter.

C. Basis of Design: Model Farr 30/30 as manufactured by Camfil Farr.

2.2 NON-SUPPORTED BAG FILTERS

A. Acceptable manufacturers
    1. AAF International
    2. Airguard
    3. Camfil Farr
    4. Filtration Group
    5. Flanders-Precisionaire
    6. Purolator

B. Description
    1. Factory-fabricated, disposable, extended non-supported filters with header frames.
    2. Media: Glass fiber or synthetic material constructed so individual pockets are maintained in tapered form under rated airflow conditions by flexible internal supports.
    3. Filter-media frames: Galvanized steel.
    4. Manufacturer shall guarantee the integrity of the filter pack to 5” w.g.
    5. Capacities and characteristics
        a. Thickness or depth: 21”
        b. Maximum rated face velocity: 625 fpm
        c. Initial resistance: 0.40” w.g., or less, at 500 fpm
        d. Recommended final resistance: 1.0” w.g.
        e. Efficiency
            (1) MERV-13 when tested according to ASHRAE 52.2.
            (2) Dust spot efficiency of 90-95% when tested according to ASHRAE 52.1.
            (3) The media shall maintain or increase in efficiency over the life of the filter.
    6. Basis of Design: Model Hi-Flo ES as manufactured by Camfil Farr.

2.3 FILTER FRAMES

A. Acceptable manufacturers

1. AAF International
2. Airguard
3. Camfil Farr
4. Filtration Group
5. Flanders-Precisionaire
6. Purolator

B. Framing system: Galvanized steel framing members with access for either upstream (front) or downstream (rear) filter servicing. Frames shall be pre-punched for assembly into modules. Frames shall be welded to assure a rigid assembly. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.

C. Sealing: Factory-installed, positive-sealing device for each row of filters, to ensure seal between gasketed filter elements and to prevent bypass of unfiltered air. Frames shall include gasketing between the frame and filter.

D. Standard sizes: Provide for interchangeability of filter media of other manufacturers; for panel filters, size for filter media, minimum 2" thick. For extended surface and high efficiency particulate air filters, provide for upstream mounting of panel filters.

E. Filter latches: The holding frame manufacturer shall provide zinc plated latches compatible with frame and filter media.

F. Basis of Design: Universal Holding Frame as manufactured by Camfil Farr.

2.4 STATIC PRESSURE GAUGES AND FILTER GAUGES

A. Acceptable manufacturers

1. Airguard
2. Dwyer

B. 4" diameter diaphragm-type gage with dial and pointer in metal case, vent valves, black figures on white background, front recalibration adjustment, 2% of full scale accuracy.

C. Accessories: Vent valves, surface mounting bracket, static pressure taps with integral compression fittings, ¼" aluminum tubing, and plastic vent valves.

D. Scale range

1. Filter media having a recommended final resistance of
   a. Less than 1.0" w.g.: 0 to 1.0" w.g.; or
   b. 1.0 – 2.0" w.g.: 0 to 2.0" w.g.

E. Basis of Design: Series 2000 Magnehelic manufactured by Dwyer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air cleaning devices in accordance with manufacturer's instructions.

B. Do not downsize filter banks. Provide the size and number of filters as shown on drawings. Operating face velocities and pressure drops shall not exceed those scheduled on drawings.

C. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

D. Install filters in position to prevent passage of unfiltered air.

E. Prevent passage of unfiltered air around filters with rubber or neoprene gaskets.

F. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction.

G. Install filter gage for each filter bank. Install filter gauge static pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum, in accessible position. Adjust and level.

H. Coordinate filter installations with duct and air handling unit installations.

3.2 TESTING

A. Manufacturer installation inspection report: Provide report prepared by manufacturer's representative, stating that systems installed and services provided under this Section are in accordance with manufacturer's recommendations and are properly operating.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 23\23 4100-Particulate Air Filtration.docx

SECTION 23 7300
CUSTOM INDOOR AIR HANDLING UNITS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This specification pertains to the supply air handling unit and separate return fan scheduled with fan array (also referred to as fan matrix) technology fan systems.

B. Custom indoor Air Handling Unit (AHU) shall be factory assembled to meet the performance criteria as identified on the plans and within this specification. Unit shall be shipped in multiple sections to construction site. Refer to drawings for mechanical room maximum wall opening dimensions. Contractor and manufacturer representative shall determine the best method of delivery and coordinate delivery of the air handling unit with Owner. AHU shall be field assembled, and pressure tested in the mechanical room by the installing mechanical contractor. Submit testing results to Owner and Engineer.

C. Casing Construction

D. Floor Construction

E. Access Doors and Plenums

F. Mixed Air Section

G. Fan Section

H. Air Blender

I. Motors and Drives

J. Coil Sections

K. Condensate Drain Pans

L. Filter Sections

M. Humidifier Section

N. Return Fan Section

O. Electrical Components

P. Factory Testing

Q. Factory Provided Field Services

1.2 REFERENCES

A. AMCA 99 - Standards Handbook.

B. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.

C. AMCA 300 - Test Code for Sound Rating Air Moving Devices.

D. AMCA 301 - Method of Calculating Fan Sound Ratings from Laboratory Test Data.

E. AMCA 500 Test Methods for Louver, Dampers, and Shutters.

F. AMCA 611-06 Certified Ratings Program - Product Rating for Airflow Measurement Performance

G. ANSI/AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.

H. ANSI/AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

I. ANSI/UL 586 - Test Performance of High Efficiency Particulate Air Filter Units.

J. ANSI/UL 900 - Test Performance of Air Filter Units.

K. ARI 410 - Forced Circulation Air Cooling and Air Heating Coils.

L. ARI 430 - Standard for Central Station Air Handling Units.

M. ARI 435 - Standard for Application of Central Station Air Handling Units.

N. ASHRAE 52 - Method of Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter.

O. ASHRAE 62.1-2004 - Ventilation for Acceptable Indoor Air Quality.

P. ASHRAE 90.1-2004 - Energy Standard for Building except Low-Rise Residential Buildings.

Q. ASTM A 36/A 36M-97a - Specification for Carbon Structural Steel

R. ASTM A 366/A 366M-97 - Specification for Steel, Sheet, Carbon, Cold-Rolled, Commercial Quality

S. ASTM A 480/A 480M-98a - Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip

T. ASTM A 653/A 653M-99a - Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanealed) by the Hot-Dip Process

U. ASTM B 209-96 - Specification for Aluminum and Aluminum-Alloy Sheet and Plate

V. ISO 9000, 9001, 9002 - International Organization for Standardization Certified Manufacturing Facility

W. NFPA 70 - National Electrical Code

X. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.

Y. SMACNA - HVAC Duct Construction Standard, Metal and Flexible.

Z. UL - Underwriters Laboratory

AA. ETL listed - Intertek Testing Laboratories (an alternative to the CSA and UL marks)

BB. CSA - Canadian Testing Association (According to OSHA regulations, the CSA-US mark qualifies as an alternative to the UL mark).

1.3 SUBMITTALS

A. Refer to General Conditions and Division 01.

B. Submit the following data:

1. Drawings indicating unit dimensions, shipping splits, unit shipping and operating weight, weight loading, required clearances, construction details and field connections.

2. Product data indicating individual components; dimensions, shipping and operating weights, capacities, ratings, performance, electrical characteristics, gauges and finishes.

3. Provide computer generated fan curves with specified operating point clearly plotted. The fan curve provided must be for all fans and motors operating in an array. Standalone individual cell performance shall not be acceptable.

4. Provide sound power levels for fan outlet, unit outlet, and unit casing radiated for the design capacity.

5. Product data for filter media, filter performance data, filter assembly and filter frames.
6. Coil performance ratings at system design operating conditions.
7. Fan, motor and drive component characteristics.
8. Electrical requirements for all power supply wiring including wiring diagrams for interlock, access lights, service outlets and control wiring. Clearly indicate factory installed wiring and field installed wiring.
9. Provide a copy of field testing procedures for tests required within this specification.
10. Provide unit manufacturer's installation instructions including any unit support requirements.
11. Operation and maintenance instructions.
12. Instructions for lubrication, filter replacement, motor and drive replacement, spare part list and wiring diagrams.

C. At contract closeout provide the following in accordance with specification 20 0500 – Basic Requirements for Mechanical, Plumbing and Fire Suppression:
1. Source quality control test reports
2. Operating and Maintenance Data including:
   a. Product Data
   b. Installation Instructions
   c. Assembly Drawings
   d. Replacement parts list
   e. Maintenance and operation instructions
3. Test Reports
   a. Manufacturer installation inspection report
   b. Factory test report
   c. Field test report
4. Warranties

1.4 QUALITY ASSURANCE

A. Refer to General Conditions and Division 01.

B. Comply with product data under provisions of Division 01.

C. Fan Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal.

D. Fan Sound Ratings: AMCA 301; tested to AMCA 300 and bear the AMCA Certified Sound Rating Seal.

E. Fabrication: Conform to AMCA 99 and ARI 430.

F. Filter Media: ANSI/UL900 listed, Class I or Class II, approved by local authorities.

G. Air Coils: Certify capacities, pressure drops and selection procedures in accordance with ARI 410.

H. Air handling unit assembly shall have UL 1995 certification for safety, including use with electric heat.

I. Products requiring electric components shall be listed and classified by UL, ETL and CSA as suitable for the purpose specified and indicated.

1.5 DELIVERY, STORAGE AND HANDLING

A. Refer to General Conditions and Division 01.

B. Deliver products to site under provisions of Division 01.

C. Store and protect products under provisions of Division 01.

D. The unit shall be cleaned and inspected before crating.

E. All equipment shall be delivered to the job site suitably packaged and protected for overland trucking and for storing the equipment outside exposed to the weather.

F. Match-mark factory disassembled parts to facilitate erection in the field. Suitable brace units and pack for shipment to prevent distortion and damage while in transit. Protect from damage by weather or road conditions during shipment and storage.

G. Provide temporary closure on all openings of all sections of the units. Duct connection openings shall be covered with plywood or sheet metal caps. Coil fins shall be protected from damage during shipping and installation. Coil piping connections shall be protected with plastic caps.

H. Shrink-wrap unit for shipment with minimum 10 mil plastic.

I. Comply with applicable regulations and laws for crating and shipment.

J. Where multiple units are required, a schedule of priority will be furnished which shall determine the manufacturing and delivery sequence.

K. All items shipped loose such as filters, steam humidifier assemblies, caulking, etc. shall be itemized on the shipping ticket and be suitable secured in the unit or on a separate pallet. Clearly mark crates, boxes, and cartons in order to immediately identify the equipment. Show unit number, contents, and contract number.

L. Fan assemblies stored more than two months shall have their fan wheels rotated and shafts shall be treated to protect them from degradation due to humidity, dust, or debris. The packaging shall be maintained at all times while in transit, in storage, or on site. Failure to comply with this requirement will allow the Owner the right to reject damaged or exposed components and demand new replacements if necessary.

M. A factory representative shall be on site to supervise all assemblies of components, modules and parts of the Air Handling Units. No components or modules or parts will be assembled without factory supervision.

1.6 START-UP REQUIREMENTS

A. Do not operate unit(s) until air handling unit is clean, filters are in place, bearings lubricated, condensate properly trapped, piping connections verified and leak tested, belts aligned and tensioned, all shipping braces have been removed, and fans have been run under observation.

1.7 ENVIRONMENTAL REQUIREMENTS

A. Do not operate air handling unit(s) for any purpose, temporary or permanent, until the ductwork has been pressure tested, cleaned, filters in place, fan bearings lubricated and fans tested and run under observation.

1.8 OPERATION AND MAINTENANCE DATA

A. Refer to General Conditions and Division 01.

B. Submit operation and maintenance data under provisions of Division 01.

C. Include instructions for lubrication, motor and drive replacement, spare parts list and wiring diagrams.

1.9 EXTRA STOCK

A. One extra set of pre-filters, secondary filters and final filters to be provided to Owner.

B. One additional set of access door gasket for each size door to be provided to Owner.

1.10 WARRANTY

A. The complete unit shall be covered by a parts warranty issued by the manufacturer covering the first year of operation. This warranty period shall start on the date of startup or eighteen months after the date of shipment (whichever is the shortest). This includes all third party devices provided by the factory as part of the air handling unit.

B. The contractors warranty shall cover parts and labor from the date of final completion of the project.

1.11 FACTORY TESTING

A. The assembled units will be visually inspected for completeness, deficiencies in workmanship, and conformance with specifications.

B. Factory testing to be witnessed by the Owner and Engineer shall include the following tests.

1. Leak testing of air handling unit casing.
    a. All air handling units shall be air leak tested at plus 6 in. wg (doors swing in) and minus 6 in. wg (doors swing out).
        (1) Tests shall be conducted in compliance with SMACNA's HVAC Air Duct Leakage Test Manual, latest edition.
        (2) The leakage rate of the entire unit shall not exceed 0.5% design flow or 5 cfm per 100 ft^2 surface area at ±6-in. wg, whichever is greater.
        (3) Surface caulking shall not be used to correct any leakage problems.
2. Air performance testing.
    a. Air handling units shall be tested to verify the AHU airflow is within the range of 100%-110% of the schedule system CFM at the scheduled external system resistance.
        (1) The test shall include an airflow measuring point downstream or upstream of the AHU, and static pressure ports across the entire AHU.
        (2) Resistance external to the AHU shall be simulated by dampers in the ductwork.
        (3) Corrective action shall be by the AHU manufacturer to meet the design system airflow and resistance.
3. Sound testing.
    a. System sound levels shall be measured in all nine (9) octave bands (31.25 Hz through 8000 Hz) at system design operating conditions. Airborne sound levels at all openings shall be read in the test ductwork 5'-0" from the openings. Transmitted sound levels shall be read 5'-0" from the outside of the fan section.
    b. Sound tests shall be conducted while the unit is running at design conditions. An octave band sound pressure level reading shall be taken at outside louver, exhaust louver, supply

discharge opening, return air opening, economizer opening and adjacent to each fan section outside of the unit casing.

c. The test results shall verify that inlet and outlet sound power levels are within the tolerance limits of AMCA 311 (Certified Sound Ratings Program) of the specified levels.

4. Vibration testing.

a. Factory test fan assemblies for vibration.

(1) Testing shall be performed using an FFT analyzer with a minimum dynamic range of 72 dB, and capable of applying a Hanning window, linear non-overlap averaging, and anti-aliasing filters. Instrument accuracy shall be ±1 dB for displacement and velocity measurements and ±5 dB for acceleration measurements.

(2) Vibration testing shall be performed at the following locations:

(a) Each fan bearing vertical and horizontal.

(b) Fan shaft axial.

(c) Fan motor inboard and outboard vertical and horizontal.

(d) Fan motor axial.

(3) Testing shall be performed with fan operating throughout its operating range. Testing shall be performed from 30 HZ to 60 HZ fan speed at 10 HZ increments.

(4) The overall vibration limits in any direction of fan or motor bearings during normal operation at temperatures and load shall not exceed 0.15 in/sec pk in each of the measured bands.

(5) No resonant mode shall exist within the operating frequency range of the motor and fan.

C. All deficiencies noted during the factory inspection and testing must be corrected by the manufacturer prior to shipping the unit. At the discretion of the Owner or Engineer any major deficiencies may require a second factory inspection to confirm that satisfactory corrections have been performed.

1.12 FIELD TESTING

A. The air handling unit manufacturer and contractor shall provide with all test results a comprehensive list of all instruments used for measurements and a copy of their latest calibration certificates.

B. The air handling unit manufacturer shall factory run-test each fan/motor set to insure design integrity and proper fan rpm.

C. Factory and field leak test all coils: fill water coils with water and test coils and connections for leaks.

D. All factory installed piping shall be hydrostatically leak-tested. Steam and hydronic systems shall be tested for minimum of four hours at 1½ times design pressure or 100 psig minimum, whichever is greater, unless otherwise specified.

E. After the AHU has been field assembled and the manufacturer's representative has been onsite to verify and approve the assembly/construction, the unit shall be positive and negative pressure leak tested. Air handling unit shall be air leak tested by the contractor under the manufacturer's representatives supervision in the field at plus 8 in. wg (doors swing in) and minus 8 in. wg (doors swing out).

1. Tests shall be conducted in compliance with SMACNA's HVAC Air Duct Leakage Test Manual, latest edition.

2. The leakage rate of the entire unit shall not exceed 0.5% of design flow or 5 cfm per 100 ft2 surface area at 8-in. wg, whichever is greater.

3. Surface caulking shall not be used to correct any leakage problems.

F. After the AHU has been field assembled and the manufacturer's representative has been onsite to verify and approve the assembly/construction, the Air handling unit shall be tested to verify that the AHU airflow is within the range of 100% to 110% of the scheduled system CFM at the scheduled external system resistance.

1. The test shall include an airflow measuring downstream or upstream of the AHU, and static pressure ports across the entire AHU.

2. Resistance external to the AHU shall be simulated by dampers in ductwork or other means to build up design operating pressure for the fan system.

3. Corrective action shall be by the AHU manufacturer to meet the design system airflow and resistance.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Ventrol (Basis of Design)

B. Air Flow Equipment, Inc.

C. Ingenia

2.2 GENERAL

A. All proposed units shall meet the following parameters with respect to the basis of design. If any of the following parameters are not met by the proposed unit the unit will be rejected. If the proposed unit manufacturer cannot provide a unit within these parameters an alternate unit manufacturer shall be selected.

1. All proposed units shall be no greater than 3" longer and 3" wider than the basis of design. All proposed units shall have a height above finished floor (including required equipment pad height for cooling coil trapping) equal to or less than the basis of design.

2. All proposed units shall have supply fan inlet and outlet sound power performance less than or equal to the basis of design in all octave bands.

3. All proposed units shall have a rated fan power (HP) less than or equal to the basis of design.

B. The unit shall be custom field assembled indoor air handling unit and consists of the components as specified on the drawings or within this specification.

C. The air handling unit shall be double wall construction; walls, floor and roof panels shall have a minimum thickness of 2 inches and match the overall thermal conductivity as specified.

D. This custom air handling unit shall be factory and field tested. Unit shall be transported to job-site ready for assembly. It shall be the installing contractor's responsibility to reconnect the adjoining modules, re-connect any wiring and ensure the unit is leak tight.

E. These units are variable volume systems. These units shall be of a draw-through configuration. The units shall consist of the following components and/or sections: filter section, pre-heat coil section,

steam humidifier section, cooling coil section, supply fan section, and all required access sections. The unit configuration is as indicated on the drawings and schedules.

F. When sections are supplied as separate components either assembled or shipped separately, each section shall have mating flanges for bolted assembly. The flange shall extend around the complete perimeter of each section. The manufacturer shall supply bolts, and sufficient closed cell gasket for full perimeter coverage. If unit is supplied with corner-only connection points, the equipment manufacturer shall install mating flanges for each of the sections to match this specification.

G. The air handling unit manufacturer shall provide the airflow resistance of the unit from the inlet to the outlet in terms of static pressure difference at design airflow and standard air density (0.075 lbs/ft^3).

H. The air handling unit housing shall be constructed of galvanized steel.

I. Return fan-array unit shall be of the same quality and type as the supply fan array. Return fan cubes shall be filed installed. Air handling unit manufacturer shall provide fan cubes, air flow monitoring and variable frequency drives.

J. The air handling unit manufacturer shall furnish one set of pre-filters, and final filters.

K. Fans and components weighing more than 150 pounds shall have a lifting rail permanently installed.

L. A manufacturer's representative shall be on site during the entire assembly process to ensure the unit is assembled properly and will meet the performance requirements.

2.3 UNIT CASING CONSTRUCTION (WALLS AND ROOF)

A. Casing shall be double wall construction with insulation completely encapsulated. The walls and roof panel thickness shall be a minimum of 2". The cabinet shall consist of dual formed panels; an external galvanized shell and an internal galvanized steel liner. The panel and casing joints and connections inside and outside shall be smooth and finished. *Perforated liners* are not acceptable. All casing panels shall be removable for easy access without affecting the structural integrity of the air handling unit. Manufacturer shall guarantee that there will be no exterior condensation when the inside air is 55F saturated and the ambient air is 60F dew point.

B. The air handling unit shall be suitable for operating at a standard differential pressure up to +/- 8" w.g. static pressure or the shutoff pressure of the fan (no flow), whichever is greater.

C. The exterior cabinet walls and roof shall be a minimum 18 Gauge Galvanized Steel.

D. The interior cabinet walls and roof shall be a minimum of 20 Gauge Galvanized Steel; the humidifier section, cooling coil section and downstream plenum shall be a minimum of 20 Gauge Stainless Steel.

E. Bolts and screws shall be stainless steel (chromium coated/plated not allowed). Panels shall be bolted together. No fan supports, structural members, panels or flooring shall be welded unless aluminum, stainless steel or other corrosion-resistant material is used. Painted welds on steel or galvanized steel are not acceptable. Panels shall have gasketing material between sections. A minimum of silicone caulk shall be used and only after start-up and leaks are identified.

F. Panels to be injected with a minimum 2" thick, 2.5 lb/ft^3 polyisocyanurate foam, UL rated, non-combustible, semi-rigid insulation with a minimum R-value of 12 sf-F/Btu.

1. Assembly shall meet the requirements of NFPA 90A, NFPA 90B and ASTM E 84 for Flame Spread of 25 or less and Smoke Development of 50 or less.

2. Insulation shall have a thermal conductivity K factor, k=0.23 Btu/hr/sq ft/degree F at a mean temperature of 75°F.

3. Insulation shall provide the following sound attenuation characteristics (per ASTM C 423 - Type "A" Mounting):

Octave bands	125	250	500	1k	2k	4k	8k
Absorption Coefficient	.17	.80	1.16	1.15	1.11	1.10	1.05

4. All cut edges of the board insulation shall be completely enclosed by the unit panels.

G. Unit panel shall have a minimum R-value of 12 sf-F/Btu.

H. Roof and wall panel joints and panel reinforcement members shall not deflect more than 1:240 or ¼-in., whichever is smaller. Panels shall not deflect more than 3/8-in. between joints and reinforcement.

I. Casing construction shall be constructed as to minimize thermal losses and prevent condensation on the exterior of the unit. Manufacturer shall guarantee that there will be no exterior condensation when the inside air is 55F saturated and the ambient air is 60F dew point.

2.4 FLOOR CONSTRUCTION (INCLUDING BASE RAIL)

A. Base rail shall be 5-in. minimum, 8.2-lb/ft minimum aluminum structural channel or tube fully seam welded with a 2-in. perimeter lip. Manufacturer shall size and factory install base rail. The air handling unit manufacturer shall provide adequate intermediate structural members to transfer component loads to base rail.

B. Manufacturer shall size perimeter base rail and intermediate structural supports as to ensure sufficient height for field installed condensate P-traps.

C. Floor structural members and the floor panels between structural members shall not deflect more than 1:360.

D. Floor shall be 5 gauge minimum aluminum diamond tread plate fully welded.

E. Sub-floor shall be 12-gauge galvanized steel.

F. Base shall be provided with removable minimum 10-gauge lifting lugs minimum (4) per section, properly located to assure uniform loading. Maximum spacing between lifting lugs shall be 8 feet.

G. The underside of the floor panels shall be insulated with 2" thick minimum polyurethane foam insulation (under the base skin and covered with 18-gauge galvanized steel**.** Manufacturer shall guarantee that there will be no exterior condensation when the inside air is 55°F saturated and the ambient air is 60°F dew point.

H. Drain pans shall be 304 Stainless Steel, double wall construction with solid welded seams for complete water capture and containment. Pans shall be insulated between the liner and the main pan. Pans shall be IAQ type, double sloping to a single drain. Drain connection shall be a minimum 1¼" diameter MIPS thread extending out through the channel base the same side as the coil connections unless otherwise indicated on the drawings. Pans under coils, including intermediate drain pans shall extend a minimum of one-half the vertical dimension of the water producing device beyond the leaving air edge. Pans shall be provided for cooling coils, humidifiers, outside air intakes

and under other components as required. Drain pan shall meet the requirements of ASHRAE 62.1-2004. Intermediate drain pans shall be insulated.

I. Provide 2-in. floor drains in cooling coil and heating coil sections and pipe externally to the peripheral channel base on the same side as the doors.

J. Provide 2-in. upturned lip, fully welded around perimeter of entire base to facilitate cleaning of unit. Provide a floor drain for each section that doesn't have a drain pan.

K. The air handling unit base shall be flood tested to ensure no leaks in the base or at the perimeter exist.

2.5 ACCESS DOORS AND PLENUMS

A. Plenums and access doors shall be double wall construction and shall be consistent with the double wall construction as specified in paragraphs 2.3 and 2.4 of this specification. Door panels shall match requirements given for insulation of walls and roof panels.

B. Doors shall be provided with a minimum of (2) dual acting stainless steel latches through 48" high, (3) latches through 72" high. Latches shall be operable from both the interior and exterior of the unit. Fan section door latches shall be provided with a mechanism to facilitate locking of the doors. Door hinge shall be heavy duty stainless steel. Door shall be sealed with continuous closed cell foam gasket.

C. Doors to be provided with a continuous double high performance closed cell replaceable neoprene bulb type gasket seal around the entire perimeter of the door/frame. One system will be placed on the door and one system will be placed on the frame.

D. Doors located downstream of the cooling coil shall have a thermal break frame.

E. Each access door or section shall have a static pressure port.

F. Doors shall open against pressure for safety. Standard door size shall be a minimum 20" wide by 60" high unless restricted by height or section width. Recommended minimum length of access section is 24".

G. Doors shall be provided with hermetically sealed dual pane thermal glass viewing wire-mesh reinforced windows. Minimum window size to be 9" x 9" with 12" x 12" frame provided. Viewing windows to be provided on all access doors. Centerline height of window above finished floor shall be 5'-6" (assume concrete curb height is adequate for the cooling coil and condensate drain).

H. All doors shall have a port for the insertion of temperature and pressure measuring devices for troubleshooting and commissioning.

I. All doors with access to moving parts shall have provision for padlocking and meet UL 1995 mechanical protection guidelines. The Safety "lockout" provision allows the owner the opportunity to provide padlocks to lock doors in the closed position.

J. Access doors shall be provided upstream and downstream of the following equipment for means of providing routine inspection, maintenance, or calibration to equipment: fan, coils, humidifier, filters, and dampers.

K. Discharge air plenum shall have a top or front discharge opening per drawings. Plenum shall be double wall construction and shall match the unit casing in materials and details.

2.6 DRAIN PANS

A. Provide cooling coil, humidifier and heating coil drain pans.

B. Drain pans recessed into the base shall be type 304 stainless steel, 12 gauge.

C. Drains from each pan shall be 304 stainless steel, 2-in. minimum.

D. Floor drain pan shall be completely under the coil, 2-in. minimum upstream, and 12-in. minimum downstream. Drain shall be in the middle of the downstream section sloped from the far side of the drain, and from each side to the center. Underside of the drain pan shall have insulation attached to the pan and a vapor barrier (pan may be double wall with insulation).

E. Drain pan seams shall be continuously welded watertight and dye penetrant checked.

F. Provide intermediate drain pan for split cooling coil a minimum of 4" from the face of the cooling coil. Provide 2" downspout to floor drain pan and terminate with 2-in. gap. Intermediate drain pan shall be supported independently of the coils.

G. If coils are staggered, manufacturers shall provide drain pans that fully extend beneath all piping extensions, U-bends and headers.

2.7 MIXED AIR SECTION/INTAKE PLENUM

A. This section shall match unit and floor construction as specified in paragraphs 2.3 and 2.4.

B. Mixing box section shall be arranged to eliminate freeze stat trips, minimize sensor error and enhance outdoor air distribution due to stratification. AHU manufacturer shall provide air blending devices. See 2.8 Air Blender Section for details.

C. Mixing box section equipped with air blenders shall have a minimum section length of 3'-6" or as required by air blending devices manufacturer.

D. Control dampers:

1. Control dampers shall not be required to be supplied with the unit. Mechanical contractor shall provide control dampers for field installation. Temperature controls contractor shall provide control damper actuators for field installation.

2. Dampers shall be low leakage type Tamco 1500 series with silicone seals extruded aluminum 0.08" min thickness. Blades shall be 4" parallel type. Axles shall be plated steel. Leakage based on 24"x24" damper shall not exceed 7.6 cfm and 27.2 cfm for 48"x48" damper.

3. Bearing materials shall meet or exceed tensile strength of 8,800 psi and flexural strength of 12,000 psi.

4. Damper leakage not to exceed 3.0 cfm/sf at 1" W.G. pressure differential when a maximum of 3 in-lb/sf of holding torque is applied to the operating axle.

5. Arrange maximum outside air blades alongside air direction such that blades direct air toward return air opening.

2.8 FAN SECTION

A. The fan section shall be consistent with the double wall construction and shall utilize the fan-array (fan-matrix) system of multiple plenum-type fans with direct drive motors.

B. Fans shall be factory mounted on a structural steel platform. The fan array shall be provided with vibration isolation per stacked fan section or as an entire fan assembly to prevent the transmission of sound and/or vibration to the floor of the unit and to the floor of the mechanical room.

C. Motors shall be permanently lubricated EC type.

D. The Fan-Array (fan-matrix) System shall consist of multiple, direct driven, arrangement 4 plenum fans constructed per AMCA requirements for the duty specified. The Fan Array shall be selected to operate at a system total static pressure that does not exceed 90% of the specified fan's peak static pressure producing capability at the specified fan/motor speed. All motors shall be standard pedestal mounted type, TEFC, T-frame motors. All motors shall include isolated bearings or shaft grounding to prevent bearing damage associated with stray electrical current. Each fan and motor assembly shall be statically and dynamically balanced to meet AMCA standard 204-96, category BV-5, to meet or exceed Grade 1.0 residual unbalance.

E. Each fan/motor assembly shall be dynamically balanced to meet AMCA standard 204-96, category BV-5, with a maximum of .55 mil peak (0.022 in/sec peak, filter in) deflection at the design operating speed for the fan/motor assembly. Final balancing of the fan and motor combination shall be performed while the fan/motor is secured to the actual fan cell mounting rail. Certified copies of all dynamic balancing results for all fans shall be provided with the unit Operation and Maintenance manuals prior to unit shipment.

F. Wheel and Inlet: Airfoil wheel shall be of Class III aluminum construction with smooth curved inlet flange, heavy back plate die formed hollow airfoil shaped blades continuously welded at tip flange and back plate.

G. The fan array shall consist of multiple fan and motor cubes, spaced in the airway tunnel cross section to provide a uniform air flow and velocity profile across the entire air way tunnel cross section and components contained therein. Each fan shall be individually wired to a VFD, as specified elsewhere. If at least (1) VFD per fan is provided, a bypass will not be required. A single VFD serving the entire array will not be accepted. Wire sizing shall be determined and installed in accordance with applicable NEC standards.

H. The basis of design shall have individual fans which are staged on and off by manufacturer supplied controller. A PLC controller shall be provided with internal logic to sequence fans/motors on and off dynamically in response to airflow needs.

I. Each fan shall be equipped with an airflow monitoring device. The airflow of each fan shall be transmitted to the PLC for use with the fan sequencing system. The fan manufacturer shall field install all required tubing from each fan to the unit mounted overload/control panel.

J. All variable frequency drives shall be factory wired in a UL-508A electrical panel and shall be listed as such. Wire sizing shall be determined in accordance with NEC standards. The supply fan array shall each have its own individual unit mounted and wired control panels. The control panels shall incorporate individual thermal overloads/disconnects for each motor. Each overload will have an auxiliary contact wired in series. The dry contact will be used as an alarm for the building automation system indicating that there has been a fan motor failure. In addition, the unit control panel shall be provided with individual door mounted pilot lights showing the status (ON/OFF) of each motor. If the motors are enabled and functioning properly, the lights shall be "ON." It is the intent to have the control panels mounted on the same sections as their respective fan arrays. It is mandatory that the unit manufacturer factory mount and wire all control panels to the units in the factory. If the panels must be removed to facilitate rigging or shipment, the installing Contractor is responsible for reconnecting any wiring.

K. Each fan & motor assembly shall be removable through a 24" wide, free area, access door located on the discharge side of the fan array without removing the fan wheel from the motor.

L. Provide each fan section with a motor removal rail.

M. Motor and Drive:

1. Refer to Specification 20 0513 – Motor Requirements for HVAC and Plumbing Equipment.

2. Variable frequency drives to be provided by others. The Unit manufacturer shall wire each group of motors of the fan array system for the number of VFDs indicated in the equipment schedule to a NEMA 1 enclosure. The NEMA 1 enclosure shall be fitted with indicating lights for motor fault status and the required number of knockouts for field wiring of the VFDs. Refer to Section 20 2923.

3. The air handling unit shall be capable of meeting the design air volume flow rate (cfm) at the design static pressure rating without over-speeding the motors.

N. Each fan array shall be provided with acoustical coplanar silencers that reduce the bare fan discharge sound power levels by a minimum of 15 dB re 10^-12 watts throughout the eight octave bands with center frequencies of 125, 250, 500, 1000, 2000, 4000, and 8000 Hz when compared to the same unit without the silencers. The silencer system shall have the equivalent discharge sound power values throughout the eight octave bands as the basis of design with sound attenuation, provide additional sound attenuation as required.

1. Silencer filler material shall be inorganic glass fiber of a proper density to obtain the specified acoustic performance and be packed under not less than 5% compression to eliminate voids due to vibration and settling. Material shall be inert, vermin- and moisture-proof. Filler material shall be totally encapsulated and sealed with polymeric film of an appropriate thickness. The encapsulated fill material shall be separated from the interior baffles by means of a non-combustible, erosion resistant, factory-installed, acoustic stand-off

2.9 MOTOR AND DRIVES

A. Motors: Refer to specification Section 20 0513 – Motor Requirements for HVAC and Plumbing Equipment.

B. Air handling unit fans shall be provided with premium efficient, inverter duty and inverter ready rated motor with AEGIS bearing protection ring for use with variable frequency drives.

C. Each supply fan shall be provided with factory installed variable frequency drive with bypass where required above.

D. Variable frequency drives: Refer to specification Section 20 2923 – Variable Frequency Drives.

2.10 COIL SECTIONS

A. General Requirements for Coil Sections

1. Fabricate coil section to allow removal and replacement of coil for maintenance to allow in-place access for service and maintenance of coil(s). All coils must be easily removable from the side of horizontal units.

2. Coils shall not act as a structural component of unit.

3. Coil section shall be consistent with the double wall construction as specified in paragraphs 2.3 and 2.4 of this specification.

4. These air handling units shall be provided with hot water pre-heat coils and chilled water cooling coils as indicated on drawings.

5. Coils shall include stainless steel blank-off sheets to hold coils rigid and prevent air from bypassing the coils.

6. Water Coils
    a. Water coils shall comply with ARI 410.
    b. Coil Connections: All coils shall be threaded, flanged or grooved, extended to a minimum of 4" outside of casing through rubber grommets and be clearly labeled. All coil sections shall include dual rubber grommets; on the outer skin and inner liner.
    c. All coil piping connections shall be extended to the outside of the casing from the factory. Factory insulate gap between coil stub-out connection and casing with spool shaped sleeve grommets.
7. Cooling Water Coils
    a. Coil Type: Continuous serpentine
    b. Headers: Seamless copper tube with brazed joints, prime coated.
    c. Tubes: ⅝" outer diameter (OD) seamless copper with smooth interior surface (no heat transfer enhancement devices), 0.035" nominal tube wall, silver brazed at joints. Return bends shall have a final thickness of 0.035".
    d. Fins: Aluminum with a minimum thickness of 0.0075"continuous plate type with full fin. Fins shall be mechanically bonded or silver brazed to tube.
    e. Coil Casing: Die formed channel frame of 304 stainless steel. Provide tube supports for coils longer than 36".
    f. Coil Working-Pressure Ratings: Cooling: 200 psig and 220°F
    g. Maximum physical height of an individual cooling coil is 45". Provide stacked coils if coil height exceeds 45". Stacked coils shall have an intermediate pan under each coil in conformance with the Condensate Drain Pans for Humidifiers and Cooling Coils paragraph earlier in this section.
    h. Maximum Fins per Inch: 11
    i. An overlapping staggered coil arrangement is not acceptable.
    j. Maximum Face Velocity: As scheduled on drawings.
8. Heating Water Coils
    a. Coil Type: Continuous serpentine
    b. Headers: Cast iron; seamless copper tube with brazed joints, prime coated; or fabricated steel, with brazed joints, prime coated.
    c. Tubes: ⅝" outer diameter (OD) seamless copper with smooth interior surface (no heat transfer enhancement devices), 0.035" nominal tube wall, silver brazed at joints. Return bends shall have a final thickness of 0.035".
    d. Fins: Aluminum with a minimum thickness of 0.0075"continuous plate type with full fin. Fins shall be mechanically bonded or silver brazed to tube.
    e. Coil Casing: Die formed channel frame of 304 stainless steel. Provide tube supports for coils longer than 36".
    f. Coil Working-Pressure Ratings: 200 psig and 325°F
    g. Maximum Fins per Inch: 11
    h. Maximum Face Velocity: As scheduled on drawings.

2.11 FILTER SECTIONS

A. This section shall be consistent with the double wall construction as specified in paragraphs 2.3 and 2.4 of this specification. Omit inspection window on the filter section access doors.

B. Filters shall be arranged for face, rear or side loading as indicated on the detailed drawings. Face loading is preferred where space allows. Face or rear loading to be in gasketed universal holding frames. The filter rack assemblies shall be blanked off to the sides, roof and floor of the unit and properly sealed to minimize filter bypass.

C. The pre-filter section shall be factory fabricated as an integral part of the air handling unit. Filters to be arranged for face (rear) loading into a gasketed universal holding frame. Filters are to be a MERV 8 (30% efficiency and performance). Refer to drawing schedules for quantity and size of filters.

D. The secondary pre-filter section shall be factory fabricated as an integral part of the air handling unit. Filters to be arranged for face (rear) loading into a gasketed universal holding frame. Filters are to be a MERV 13 (85% efficiency and performance). Refer to drawing schedules for quantity, efficiency and size of filters.

E. Each filter bank shall be provided with a flush mounted air filter gauge with an adjustable signal flag.

F. Provide access sections upstream and downstream of filter section of adequate size for filter service.

G. Filter banks shall be sized so the maximum filter face velocity does not exceed 500 fpm.

H. Refer to specification Section 23 4100 – Particulate Air Filtration.

2.12 INSTRUMENTATION

A. Filter gauges

1. Approved Manufacturers
    a. Dwyer Instruments
    b. Trerice
    c. B. Ashcroft
    d. Marsh Instruments
2. Direct Reading Dial: 4" diameter diaphragm actuated dial in metal case, vent valves, black figures on white background, front recalibration adjustment, range of 0.0 inches though 3.0 inches w.c., 2% of full scale accuracy. Series 2000 Magnehelic manufactured by Dwyer.
3. Accessories: Vent valves and static pressure taps with integral compression fittings, ¼" aluminum tubing, plastic vent valves.

2.13 ELECTRICAL COMPONENTS

A. The unit shall come with electrical connections sized to accommodate all unit electrical requirements; 480V for equipment and 120V for lights and courtesy power outlets.

B. Each unit shall be equipped with a unit mounted fused disconnect switch. The disconnect switch shall be mounted on the exterior of the unit in a NEMA 1 enclosure. The disconnect switch shall be UL listed.

C. Provide one (1) 20 amp, 120 volt, GFI receptacle at the motor section. Receptacle shall be factory wired power/control panel.

D. A linear LED vapor proof service light with guard shall be provided in the fan section, mixing box and all accessible sections. Each light shall be 100 watt incandescent equivalent and shall be wired to one master switch. Lights require a 115/1/60 power source that is separate from the main power to the unit to permit light operation during periods of unit shutdown.

E. Provide required step-down transformers for 120 volt electrical service requirements other than lights and courtesy power outlets.

2.14 RETURN FAN UNIT

A. Return air handling unit shall be fan array (fan matrix type) manufactured by the same manufacturer as supply air handling unit and consisting of multiple plenum type fans with direct driven motors.

B. The return fan casing shall be field built by the Contractor to include the fan array cubes, and variable speed drives. Contractor shall provide adequate sized access doors downstream of the fans to allow for motor removal and replacement.

C. Each fan cell shall be provided with a coplanar silencer surrounding all sides of the fan.

2.15 CONTROLS

A. All controls shall be furnished and installed at the Project site by the Controls Contractor.

B. See Project documents for controls sequence.

2.16 FACTORY PROVIDED FIELD SERVICES

A. Air handling unit(s) shall be field certified by an authorized factory representative.

B. Field testing shall performed by the installing contractor under factory supervision.

C. Field certification of compliance with design shall be signed by the authorized factory representative and incorporate a list of all repairs and modifications made to the unit.

PART 3 - EXECUTION

3.1 AIR HANDLING UNIT INSTALLATION

A. Install in accordance with ARI 435 and manufacturer installation instructions.

B. Assemble units per manufacturer installation instructions.

3.2 COIL INSTALLATION

A. Protect coils to prevent damage to fins and flanges. Comb out bent fins.

B. Make connections to coils with unions and flanges.

C. On water coils, provide shut-off valve on supply line and balancing valve with memory lock on return line for each of coil sections. Locate water supply at bottom of supply header and return water connection at top. Provide manual air vents at high points complete with stop-valve. Ensure water coils are drainable and provide drain connection at low points.

D. Connect chilled or hot water supply to air leaving side of coil (counterflow arrangement).

E. Coordinate floor drain installation with plumbing trade. Provide floor drains as close to unit cooling coil drains as possible.

3.3 FILTER INSTALLATION

A. Install air cleaning devices in accordance with manufacturer's instructions.

B. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction.

C. Locate each filter accurately in position indicated in relation to other work. Position unit with sufficient clearance for normal service and maintenance.

D. Coordinate with other work, including ductwork and air handling unit work, as necessary to interface installation of filters properly with other work.

E. Operate installed air filters to demonstrate compliance with requirements. Test for air leakage of unfiltered air while system is operating. Correct malfunctioning units at site, then retest to demonstrate compliance; otherwise remove and replace with new units and proceed with retesting.

F. Demonstrate each filter installation to the Owner. Filters shall be installed snug with no gaps left between filters or filters and housing.

3.4 EQUIPMENT SUPPORT/BASES

A. Refer to specification Section 20 0529 – Supports, Anchors and Sleeves.

B. Furnish anchor bolts and anchor bolt sleeves of adequate size and length to properly anchor all equipment to be installed.

3.5 CONNECTIONS

A. Arrange piping installations adjacent to units to allow servicing and maintenance.

B. Connect condensate drain pan piping to the nearest floor drain. Construct deep trap at piping connection to drain pan and install cleanouts at changes in direction.

C. Electrical power wiring to be provided under Division 26.

3.6 ADJUSTING, CLEANING AND PROTECTING

A. Adjust water coil flow, with control valves at full coil flow, to indicated gpm.

B. Adjust damper linkages for proper damper operation.

C. Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel, fan cabinet and coils entering air face.

3.7 FIELD INSPECTION AND REPORT

A. Provide report, in accordance with Section 20 0001, prepared by manufacturer's representative, stating that systems installed and services provided under this Section are in accordance with manufacturer's recommendations and are properly operating.

3.8 MANUFACTURER FIELD SERVICES

A. The air handling unit manufacturer shall provide the services of a factory trained, field service representative to supervise the unit assembly and installation.

B. Provide services of factory trained representative for minimum two days (16 hours) to supervise start up, calibration of controls and final installation of the air handling units.

C. Provide a written report prepared by the manufacturer's representative stating that systems are installed and services provided under this section are in accordance with manufacturer's recommendations and are operating properly.

D. Provide training for Owner's maintenance personnel on the following:

1. Procedures and schedules related to start-up and shut-down, troubleshooting, servicing, preventative maintenance and how to obtain replacement parts.

2. Familiarization with contents of Operating and Maintenance Manuals specified in Division 01, Section 01 7700 – Closeout Procedures, and Division 20, Section 20 0001 – Basic Mechanical Requirements.

E. Schedule training with at least seven days' advance notice. Provide two (2), 4-hour training sessions to accommodate hospital shifts. One training session shall be in the morning and the second training session shall be in the late afternoon/evening to accommodate the hospital's different shifts. Coordinate exact requirements with the Owner.

3.9 SYSTEM START-UP

A. Final checks before start-up:

1. Remove shipping, blocking and bracing.

2. Verify unit is secure on mountings and supportive devices and that connection for piping, ductwork and electrical are complete. Verify proper thermal overload protection is installed in motors, starters and disconnects.

3. Perform cleaning and adjusting specified in this Section.

4. Verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations.

5. Lubricate bearings, pulleys and other moving parts with factory-recommended lubricants.

6. Comb coil fins for parallel orientation.

7. Install clean filters.

8. Verify manual and automatic volume control, fire and smoke dampers in connected ductwork systems are in the full-open position.

9. Disable automatic temperature control operators.

B. Starting procedures for central station air handling units:

1. Energize motor; verify proper operation of motor, drive system and fan wheel. Adjust fan to indicated rpm.

C. Shut unit down and reconnect automatic temperature control operators.

D. Refer to Division 23, Section 23 0593 – Testing, Adjusting and Balancing for HVAC for procedures for air handling unit testing, adjusting and balancing.

3.10 AIR HANDLING UNIT SCHEDULE

A. Refer to schedule on drawings.

3.11 TESTING

A. Manufacturer Installation Inspection Report - Provide report prepared by manufacturer's representative, stating that systems installed and services provided under this Section are in accordance with manufacturer's recommendations and are properly operating.

B. Factory Testing

1. The assembled units shall be inspected by the Owner and Engineer at the manufacturer's facility prior to authorizing shipment. Unit pricing shall include cost of one trip to the facility for two people.

2. The air handling unit manufacturer and contractor shall provide a report with all test results and a comprehensive list of all instruments used for measurements and a copy of their latest calibration certificates.

3. The assembled units will be visually inspected for completeness, deficiencies in workmanship, and conformance with specifications.

4. Factory testing to be witnessed by the Owner and Engineer shall include the following tests.

a. Leak testing of air handling unit casing.

(1) All air handling units shall be air leak tested at plus 6 in. wg (doors swing in) and minus 6 in. wg (doors swing out).

(a) Tests shall be conducted in compliance with SMACNA's HVAC Air Duct Leakage Test Manual, latest edition.

(b) The leakage rate of the entire unit shall not exceed 0.5% design flow or 5 cfm per 100 ft^2 surface area at ±6-in. wg, whichever is greater.

(c) Surface caulking shall not be used to correct any leakage problems.

b. Air performance testing.

(1) Air handling units shall be tested to verify the AHU airflow is within the range of 100%-110% of the schedule system CFM at the scheduled external system resistance.

(a) The test shall include an airflow measuring point downstream or upstream of the AHU, and static pressure ports across the entire AHU.

(b) Resistance external to the AHU shall be simulated by dampers in the ductwork.

(c) Corrective action shall be by the AHU manufacturer to meet the design system airflow and resistance.

c. Sound testing.

(1) System sound levels shall be measured in all nine (9) octave bands (31.25 Hz through 8000 Hz) at system design operating conditions. Airborne sound levels at all openings shall be read in the test ductwork 5'-0" from the openings. Transmitted sound levels shall be read 5'-0" from the outside of the fan section.

(2) Sound tests shall be conducted while the unit is running at design conditions. An octave band sound pressure level reading shall be taken at outside louver, exhaust louver, supply discharge opening, return air opening, economizer opening and adjacent to each fan section outside of the unit casing.

(3) The test results shall verify that inlet and outlet sound power levels are within the tolerance limits of AMCA 311 (Certified Sound Ratings Program) of the specified levels.

d. Vibration testing.

(1) Factory test fan assemblies for vibration.

(a) Testing shall be performed using an FFT analyzer with a minimum dynamic range of 72 dB, and capable of applying a Hanning window, linear non-overlap averaging, and anti-aliasing filters. Instrument accuracy shall be ±1 dB for displacement and velocity measurements and ±5 dB for acceleration measurements.

(b) Vibration testing shall be performed at the following locations:

i) Each fan bearing vertical and horizontal.

ii) Fan shaft axial.

iii) Fan motor inboard and outboard vertical and horizontal.

iv) Fan motor axial.

(c) Testing shall be performed with fan operating throughout its operating range. Testing shall be performed from 30 HZ to 60 HZ fan speed at 10 HZ increments.

(d) The overall vibration limits in any direction of fan or motor bearings during normal operation at temperatures and load shall not exceed 0.15 in/sec pk in each of the measured bands.

(e) No resonant mode shall exist within the operating frequency range of the motor and fan.

5. All deficiencies noted during the factory inspection and testing must be corrected by the manufacturer prior to shipping the unit. At the discretion of the Owner or Engineer any major deficiencies may require a second factory inspection to confirm that satisfactory corrections have been performed.

C. Field Testing

1. The air handling unit manufacturer and contractor shall provide a report with all test results and a comprehensive list of all instruments used for measurements and a copy of their latest calibration certificates.

2. The air handling unit manufacturer shall factory run-test each fan/motor set to insure design integrity and proper fan rpm.

3. Factory and field leak test all coils: fill water coils with water and test coils and connections for leaks.

4. All factory installed piping shall be hydrostatically leak-tested. Steam and hydronic systems shall be tested for minimum of four hours at 1½ times design pressure or 100 psig minimum, whichever is greater, unless otherwise specified.

5. After the AHU has been field assembled and the manufacturer's representative has been onsite to verify and approve the assembly/construction, the unit shall be positive and negative pressure leak tested. Air handling unit shall be air leak tested by the contractor under the manufacturer's representatives supervision in the field at plus 8 in. wg (doors swing in) and minus 8 in. wg (doors swing out).

a. Tests shall be conducted in compliance with SMACNA's HVAC Air Duct Leakage Test Manual, latest edition.

b. The leakage rate of the entire unit shall not exceed 0.5% of design flow or 5 cfm per 100 ft2 surface area at 8-in. wg., whichever is greater.

c. Surface caulking shall not be used to correct any leakage problems.

6. After the AHU has been field assembled and the manufacturer's representative has been onsite to verify and approve the assembly/construction, the Air handling unit shall be tested to verify that the AHU airflow is within the range of 100% to 110% of the scheduled system CFM at the scheduled external system resistance.
   a. The test shall include an airflow measuring downstream or upstream of the AHU, and static pressure ports across the entire AHU.
   b. Resistance external to the AHU shall be simulated by dampers in ductwork or other means to build up design operating pressure for the fan system.
   c. Corrective action shall be by the AHU manufacturer to meet the design system airflow and resistance.

END OF SECTION

P:\25 Projects\P25-1226-00spl\04 Design\07 Specs\Division 23\23 7300-Custom Indoor Air Handling Units.docx