



HARRISHEALTH
SYSTEM

**LBJ L2 ICU
RENOVATION**

PROJECT MANUAL

Permit and Construction

FKP Project No. 035009.0001

OWNER: Harris Health System

PROJECT: LBJ L2 ICU Renovation

PROJECT NUMBERS: FKP Architects Project No. 035009.0001

ISSUE: Construction Documents

DATE: March 2, 2018

ARCHITECT

FKP Architects, Inc.
3737 Buffalo Speedway, Suite 1200
Houston, Texas 77098
713-621-2100
713-621-2178 (Fax)



03/02/2018

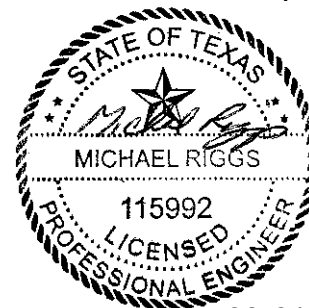
MEP ENGINEER

Smith, Seckman, Reid, Inc.
3700 W. Sam Houston Pkwy, S, Suite 200
Houston, Texas 77042
713-784-8211
713-952-8655 (Fax)



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SECTION 00 63 23 – SUBSTITUTION REQUEST FORM (After Contract Award)

To: FKP Architects, Inc.
 3737 Buffalo Speedway, Suite 1200
 Houston, Texas 77098

For the project identified at top of this page, in lieu of the following specified item(s):

(Spec Section No.)	(Spec Section Title)	(Page No.)	(Paragraph)
(Description)			

the undersigned Contractor requests consideration of the following substitution:

(Specific Manufacturer and Model Number)

Attachments include product description, specifications, drawings, photographs, performance data, and test data adequate for evaluation of the request as it compares to the specified item. Applicable portions are clearly identified.

Attached data also includes description of changes to the Contract Documents which will be required for proper installation of the proposed substitution.

The undersigned Contractor states that the following statements, unless specifically indicated to the contrary below, are correct:

1. The proposed substitution does not materially affect dimensions given in the Contract Documents.
2. The undersigned will pay for required changes to the Project design, including architectural and engineering design, detailing, construction cost, and all other additional expenses caused by the substitution.
3. The proposed substitution will have no adverse effect on other trades, the construction schedule, or specified warranty/guarantee requirements and meets all applicable code requirements.
4. Maintenance and service parts for the substitution will be locally available.

The undersigned Contractor certifies that the function, appearance, and quality of the proposed substitution are equal or superior to the specified item, that the proposed substitution will result in work that in every significant respect is equal to or better than the work required by the Contract Documents, and that the proposed substitution is suitable for the intended purpose on this Project.

The proposed substitution will result in a Cost Increase to the Owner in the amount of \$ _____ Dollars.

The proposed substitution will result in a Cost Savings to the Owner in the amount of \$ _____ Dollars.

The proposed substitution will result in a Time savings to the Owner in the amount of _____ Calendar Days.

SUBMITTED BY _____ (Contractor) _____ (Signature) _____ (Date)	FOR DESIGN TEAM USE <input type="checkbox"/> Accepted <input type="checkbox"/> Accepted <input type="checkbox"/> As Noted <input type="checkbox"/> Rejected _____ Signed: (FKP Architects, Inc.) _____ (Date)	FOR OWNER USE <input type="checkbox"/> Accepted <input type="checkbox"/> Accepted <input type="checkbox"/> As Noted <input type="checkbox"/> Rejected _____ Signed: (Owner) _____ (Date)
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COMMENTS:

Attachments:

DOCUMENT 00 72 00 - GENERAL CONDITIONS

1.01 FORM:

- A. The "General Conditions of the Contract for Construction", AIA Document A201, 2007 Edition, as published by the American Institute of Architects, except as modified by the Document 007300, Supplementary Conditions, will be used for the General Conditions for this Project.
- B. Copies of the General Conditions are available for examination at the office of the Architect. Copies of the General Conditions may be obtained from The American Institute of Architects, 1735 New York Avenue, N.W., Washington, D.C. 20006 or the local AIA office.

END OF DOCUMENT 00 72 00

SECTION 00 73 00 - SUPPLEMENTARY CONDITIONS (Note: This section to be modified at a later date per owner instructions)

The following supplements modify the "General Conditions of the Contract for Construction", AIA Document A201, 2007 Edition. Where a portion of the General Conditions is modified or deleted by these Supplementary Conditions, the unaltered portions of the General Conditions shall remain in effect.

ARTICLE 1 - GENERAL PROVISIONS

Add the following Clauses to Subparagraph 1.2.1:

- 1.2.1.1 Precedence of the Contract Documents: The most recently issued Document takes precedence over previous issues of the same Document. The order of precedence is as follows with the highest authority listed as "1":
- .1 Contract Modifications signed by Contractor and Owner.
 - .2 Agreement.
 - .3 Addenda, with those of later date having precedence over those of earlier date.
 - .4 Supplementary Conditions.
 - .5 General Conditions - AIA A201.
 - .6 Division 01 of the specifications
 - .7 Drawings and Divisions 02 -49 of the Specifications.
 - .8 Other documents specifically enumerated in the Agreement as part of the Contract Documents.
- 1.2.1.2 Relation of Specifications and Drawings: To be equivalent in authority and priority. Should they disagree in themselves, or with each other, prices shall be based on the most expensive combination of quality and quantity of work indicated. In the event of the above mentioned disagreements, the resolution shall be determined by the Architect.

Add the following Clauses to Subparagraph 1.2.3:

- 1.2.3.1 Technical terms not specifically defined in the Contract Documents shall have the meanings given in AIA Document, "Glossary of Construction Industry Terms", July 1982 edition. Technical terms not defined as above and used to describe items of the Work and which so applied have a well known technical or trade meaning, shall be held to have such recognized meaning.
- 1.2.3.2 Additional requirements are specified in Division Zero One Section, "Reference Standards and Definitions".

Add the following Subparagraph:

- 1.2.4 Where in the Drawings and Specifications, certain products, manufacturer's trade names, or catalog numbers are given, it is done for the express purpose of establishing a standard of function, dimension, appearance, and quality of design, in harmony with the Work, and is not intended for the purpose of limiting competition. Materials or equipment shall not be substituted unless such substitution has been specifically accepted for use on this Project by the Architect.

ARTICLE 3 – CONTRACTOR

Add the following Subparagraph to 3.2:

- 3.2.5 The Owner is entitled to reimbursement from the Contractor for amounts paid to the Architect for evaluating and responding to the Contractor's requests for information that are not prepared in accordance with the Contract Documents, or where the requested information is available to the Contractor from a careful study and comparison of the Contract Documents, field conditions, other

Owner-provided information, Contractor-prepared coordination drawings, or prior Project correspondence or documentation.

Add the following Clauses to Subparagraph 3.4.2:

- 3.4.2.1 After the Contract has been executed, the Owner and the Architect will consider a formal request for the substitution of products in place of those specified only under the conditions set forth in Section 012500, "Substitution Procedures (After Contract Award)".
- 3.4.2.2 The Owner is entitled to reimbursement from the Contractor for amounts paid to the Architect for reviewing the Contractor's proposed substitutions and making agreed-upon changes in the Drawings and Specifications resulting from such substitutions.
- 3.4.2.3 Requests for substitution, received by the Architect later than 45 days after "Notice To Proceed" or "Date of Commencement of the Work" (whichever occurs first), will result in additional costs to the Owner. Contractor agrees to reimburse the Owner through deductive Change Order to the Contract, for all costs associated with such requests.
- 3.4.2.4 By making requests for substitutions based on this Subparagraph 3.4.2, the Contractor:
- .1 represents that the Contractor has personally investigated the proposed substitute product and determined that it is equivalent or superior in all respects to that specified, and is suitable for the intended purpose;
 - .2 represents that the Contractor will provide the same warranty for the substitution that the Contractor would for that specified;
 - .3 certifies that the cost data presented is complete and includes all related costs under this Contract except the Architect's redesign costs, and waives all claims for additional costs related to the substitution which subsequently become apparent; and
 - .4 will coordinate the installation of the accepted substitute, making such changes as may be required for the Work to be complete in all respects.

Add the following Subparagraph to 3.5:

- 3.5.1 In addition to the requirements of Paragraph 3.5 and Paragraphs 9.8 and 12.2, the Contractor shall submit to the Architect the project warranty for the entire Work and special warranty-guarantees required by the specifications, on his letterhead and in the forms represented in Division Zero One Section, "Warranties and Bonds". Submittal of all warrantys and guarantees is required as prerequisite to the final payment.

Delete 3.6.1 and insert the following in lieu thereof:

- 3.6.1 The Owner is exempt from sales tax on products permanently incorporated in the Work. The Contractor will be provided with Owner's exemption number upon request. Place exemption certificate number on invoices for materials incorporated in Work and furnish copies of invoices to Owner.
- 3.6.1.1 Upon completion of Work, file with Owner notarized statement that all purchases made under exemption certificate were entitled to be exempt.
- 3.6.1.2 Pay legally assessed penalties for improper use of exemption certificate number.

Delete Subparagraph 3.7.1 and substitute the following:

- 3.7.1 The Owner shall secure and pay for the building, mechanical, electrical and plumbing permits, the health and environmental impact fees due to water and sewer connections, and the zoning regulation fees and permits. The Contractor shall secure and pay for all other permits and governmental fees,

licenses and inspections necessary for proper execution of and completion of the Contract which are legally required when bids are received or negotiations concluded.

Add the following Clauses to Subparagraph 3.9.1:

- 3.9.1.1 The phrase "competent superintendent" above is defined as having served as superintendent on at least one prior project of similar building type, size, and scope as the Work of this Contract.
- 3.9.1.2 Contractor's superintendent shall be on the Project Site at all times when the work is in progress.

Add the following Clause to Subparagraph 3.10.1:

- 3.10.1.1 The form of the Contractor's Construction Schedule shall be a computerized CPM scheduling program capable of providing sufficient data to control and monitor the progress of the work including, but not limited to; long lead time items, fabrication and delivery activities, submittal reviews, installation, coordination, and normal adverse weather.

Delete Subparagraph 3.10.2 and substitute the following:

- 3.10.2 The Contractor shall prepare and keep current, for the Architect's review, a schedule of submittals which is coordinated with the Contractor's construction schedule and allows the Architect reasonable time to review submittals.
- 3.10.2.1 Schedule all submittals to be submitted for Architect's review no later than the mid-point of construction, or six (6) months from Date of Commencement of the Work (whichever comes first)

Add the following Clauses to Subparagraph 3.12.5:

- 3.12.5.1 Shop Drawings, Product Data, or Samples that contain excessive errors or that are incomplete will be rejected and any delay caused thereby will be the responsibility of the Contractor.
- 3.12.5.1.1 More than two reviews of the same submittal by the Architect, necessitated by continuing errors and deficiencies, will result in additional costs to the Owner. Contractor agrees to reimburse the Owner through deductive Change Order to the Contract, for all costs associated with such reviews.
- 3.12.5.2 The Architect will take no action on Shop Drawings, Product Data, and Samples that have not first been certified, by stamped, signed notation, as having been checked and approved by the Contractor for use in the Work.
- 3.12.5.3 The Architect will take no action on Shop Drawings, Product Data, and Samples that are not specifically required by the Contract Documents.
- 3.12.5.4 Requests for Architect's review of submittals that are not specifically required by the Contract Documents will result in additional costs to the Owner. The Owner is entitled to reimbursement from the Contractor for amounts paid to the Architect for all costs associated with such requests.
- 3.12.5.5 Requests for submittal review, received by the Architect after mid-point of construction, or later than six (6) months from Date of Commencement of the Work (whichever comes first), will result in additional costs to the Owner. The Owner is entitled to reimbursement from the Contractor for amounts paid to the Architect for evaluation of late submittals.
- 3.12.5.5.1 For purposes of the above, the term "Mid-Point of Construction" is defined as that time when the aggregate dollar amount certified for payment equals or exceeds one half of the total construction contract amount.

Add the following clause to Subparagraph 3.12.9:

- 3.12.9.1 Deviation from the requirements of the Contract Documents indicated on Shop Drawings, Product Data, and Samples, does not constitute the required notification "in writing" unless specific notation is made of each deviation on the submittal.

Add the following Paragraph to Article 3:

3.19 ADDITIONAL REQUIREMENTS:

- 3.19.1 The Contractor shall halt the affected work when notified of a proposed change, or if unsatisfactory results are anticipated and shall proceed only after receiving additional instructions from the Architect.
- 3.19.2 The Contractor shall establish and maintain bench marks, and all other grade, lines, and levels necessary for the Work; report errors and inconsistencies to the Architect, in writing, before commencing work; confirm the placement of the building on the Site to the Architect after all lines are staked out. The Contractor shall be responsible for the accuracy of the layout and shall make all corrections necessary to achieve an accurate layout of all Work. Refer to Division Zero One Section, "Execution Requirements", for additional requirements.
- 3.19.3 The Contractor shall arrange to accommodate N.I.C. work. When information is inadequate, the Contractor shall request further instructions before proceeding. Refer to Division 01 Section, "Summary", for additional requirements.
- 3.19.4 The Contractor shall prepare quotations, for proposed changes in the Work as directed by the Architect. Quotations shall be in a "break-down" form giving the number of units, unit cost of materials, hours of labor, hourly cost of labor, tool costs, overhead and profit, and shall reflect credits as well as extras.
- 3.19.5 The Contractor shall secure required inspection and occupancy certificates, and transmit them to the Architect. Refer to Division Zero One Section, "Closeout Procedures", for additional requirements.
- 3.19.6 For all Work within, or governed by the requirements of, The Texas Medical Center, unless more restrictive conditions are required by authorities having jurisdiction, comply with the current edition of the Texas Medical Center Architectural Standards. Those Standards include, but are not limited to: Design Requirements, Construction Requirements, Special Conditions, and General Specifications.
- 3.19.6.1 Comply with recent amendments regarding severe weather preparedness that include requirements for:
- .1 Construction security fencing.
 - .2 Covered walkways.
 - .3 Construction cranes.
 - .4 Securement of loose materials and equipment.
 - .5 Removal of debris.
 - .6 Clearing of obstructions from storm drains.

ARTICLE 4 - ARCHITECT

Add the following Clause to Subparagraph 4.2.1:

- 4.2.1.1 The Contractor shall provide written confirmation of all communications made directly with the Owner and provide copies of such confirmation to the Architect.

Add the following Clause to Subparagraph 4.2.2:

- 4.2.2.1 The Owner is entitled to reimbursement from the Contractor for amounts paid to the Architect for site visits made necessary by the fault of the Contractor or by defects and deficiencies in the Work.

Add the following Clause to Subparagraph 4.2.14:

- 4.2.14.1 Contractor's requests for information shall be prepared and submitted in accordance with Division 01 General Requirements sections on the form included in the Contract Documents. The Architect will return "Without action" requests for information that do not conform to the requirements of the Contract Documents.

ARTICLE 5 - SUBCONTRACTORS

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

Delete first sentence in Subparagraph 5.2.1 and inset the following:

"Unless otherwise required by the Contract Documents or the Bidding Documents, the Contractor, at least five (5) working days prior to the execution of the agreement between the Owner and Contractor, shall furnish to the Owner and the Architect in writing the names of all proposed Subcontractor's including a completed copy of AIA Document A305 for each Subcontractor proposed for each of the principal portions of the Work. In addition, this list should also include the names of the persons, entities, vendors or manufacturers who are to furnish materials or equipment supplied or fabricated for the project."

ARTICLE 8 - TIME

Delete Subparagraph 8.1.4 and substitute the following:

- 8.1.4 Unless specific reference is made to "Calendar Day", the term "day" as used in the Contract Documents shall mean working day, excluding Saturdays, Sundays, and legal holidays.

ARTICLE 9 - PAYMENTS AND COMPLETION

Add the following sentence to Subparagraph 9.3.1:

The form of Application for Payment shall be a notarized AIA Document G702, Application and Certification for Payment, supported by AIA Document G703, Continuation Sheet.

Add the following Clause to 9.3.1:

- 9.3.1.3 Until Substantial Completion, the Owner shall pay <90%> <95%> of the amount due the Contractor on account of progress payments.

Add the following Clauses to 9.3.1:

- 9.3.1.3 Until the Work is 50% complete, the Owner shall pay 90% of the amount due the Contractor on account of progress payments. At the time the Work is 50% complete and thereafter, if the Work and its progress are and remain satisfactory, the Architect will, on presentation by Contractor of Consent of Surety for each Application (AIA G707A), authorize remaining partial payments to be paid in full.
- 9.3.1.4 The Contract retainage may be reinstated if the Work and its progress do not remain satisfactory, or if the Surety withholds its consent.

Delete the last sentence of 9.6.7 and add the following Clauses:

- 9.6.7.1 Upon commencement of the Work, an escrow account shall be established in a financial institution chosen by the Contractor and approved by the Owner.
- 9.6.7.2 The escrow agreement shall provide that the financial institution will act as escrow agent, will pay interest on funds deposited in such account in accordance with the provisions of the escrow agreement

and will disburse funds from the account upon the direction of the Owner as set forth below. Compensation to the escrow agent for establishing and maintaining the escrow account shall be paid from interest accrued in the escrow account.

- 9.6.7.3 As each progress payment is made, the retainage with respect to that payment shall be deposited by the Owner in the escrow account.
- 9.6.7.4 The interest earned on funds in the account shall accrue for the benefit of the Contractor until the completion date named in the Construction Contract or the expiration of any authorized extension of such date. Interest earned after such date shall accrue for the benefit of the Owner. Cost of compensation to the escrow agent paid out of interest earned shall be borne by the Contractor.
- 9.6.7.5 When the Contractor has fulfilled all of the requirements of the Contract providing for reduction of retained funds, the escrow agent shall release to the Contractor one-half of the accrued funds but none of the interest thereon. When the Work has been fully completed in a satisfactory manner and the Architect has issued a final Certificate for Payment, the escrow agent shall pay to the Contractor the full amount of funds remaining in the account, including net balance of the interest paid to the account, but less any interest that may have accrued for the benefit of the Owner, which shall be paid to the Owner.
- 9.6.7.6 If, after Substantial Completion of the Work, final completion thereof is materially delayed through no fault of the Contractor, the escrow agent shall make payment to the Contractor as provided in Subparagraph 9.10.3.

Add the following Clause to Subparagraph 9.8.3:

- 9.8.3.1 The Architect will perform no more than Two (2) inspections to determine whether the Work, or a designated portion thereof has attained Substantial Completion in accordance with the Contract Documents. The Owner is entitled to reimbursement from the Contractor for amounts paid to the Architect for any additional inspections.

Add the following Clause to 9.10.2:

- 9.10.2.1 The Contractor shall furnish to the Owner the original copy of final release of liens. The form of final release of liens shall be the current edition of AIA Document G706, "Contractor's Affidavit of Payment of Debts and Claims".

Add the following Paragraph to Article 9:

9.11 LIQUIDATED DAMAGES

- 9.11.1 The Owner will suffer financial loss if the Project is not Substantially Complete on the date set forth in the Contract Documents. The Contractor (and the Contractor's Surety) shall be liable for and shall pay to the Owner the sums hereinafter stipulated, fixed, and agreed as liquidated damages for each calendar day of delay until the Work is substantially complete:

_____ Dollars (\$_____)

- 9.11.2 The exact amount of financial loss is, and will be, difficult to ascertain. By submission of his Bid, each bidder agrees that the sum stipulated above is reasonable in light of the scope of the Work to be prosecuted hereunder and the Owner's need for completion of the same. Such sum shall in no event be construed as a penalty, but only as damages fixed and agreed upon in advance.

9.11 PENALTY/BONUS:

- 9.11.1 The Contractor shall pay to the Owner a sum of:

_____ Dollars (\$_____)

for each calendar day beyond the required date of Substantial Completion until the actual date of Substantial Completion, in consideration of which the Owner agrees to pay to the Contractor a sum of

_____ Dollars (\$_____)

for each calendar day before the required date of Substantial Completion that the Work is determined to be substantially complete.

ARTICLE 10 - PROTECTION OF PERSONS AND PROPERTY

Revise the first sentence of Paragraph 10.3.4 to read as follows:

10.3.4 The Owner and the Architect shall not be responsible under this Section 10.3 for materials or substances the Contractor brings to the site unless such materials or substances are required by the Contract Documents.

Add the following Sub-Paragraph:

10.3.4.1 It is the intention to exclude from the Work of the Project, all products, materials, and equipment that contain hazardous materials in any shape or form. For purposes of this intent, hazardous materials are defined as containing, but not limited to, the following substances:

- .1 Asbestos.
- .2 Polychlorinated Biphenyl (PCB).
- .3 Volatile Organic Compounds (VOCs) in excess of the limits required by Law.

10.3.4.2 If Contractor becomes aware of a product scheduled for use on this project that contains any hazardous material, notify the Architect and request confirmation of acceptability prior to commencing installation.

Revise Paragraph 10.3.6 to read as follows:

10.3.6 If, without negligence on the part of the Contractor or the Architect, the Contractor or the Architect are held liable for the cost of remediation of a hazardous material or substance solely by reason of performing work as required by the Owner, the Owner shall indemnify the Contractor and the Architect for all cost and expense thereby incurred.

ARTICLE 11 - INSURANCE AND BONDS

Delete the semicolon at the end of 11.1.1.1 and add:

, including private entities performing Work at the site and exempt from the coverage on account of number of employees or occupation, which entities shall maintain voluntary compensation coverage at the same limits specified for mandatory coverage for the duration of the Project;

Delete the semicolon at the end of 11.1.1.2 and add:

or persons or entities excluded by statute from the requirements of Clause 11.1.1.1 but required by the Contract Documents to provide the insurance required by that Clause;

Delete Clause 11.1.1.4 and substitute the following:

11.1.1.4 Claims for damages which are sustained (1) by any person as a result of an offense directly or indirectly related to the employment of such person by the Contractor, or (2) by any other person;

Add the following Clauses after 11.1.1.7:

11.1.1.8 Liability Insurance shall include all major divisions of coverage and be on a comprehensive basis including:

- .1 Premises Operations (including X, C and U coverages as applicable).
- .2 Independent Contractors' Protective.
- .3 Products and Completed Operations.
- .4 Personal Injury Liability with Employment Exclusion deleted.

- .5 Contractual, including specified provision for Contractor's obligation under Paragraph 3.18.
- .6 Owned, non-owned and hired motor vehicles.
- .7 Broad Form Property Damage including Completed Operations.

11.1.1.9 If the General Liability coverages are provided by a Commercial General Liability Policy on a claims-made basis, the policy date or Retroactive Date shall predate the Contract; the termination date of the policy or applicable extended reporting period shall be no earlier than the termination date of coverages required to be maintained after final payment, certified in accordance with Subparagraph 9.10.2.

Add the following Clauses to 11.1.2:

11.1.2.1 The insurance required by Subparagraph 11.1.1 shall be written for not less than the following limits, or greater if required by law:

.1 Workmen's Compensation:

- (a) State: Statutory
- (b) Applicable Federal (e.g., Longshoremen, harbor work, Work at or outside U.S. Boundaries): Statutory
- (c) Maritime: \$
- (d) Employer's Liability:
 - \$ per Accident
 - \$ Disease, Policy Limit
 - \$ Disease, Each Employee
- (e) Benefits Required by Union labor contracts: As applicable

.2 Comprehensive and Commercial General Liability (including Premises-Operations; Independent Contractors' Protective; Products and Completed Operations; Broad Form Property Damage):

- (a) Bodily Injury:
 - \$ Each Occurrence
 - \$ Aggregate
- (b) Property Damage:
 - \$ Each Occurrence
 - \$ Aggregate
- (c) Products and Completed Operations to be maintained for 2 years after final payment. Additionally named insured: <Owner's Name>

- (d) Property Damage Liability Insurance shall provide Explosion (X), Collapse (C) and Underground (U) coverage.
- (e) Broad Form Property Damage Coverage shall include Completed Operations.
- .3 Contractual Liability - Broad Form (Including specified provision for the Contractor's Obligation under Paragraph 3.18. Additionally named insured: The Owner and the Architect and their consultants, their agents, and employees.):
 - (a) Bodily Injury:
 - \$ Each Occurrence
 - \$ Aggregate
 - (b) Property Damage:
 - \$ Each Occurrence
 - \$ Aggregate
- .4 Personal Injury, with Employment Exclusion Deleted and 0% Participation:
 - \$ Aggregate
- .5 Business Auto Liability (including owned, non-owned, and hired vehicles):
 - (a) Bodily Injury:
 - \$ Each Person
 - \$ Each Occurrence
 - (b) Property Damage:
 - \$ Each Occurrence
- .6 Aircraft Liability (Owned and Non-Owned) When Applicable:
 - \$ (Owner to approve limits proposed by Contractor.)
 - (a) Bodily Injury:
 - \$ Each Person
 - \$ Each Occurrence
 - (b) Property Damage:
 - \$ Each Occurrence
- .7 Watercraft Liability (Owned and Non-Owned) When Applicable:
 - \$

(Owner to approve limits proposed by Contractor.)

(a) Bodily Injury:

\$ Each Person
 \$ Each Occurrence

(b) Property Damage:

\$ Each Occurrence

.8 If the General Liability coverages are provided by a Commercial Liability policy, the:

- (a) General Aggregate shall be not less than \$_____ and it shall apply, in total, to this Project only.
- (b) Fire Damage Limit shall be not less than \$_____ on any one fire.
- (c) Medical Expense Limit shall be not less than \$_____ on any one person.

.9 Other Insurance:

COVERAGE	AMOUNT
[Set Coverage & Amount]	
(a) Umbrella Form Excess Liability	\$

Delete the last two sentences of Subparagraph 11.2.1 and substitute the following:

Insurance covering the Owner's contingent liability for claims which may arise from operations under the Contract provided by Contractor with Owner included as additionally named insured on Contractor's Liability Policy and with the following minimum limits:

.1 Bodily Injury:

\$ As Shown for Contractor's Liability Insurance Each Occurrence
 \$ As Shown for Contractor's Liability Insurance Aggregate

.2 Property Damage:

\$ As Shown for Contractor's Liability Insurance Each Occurrence
 \$ As Shown for Contractor's Liability Insurance Aggregate

.3 Personal Injury with Employment Exclusion Deleted and 0% Participation:

\$ As Shown for Contractor's Liability Insurance Aggregate

Add the following sentence to Clause 11.3.1.1:

The form of policy for this coverage shall be <"Completed Value".> <"Reporting".>

Add the following sentences to 11.3.1.1:

11.3.1.2 In addition to the insurance required by Subparagraph 11.3.1, Contractor's attention is directed to the fact that because of the nature of the Work, the Contractor will have in his care, custody, and control, at various stages of the Work, property of others which may be subject to damage. This situation is set forth here, so that Contractor will take into consideration this exposure and possibility of loss that would not be covered under a General Liability Policy and provide necessary protection for himself as provided in Subparagraph 11.3.1.

Add the following sentence to 11.3.1.3:

This property insurance is written with a deductible of \$_____ per occurrence with a deductible aggregate of \$_____.

Delete 11.3.1.4 and substitute the following:

11.3.1.4 The Contractor shall provide insurance coverage for portions of the Work stored off the site after written approval of the Owner at the value established in the approval, and also for portions of the Work in transit.

Add the following Clause 11.3.1.6 to Subparagraph 11.3.1:

11.3.1.6 The insurance required by Paragraph 11.3 is not intended to cover machinery, tools or equipment owned or rented by the Contractor which are utilized in the performance of the Work but not incorporated into the permanent improvements. The Contractor shall, at the Contractor's own expense, provide insurance coverage for owned or rented machinery, tools or equipment which shall be subject to the provisions of Subparagraph 11.3.7.

Add the following Clause to 11.3.2:

11.3.2.1 Insurance required by Subparagraph 11.3.2 shall be written for not less than the following, or greater if required by law:

.1 Limit: Actual Loss

.2 Objects to be Insured: Boilers, motors, miscellaneous electrical equipment, air conditioning, and materials in surrounding areas.

Modify the first sentence of 11.3.1 as follows:

Delete "Unless otherwise provided, the Owner" and substitute "the Contractor".

Add the following sentences to 11.3.1:

The form of policy for this coverage shall be Completed Value. If the Owner is damaged by the failure of the Contractor to maintain such insurance, then the Contractor shall bear all reasonable costs properly attributable thereto.

Add the following sentences to 11.3.1.1:

In addition to the insurance required by Subparagraph 11.3.1, Contractor's attention is directed to the fact that because of the nature of the Work, the Contractor will have in his care, custody, and control, at various stages of the Work, property of others which may be subject to damage. This situation is set forth here, so that Contractor will take into consideration this exposure and possibility of loss that would not be covered under a General Liability Policy and provide necessary protection for himself as provided in Subparagraph 11.3.1.

Delete Clause 11.3.1.2.

Delete Clause 11.3.1.3.

Add the following Clause to 11.3.2:

11.3.2.1 The Contractor shall purchase and maintain such insurance required by Subparagraph 11.3.2 with the following minimum limit, or greater if required by law:

.1 Limit: Actual Loss

.2 Objects to be Insured: Boilers, motors, miscellaneous electrical equipment, air conditioning, and materials in surrounding areas.

Delete Subparagraph 11.3.4.

Delete Subparagraph 11.3.6 and substitute the following:

11.3.6 Before an exposure to loss may occur, the Contractor shall file with the Owner two certified copies of the policy or policies providing this Property Insurance coverage, each containing those endorsements specifically related to the Project. Each policy shall contain a provision that the policy will not be cancelled or allowed to expire until at least 30 days' prior written notice has been given to the Contractor.

Modify Subparagraph 11.3.7 by substituting "Contractor" for "Owner" at the end of the first sentence.

Modify Subparagraph 11.3.8 by substituting "Contractor" for "Owner" as fiduciary; except that at the first reference to "Owner" in the first sentence, the work "this" should be substituted for "Owner's".

Modify Subparagraph 11.3.9 by substituting "Contractor" for "Owner" each time the latter word appears.

Modify Subparagraph 11.3.10 by substituting "Contractor" for "Owner" each time the latter word appears.

Add the following Subparagraph to 11.3:

11.3.11 Insurance coverages and amounts required by Article 11 will be set by Owner prior to commencing the Work. Contractor shall notify Owner, in writing, ten (10) days prior to commencing Work if Owner's instructions for coverages and amounts of coverages have not been received.

Delete Subparagraph 11.4.1 and substitute the following:

11.4.1 The Contractor shall furnish bonds covering faithful performance of the Contract and payment of obligations arising thereunder. Bonds may be obtained through the Contractor's usual source if acceptable to the Owner and is authorized to transact business in the State in which the Project is located and the cost thereof shall be included in the Contract Sum. The amount of each bond shall be equal to 100% of the Contract Sum.

- 11.4.1.1 The Contractor shall file the bonds in accordance with governing statutes in the jurisdiction wherein the Project is located. The Contractor shall then deliver evidence to the Owner that the Bonds have been duly filed and recorded. Such evidence shall be presented to the Owner not later than three days following the date the Agreement is entered into, or if the Work is to be commenced prior thereto in response to a letter of intent, the Contractor shall, prior to the commencement of the Work, submit evidence satisfactory to the Owner that such bonds will be filed.
- 11.4.1.2 The Contractor shall require the attorney-in-fact who executes the required bonds on behalf of the surety to affix thereto a certified and current copy of the power of attorney.

ARTICLE 13 - MISCELLANEOUS PROVISIONS

Add the following Paragraph to Article 13:

13.8 EQUAL OPPORTUNITY:

13.8.1 The Contractor shall maintain policies of employment as follows:

13.8.1.1 The Contractor and the Contractor's Subcontractors shall not discriminate against any employee or applicant for employment because of race, religion, color, sex or national origin. The Contractor shall take affirmative action to insure that applicants are employed, and that employees are treated during employment without regard to their race, religion, color, sex or national origin. Such action shall include, but not be limited to, the following: employment, upgrading, demotion or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The Contractor agrees to post in conspicuous places, available to employees and applicants for employment, notices setting forth the policies of non-discrimination.

13.8.1.2 The Contractor and the Contractor's Subcontractors shall, in all solicitations or advertisements for employees placed by them or on their behalf, state that all qualified applicants will receive consideration for employment without regard to race, religion, color, sex or national origin.

ARTICLE 14 - TERMINATION OR SUSPENSION OF THE CONTRACT

Add the following Paragraph to Article 14:

14.4 TERMINATION BY THE OWNER FOR CONVENIENCE:

14.4.1 The Owner may, at any time, terminate the Contract for the Owner's convenience and without cause.

14.4.2 Upon receipt of written notice from the Owner of such termination for the Owner's convenience, the Contractor shall:

- .1 Cease operations as directed by the Owner in the notice;
- .2 Take actions necessary, or that the Owner may direct, for the protection and preservation of the Work; and
- .3 Except for Work directed to be performed prior to the effective date of termination stated in the notice, terminate all existing Subcontracts and purchase orders and enter into no further Subcontracts and purchase orders.

14.4.3 In case of such termination for the Owner's convenience, the Contractor shall be entitled to receive payment from the Owner on the same basis provided in Subparagraph 14.1.2.

ARTICLE 15 – CLAIMS AND DISPUTES

Add the following Clause to Subparagraph 15.1.5.2:

15.1.5.2.1 The Contractor shall anticipate a normal number of days of adverse weather conditions each month. In case of claims for extension of time because of abnormal adverse weather, such extension shall be granted only because abnormal adverse weather prevented the execution of major items of work on normal working days. A five year table (N.O.A.A.) reflecting the meteorological data from the Project area will be used to determine contract time extensions due to abnormal adverse weather. For the purposes of this Contract, the phrase "abnormal adverse weather" will be interpreted as the number of days in excess of the normal on which rainfall exceeds 0.10 inch or when snow or ice pellets accumulation exceeds 1.0 inch.

Add the following Clauses to 15.1.5:

15.1.5.3 Claims for increase in the Contract Time shall set forth in detail the circumstances that form the basis of the claim, the date upon which each cause of delay began to affect the progress of the Work, the date upon which each cause of delay ceased to affect the progress of the Work, and the number of days' increase in the Contract Time claimed as a consequence of each such cause of delay. The Contractor shall provide such supporting documentation as the Owner may require including, where appropriate, a revised construction schedule indicating all activities affected by the circumstances forming the basis of the claim.

15.1.5.4 The Contractor shall not be entitled to a separate increase in the Contract Time for each one of a number of causes of delay which may have concurrent or interrelated effects on the progress of the Work, or for concurrent delays due to the fault of the Contractor.

Add the following sentence to Subparagraph 15.1.6:

If, before expiration of 30 days from the date of execution of this Agreement, the Owner obtains by separate agreement and furnishes to the Contractor a similar mutual waiver of all claims from the architect against the Contractor for consequential damages which the Architect may incur as result of any act or omission of the Owner or Contractor, then the waiver of consequential damages by the Owner and Contractor contained in this Section 15.1.6 shall be applicable to claims by the Contractor against the Architect.

END OF SUPPLEMENTARY CONDITIONS

SECTION 23 05 00 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Common work results for requirements specifically applicable to Division 23.
- B. Requirements of Division 01 Specifications, General Provisions of the Contract and General and Supplementary Conditions apply to this Division.

1.2 REGULATORY REQUIREMENTS

- A. Perform Work specified in Division 23 in accordance with standards listed below of the latest applicable edition adopted by the authority having jurisdiction. Where these Specifications are more stringent, they shall take precedence. In case of conflict, obtain a decision from the Architect.
 - 1. NFPA 30: Flammable and Combustible Liquids Code
 - 2. NFPA 54: National Fuel Gas Code
 - 3. NFPA 70: National Electrical Code
 - 4. NFPA 72: National Fire Alarm and Signaling Code
 - 5. NFPA 90A: Standard for the Installation of Air Conditioning and Ventilating Systems
 - 6. NFPA 90B: Standard for the Installation of Warm Air Heating and Air Conditioning Systems
 - 7. NFPA 92A: Standard for Smoke-Control Systems Utilizing Barriers and Pressure Differences
 - 8. NFPA 99: Health Care Facilities Code
 - 9. NFPA 101: Life Safety Code
 - 10. NFPA 101A: Guide on Alternative Approaches to Life Safety
 - 11. NFPA 101B: Standard on Means of Egress for Buildings and Structures
 - 12. NFPA 105: Standard for the Installation of Smoke Control Door Assemblies and Other Opening Protectives
 - 13. NFPA 214: Standard on Water Cooling Towers
 - 14. NFPA 241: Standard for Safeguarding Building Construction, Alterations, and Demolition Operations
 - 15. NFPA 5000: Building Construction and Safety Code
 - 16. ANSI A17.1: Elevators, Dumbwaiters, Escalators and Moving Walks
 - 17. ANSI Handicapped Code-A117.1
 - 18. ASTM E814-08B: Standard Test Method for Fire Tests Penetration Firestop Systems.
 - 19. U.L. Fire Resistance Index.
 - 20. BOCA: Building Officials Code Association
 - 21. International Building Code, with Mechanical and Plumbing Codes
 - 22. All applicable Occupational Safety and Health Administration (OSHA) Publications, Rules and Regulations.
 - 23. Americans with Disabilities Act (ADA)
 - 24. FGI Guidelines for Design and Construction of Health Care Facilities
 - 25. Texas Department of State Health Services, Hospital Licensing Regulations
 - 26. Texas Accessibility Standard.
 - 27. Special regulations, supplement, and amendments of the State and/or local authorities having jurisdiction.

1.3 REFERENCE STANDARDS

- A. AGA: American Gas Association.
- B. ANSI: American National Standards Institute.
- C. ARI: American Refrigeration Institute.
- D. ASHRAE: American Society of Heating Refrigeration and Air Conditioning Engineers.
- E. ASME: American Society for Mechanical Engineers.
- F. ASTM: American Society for Testing and Materials.
- G. AWWA: American Water Works Association.
- H. FM: Factory Mutual
- I. IRI: Industrial Risk Insurers
- J. MSS: Manufacturer's Standardization Society of the Valve and Fitting Industry.
- K. NEMA: National Electrical Manufacturers' Association.
- L. NFPA: National Fire Protection Association.
- M. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.
- N. UL: Underwriters' Laboratories, Inc.
- O. U.L. Fire Resistance Index

1.4 SUBMITTALS

- A. Submit under provisions of Division 01.
- B. Incomplete submittals containing unmarked cutsheets or not providing specific detail of what is being proposed will be rejected and will not be reviewed.
- C. Include Products as specified in the individual sections of Division 23.
- D. Submit shop drawing and product data grouped to include complete submittals of related systems, products, and accessories in a single submittal.
- E. Prepare shop drawings completely independent of the Engineer of Record's CADD files or Revit model. Should the Contractor or Vendor wish to use the Engineer of Record's CADD files or Revit model as the basis for developing their shop drawings, a release form, obtainable from the Engineer or Architect, must be signed. A nominal charge of \$50.00 per sheet must be made payable to the engineering firm to cover the cost of preparing the drawings for use by others.
- F. Submit copies of shop drawings in accordance with Division 01, including:
 - 1. Building Automation System including direct digital control drawings.
 - 2. Concrete pads and foundations including anchor bolt and sleeve locations.

3. Prepare and submit coordination drawings as specified herein. Facilitate the coordination effort with all other trades, specifically Divisions 21, 22, 26 and 28 and shall include:
 - a. Mechanical Rooms
 - b. Coordinated room layouts shall include:
 - 1) Room dimensions.
 - 2) Support column locations.
 - 3) Locations and dimensions of equipment foundations and pads required.
 - 4) Locations and dimension of equipment and apparatus, including electrical control panels and starters, and service and coil pull areas.
 - 5) Dimensioned floor drain locations.
 - 6) Locations of wall mounted equipment.
 - 7) Trench locations and sizes.
 - 8) Sleeve locations in mechanical rooms and equipment rooms.
 - 9) AHU (fan) and duct layouts in AHU equipment rooms.
 - 10) Piping 3" and larger.
 - 11) Conduit 3" and larger.
 4. Roof layouts including:
 - a. Air Intakes.
 - b. Vents.
 - c. Exposed ductwork.
 - d. Roof mounted equipment.
- G. Brochures: Submit manufacturer's product data and brochures including:
1. Complete descriptions.
 2. Illustrations.
 3. Rating data, accessories, dimensional data, and applicable options and features marked for the specific items scheduled on drawings and specified herein.
 4. Capacities stated in the terms specified.
 5. Performance curves for all air handling units, fans, and pumps.

1.5 FIELD CONDITIONS

- A. Layouts indicated on drawings are diagrammatic and intended to show relative positions and arrangement of equipment, ductwork and piping. Coordinate mechanical work with other trades and measurements obtained at the job site, as applicable, prior to installation. Generally, install work in locations shown on Drawings, using as necessary rises, drops, offsets, transitions, and alternate routings to fit in the available space unless prevented by Project conditions.
- B. If prevented by project conditions, prepare drawings showing proposed rearrangement of Work, including changes to Work specified in other sections. Obtain permission of Architect before proceeding.
- C. Place anchors, sleeves, and supports prior to pouring concrete or installation of masonry work.
- D. Cause as little interference or interruption of existing utilities and services as possible. Schedule work which will cause interference or interruption in advance with Owner, authorities having jurisdiction, and all affected trades.
- E. Determine sizes and verify locations of existing utilities on or near site.
- F. Keep roads clear of materials and debris.

- G. Visit site and be informed of conditions under which Work must be performed.
- H. Locate equipment requiring periodic servicing so that it is readily accessible. Provide means of service access, following appropriate manufacturer's recommended service clearance space or, as applicable, means of access using duct, wall, or ceiling access doors.
- I. Install ductwork and piping to leave sufficient space for AHJ inspection of wall construction.

1.6 FEES AND PERMITS

- A. Obtain and pay for all necessary permits and inspection fees required to perform Division 23 work.

1.7 COORDINATION DRAWINGS

- A. Prior to commencement of installation, prepare coordination drawings for work under this division, as specified in Division 01, in full cooperation with persons performing work under other Divisions, including but not limited to mechanical, electrical, plumbing, fire protection, telecommunications, audio/visual and miscellaneous steel.
- B. Drawings shall not be formally submitted but shall be kept on site for reference. Notify Architect and Construction Manager of conflicts that cannot be resolved.
- C. Coordination Drawings shall be prepared to include the following:
 - 1. Drawn to a scale of 1/4" = 1'-0".
 - 2. Room dimensions.
 - 3. Sheet size matching contract documents.
 - 4. Duct sizes with bottom elevation from finished floor.
 - 5. Show equipment, columns, and beams.
 - 6. Duct fitting details.
 - 7. Construction details of plenums and casings.
 - 8. Concrete pad and foundation layouts including anchor bolt and sleeve locations.
 - 9. Dimensioned floor drain locations.
 - 10. Wall mounted equipment.
 - 11. Piping 3" and larger, with elevations from finished floor to bottom of pipe.
 - 12. Space allocation for conduits and cable trays.
 - 13. Ceiling height.
 - 14. Ductwork, air terminal units, and piping 3" and larger shall be shown in proper graphic scale.
 - 15. Clearance requirements for control panels, inspections, and maintenance.
 - 16. Coordination drawings are to indicate air terminal units, fan coil units, air handling units, control panels, and all other devices and materials to proper scale.

1.8 COMPLETENESS OF WORK

- A. The Contract Documents depict HVAC systems which are intended to be complete and functioning systems. All products, materials, and labor necessary to render a fully functional system to fulfill the design intent shown on the documents shall be provided by the Contractor.
- B. Catalog numbers referenced throughout the Division 23 Drawings and Specifications are intended to convey a general understanding of the type and quality of the product required. Where written descriptions differ from information conveyed by a catalog number, the written

description shall govern. No extra shall be allowed because a catalog number is found to be incomplete or obsolete.

1.9 PRODUCT SUBSTITUTIONS

- A. Comply with provisions of Division 01.

1.10 RECORD DRAWINGS

- A. Provide record drawings that illustrate the work of Division 23 as finally constructed. Deliver record drawings to the Architect electronic format and also three (3) copies marked in red ink to reflect work as constructed.
- B. Record drawings shall reflect all changes made to the Contract Documents, whether generated by addenda, change orders, or field conditions. Maintain a daily record of these changes and keep current set of drawings showing these changes.
- C. Deliver record drawings to Architect within 30 days of Substantial Completion.
- D. Record drawings are to indicate air terminal units, fan coil units, air handling units, fans, control panels, and all other devices and materials to proper scale.

1.11 OWNING AND OPERATING MANUALS

- A. Manuals shall include clear and comprehensive instructions with appropriate graphics and project specific marked data to enable owner to operate and maintain all systems specified in this Division.
- B. Copies of final reviewed submittals indicating all model numbers, serial numbers, cut sheets, and all performance criteria on furnished equipment shall be included.

PART 2 - PRODUCTS

2.1 EQUIPMENT SUPPORTS

- A. Structural Steel for Supports: ASTM A36.
 - 1. Use galvanized members installed in fan plenums or areas of high humidity or condensation, and outside. All fasteners shall be stainless steel. Any damage caused by cutting, drilling, or welding or any other means to galvanized surface must be repaired by apply two coats of cold-galvanizing.
 - 2. Use hot dipped galvanized members installed in fan plenums or areas of high humidity or condensation, in tunnels and outside. All fasteners shall be stainless steel. Any damage caused by cutting, drilling, or welding or any other means to galvanized surface must be repaired by applying two coats of cold-galvanizing.
 - 3. Furnish other members with shop coat of primer.
 - 4. Retouch primer after field welding.

2.2 FLASHINGS AND COUNTERFLASHINGS

- A. Furnish materials and coordinate installation for flashing and counterflashing roof penetrations for ductwork and piping.
- B. Materials:

1. Sheetmetal: 24 gauge minimum ASTM A525, Class G90.
2. Sheet lead: 3 pounds per square foot.
3. Stainless steel: Minimum 20 gauge.
4. Sheet copper: 24 OZ/SF.

2.3 WALL AND CEILING ACCESS PANELS

- A. Style and type as required for material in which installed.
- B. Size: 24"x24" minimum, as indicated, or as required to allow inspection, service and removal of items served.
- C. 14 gauge minimum sheet metal for doors, 16 gauge frames of cadmium-plated or galvanized construction. Doors shall have expanded plaster rings where located in plaster walls or flanged finish where located in drywall or block construction.
- D. Panels shall have spring hinges with screwdriver locks in non-public areas. Key lock, keyed alike, for panels in public areas.
- E. Prime painted or rust inhibitive paint finish.
- F. UL labeled when in fire-rated construction, 1-1/2 hour rating.
- G. Provide in walls, floors, and ceilings to permit access to all equipment and piping requiring service or adjustment. Examples of such equipment needing access are fire and/or smoke dampers, mechanical system valves, and equipment needing periodic or replacement maintenance.
- H. Furnish and locate access panels under this Division. Coordinate with trades who are responsible for building system in which panels are to be installed.
- I. Acceptable manufactures: Milcor, Nystrom, Karp, J.L. Industries, or Williams Brothers.
 1. For masonry and drywall construction: Milcor Style M.
 2. For plastered masonry walls and ceiling: Milcor Style K.
 3. For ceramic tile or glazed structural tile: Use stainless steel panels.

2.4 PIPE ENCLOSURES

- A. For exposed vertical piping in kitchen: 18 gauge stainless steel (Type 302) with No. 4 finish.
 1. Extend from 2" above ceiling to equipment or island partition.
 2. Size covers to contain number of pipes served.
- B. Minimize number of covers by enclosing maximum number of pipes in each drop.
- C. Anchor to equipment or partition.
- D. Fasten seams and joints with stainless steel pop rivets.
- E. Provide 1-1/2" ceiling flange as closure.

2.5 SLEEVES

- A. Materials:

1. Concrete floors, concrete and masonry walls: 18 gauge galvanized steel sheetmetal or Schedule 10 galvanized steel pipe.
 2. Drywall partitions: 18 gauge galvanized steel sheetmetal or Schedule 10 galvanized steel pipe.
- B. Sleeves shall be sized such that the annular space between outside surface of pipe or pipe insulation and the inside surface of the sleeve is not less than 1/2". Provide larger annular space if required by firestopping product installation instructions.
- C. Sleeves supporting riser piping 4" and larger shall have three 6" long reinforcing rods welded radially at 120 degree spacing to the sleeve and shall be installed with the rods embedded in the concrete slab.

2.6 ESCUTCHEON PLATES

- A. Provide B & C No. 10 or equal chrome plated escutcheon plates where pipes penetrate partitions or ceilings in finished areas.

PART 3 - EXECUTION

3.1 CUTTING AND PATCHING

- A. Repair or replace damage caused by cutting or installation of work specified in Division 23.
- B. Perform repairs with materials which match existing and install in accordance with the appropriate section of these specifications.

3.2 FLASHING AND COUNTERFLASHING

- A. Counterflash ducts and pipes where penetration of roofs and outside walls occur.

3.3 CONNECTION TO EQUIPMENT FURNISHED BY OWNER

- A. Connect and/or install equipment shown on mechanical drawings that requires mechanical connections.
- B. Provide piping, isolation valves, unions, and other piping appurtenances required for a complete installation.
- C. Provide steam strainers, steam traps, and pressure reducing valves in steam lines.

3.4 DELIVERY, STORAGE, AND PROTECTION

- A. Insofar as possible, deliver items in manufacturer's original unopened packaging. Where deliver in original packaging is not practical, provide cover and shielding for all items with protective materials to keep them from being damaged. Use care in loading, transporting, unloading, and storing to keep items from being damaged.
- B. Store items in a clean, dry place, and protect from damage. Mechanical equipment may not be staged or stored outdoors unless intended for outdoor use.
- C. Protect nameplates on motors, pumps, and similar equipment. Do not paint or insulate over nameplate data.

- D. Protect valves and piping from damage. Cover equipment during work of finishing trades.
- E. Keep dirt and debris out of pipes and ducts.
- F. Repair, restore, and replace damaged items.
- G. Cover factory finished equipment during work of finished trades, such as fan coils, fin tubes, etc.
- H. Protect cooling and/or heating coils with temporary filter media during construction.

3.5 SLEEVES

- A. Floors: Sleeve all pipe penetrations. Extend sleeve 1-1/2" above finished floor, except piping within pipe chases. Sleeve shall be flush with underside of floor.
- B. Masonry or concrete walls: Sleeve all pipe penetrations. Sleeves shall be flush on both sides of wall.
- C. Drywall partitions: Sleeve all penetrations of piping in systems over 160 degree F.
- D. Seal voids between outside surface of sleeve and wall, partition or floor. Seals shall be airtight.
- E. Install piping, insulation and sleeves in strict accordance with applicable U.L. floor or partition assembly instructions. Coordinate with Division 07 Firestop manufacturer's installation instructions.
- F. Clearance between sleeve and pipe: Minimum of 1/2 inch for hot piping and 1 inch for cold piping or as otherwise dictated by U.L. Fire Resistance Directory.
- G. Penetrations not Sleeved or Firestopped:
 - 1. Seal voids between pipe and partition. Seals shall be airtight.

3.6 ESCUTCHEON PLATES

- A. Provide chromium plated escutcheon plates for exposed uninsulated pipes projecting through floors or walls in "finished" spaces. Mechanical rooms, store rooms, electric closets, and janitor closets are not considered "finished" spaces.

3.7 EQUIPMENT GUARDS

- A. Use suitable structural frames with minimum 12 gauge, 3/4" galvanized mesh, or expanded metal mesh. Attach to equipment by removable clips and bolts with wing nuts, or other approved connectors.
- B. At belts, provide opening for measuring RPM.
- C. Provide at all belts, couplings, moving machinery and equipment.
- D. Design for easy access to belts and other items requiring replacement.
- E. Comply with OSHA Regulations.

3.8 CLEANING HVAC SYSTEMS

- A. General Cleanup:
 - 1. Upon completion of contract and progressively as work proceeds, clean up dirt, debris, old materials, etc., and remove from site, keeping premises in neat and clean condition to satisfaction of the Architect. See Division 01 of specifications for further requirements.
 - 2. Seepage, discoloration or other damage to parts of the building, its finish, or furnishings due to Contractor's failure to properly clean piping systems or duct systems shall be repaired without cost to the Owner.

- B. Factory Finishes:
 - 1. Clean items with factory finishes. Touch up bare places, scratches and other minor damage to finishes. Use only factory supplied paint of matching color and formula. If finishes are badly damaged or if there are many damaged, scratched or bare places, refinish the entire item.

- C. Ducts and Apparatus:
 - 1. Thoroughly clean ducts and apparatus casings before fans and filters are operated.

- D. HVAC Closed Water Systems:
 - 1. Initial flushing:
 - a. Remove loose dirt, mill scale, metal chips, weld beads, rust, and like deleterious substances without damage to any system components.
 - b. Bypass factory equipment unless acceptable means of protection are provided, or by subsequent inspection of water boxes and other "hide-out" areas takes place.
 - c. Isolate or protect "clean" system components including pumps and pressure vessels and any component that may be damaged.
 - d. Open all valves, drains, vents, strainers, and the like at all system levels. Close all valves isolating piping from the existing central piping systems.
 - e. Remove plugs, caps, spool pieces, and components to facilitate early discharge from the system.
 - f. Sectionalized system to obtain debris carrying velocity of six feet per second.
 - g. Connect dead end supply and return headers and the like as necessary, or provide drains in dead end eccentric caps.
 - h. Install temporary strainers where necessary to protect downstream equipment.
 - i. Supply and drain-off "flushing" water by fire hoses, garden hoses, temporary or permanent piping, Contractor's booster pumps, and the like.
 - j. Flush for not less than four hours. Drain all dirt legs. If water drained is not visibly clean, repeat the above procedure until dirt legs are visibly clean.
 - k. Before starting the cleaning and flushing process, confirm a thermometer has been installed on the system. During flushing and cleaning process, monitor the water temperature to ensure the water temperature does not become too hot.
 - 2. Cleaning (Closed Systems Only):
 - a. Utilize defoamers to preclude damage to existing work, and specifically adjacent electrical equipment.
 - b. Utilize heat to maximize effectiveness of compounds or use live steam injection where practical and safe. Do not raise cleaning water temperature in excess of 150 degrees F. Install a thermometer in the piping system and constantly monitor the water during cleaning to prevent over-heating.

- c. Install temporary strainers, reinforced against blowout, sized to not impair equipment performance, to preclude passing of particles larger than 60% of smallest radial and at a minimum to retain all particles larger than 1000 microns.
- d. Permanent facility pumps shall not be used for circulating cleaning water. Contractor shall supply temporary pumps for this process.
 - 1) If the system construction, flow rates, and pressures are such that it is impractical for the Contractor to provide temporary pumps, the permanent facility pumps may be used with the specific express permission of the Owner, provided the guarantee on the entire pump assembly is unconditionally extended for two years after date of Substantial Completion. Leakage from pump seals or other damage resulting from circulating the uncleaned water shall require immediate rectification at no additional cost to the Owner.
- e. Add 20 pounds of Garratt Callahan Formula 248, or equal, alkaline cleaner for each 1000 gallons of system water for chemical cleaning (approximate .2% solution). Formula 248 is a dry blend of buffered phosphates, a corrosion inhibitor, a surfactant, and an iron oxide sequestrant.
- f. Circulate for a period of at least 72 hours.
- g. Every eight hours, blow-down the condensers and system low points for three minutes.
- h. Drain and flush the system. Rapid flushing from the lowest point in the system is needed to remove debris.
- i. Inspect the system and repeat first four steps.
- j. Begin the corrosion control program immediately at double the normal inhibitor dosage for one week. After one week, drop to the normal dosage.
- k. Chemical treatment compound: Use Garratt Callahan Company Formula 12-L closed system inhibitor strictly following manufacturer's directions.

3.9 OPERATION OF HVAC SYSTEMS DURING CONSTRUCTION

- A. Install all specified filters prior to system operation. In addition to specified filters, install a roughing filter upstream of mixed air filter. Roughing filter shall consist of two layers of roll filter media clipped and sealed to entering side of filter frame. Change roughing filter as necessary to minimize dust collection on specified filters.
- B. Cover return and exhaust air grilles with temporary filter media. Attach media to avoid damage to grille or ceiling. Change temporary media as required to protect against dust buildup on ductwork. Remove temporary media from grilles after flooring is installed, walls are sanded and painted and other dust generating construction has been completed.
- C. During periods of excessive dust generation such as drywall sanding, seal off return and exhaust openings and grilles to prevent dust from accumulating in ductwork.
- D. If outside air source contains less dust than building air, adjust A/C unit dampers to operate with as much outside air as possible without causing a freezing condition for coil or exceeding capacity of coil to adequately condition supply air.
- E. Furnish and install a new set of specified filter media prior to start of system test and balance. Furnish a new, clean set of the specified media and turn over to Owner's Representative.

3.10 TESTING MECHANICAL SYSTEMS

- A. Test all systems and equipment installed to demonstrate proper operation.

- B. Advise Architect of scheduled systems testing and completed system demonstration/operation schedules so that he may witness, if desired.
- C. Correct and retest work found defective when tested.
- D. Make repairs to piping systems with new materials. Peening, doping, or caulking of joints or holes will not be acceptable.
- E. HVAC Circulating Water Piping: Hydrostatically test piping at 150 psig pressure or at 1-1/2 times design pressure as indicated on drawings, whichever is greater, for a period of six hours without evidence of leaking.
- F. Ductwork Pressure Testing: Refer to Section 23 31 13 for required pressure testing for ductwork.
- G. System Balance and Testing: Prepare to assist test and balance firm by assuring systems are complete and operational.
- H. Test all smoke and combination fire/smoke, dampers by observing damper operation during fire alarm system commissioning.
- I. Records of Testing: Maintain records of system testing and results thereof. Deliver results as part of project closing file and on an intermediate basis as requested by Architect.

3.11 INFECTION CONTROL REQUIREMENTS

- A. Coordinate with the Owner the exact requirements for the infection control measures to be executed and performed during the course of this Project.
- B. Prior to execution, present to the Owner for approval a written execution plan for each infection control measure.
- C. Coordinate infection control measures as needed with all other trades and disciplines.
- D. Provide documentation of infection control measures to the Owner, as required and specified in the ICRA.

END OF SECTION

SECTION 23 05 23 - **GENERAL-DUTY VALVES FOR HVAC**

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Valves for chilled water systems.
- B. Valves for heating water systems.

1.2 RELATED REQUIREMENTS

- A. Section 23 21 13 - HVAC Piping

1.3 SUBMITTALS

- A. Submit product data for review in accordance with the requirements of Division 01.
- B. Indicate valve service, construction material, sizes and locations to be used.

1.4 QUALITY ASSURANCE

- A. Valve Bodies, Shells, and Seats: Factory tested.
- B. Bronze Body Valves:
 - 1. Materials for pressure containing parts: ASTM B-62 (less than 200 psi), B-61 (200 psi and above)
 - 2. Design, workmanship, testing: MSS-SP-80
- C. Iron Body Valves:
 - 1. Materials for pressure containing parts: ASTM A126, Grade B
 - 2. Face-to-face and end-to-end dimensions: ANSI B16.10
 - 3. Design, workmanship, testing: MSS-SP-70, 71 and 78.
- D. Butterfly Valves:
 - 1. Face-to-face and end-to-end dimensions: MSS-SP-67
- E. Valve Stems: ASTM B584-78, Class 13C (cast silicon brass), ASTM B-371-79, Alloy A (rolled silicon brass), or other material equally resistant to dezincification.
- F. Pressure Castings: Free of impregnating materials.
- G. Valve name or trademark and working pressure stamped or cast into body.
- H. Standard for 200 PSI and 300 PSI valves with metallic seats: ASTM B61-76.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Iron body valves: Crane, Dezurik, Kennedy, Kitz, Milwaukee, Mueller, Nibco, or Stockham.

- B. Bronze body valves: Dezurik, Kennedy, Kitz, Milwaukee, Nibco, or Stockham.
- C. Butterfly valves: Crane, Dezurik, Milwaukee, Mueller, Nibco, or Stockham.
- D. Ball valves: Apollo, Hammond, Jamesbury, Kitz, Milwaukee, Nibco, or Watts.

2.2 MATERIALS

- A. Nibco Figure numbers are indicated below unless noted otherwise:
- B. All isolation valves are to be ball valves or gate valves. Butterfly valves are not acceptable for isolation valve service.
- C. Ball Valves:
 - 1. HVAC Circulating Water Piping:
 - a. 2" and less, Figure T-585-70 or S-585-70, 2-piece, bronze, full port, 600 psi, WOG, PTFE seats.
 - 2. Provide ball valves with locking handles.
 - 3. Provide extended lever for insulated service.
- D. Valve Connections: Two inches and smaller - threaded; 2-1/2 inches and larger - flanged.
- E. Provide chain operators for gate valves, butterfly valves, and plug cocks located in mechanical rooms as required by mechanical plans or where valves are mounted above 7'-0" A.F.F.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Furnish and install valves in each piping connection at each piece of HVAC equipment to allow equipment to be isolated from piping systems.
- B. Furnish and install valves in all piping systems to isolate each floor or main section of the building. Install sufficient number of valves to minimize the portion of the system which must be shut down for service or maintenance purposes.
- C. Install valves in water piping systems so ordinary maintenance work can be performed on the equipment that the valves isolate, without having to drain the system beyond the valve.
- D. Locate valves so as to be easily accessible by maintenance personnel. Installation shall be made so that the valve can be fully opened and have a minimum clearance of 6" beyond valve stem end at the full open position and will include sufficient clearance for removal of stem for repair.
- E. Identify valves as required by Section 23 05 53.

END OF SECTION

SECTION 23 05 29 - HANGERS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Hangers for HVAC piping

1.2 RELATED REQUIREMENTS

- A. Section 23 05 23 - General Duty Valves for HVAC
- B. Section 23 07 00 - HVAC Insulation
- C. Section 23 21 13 - HVAC Piping

1.3 SUBMITTALS

- A. Submit product data for review in accordance with Division 01 requirements.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Anvil, B-Line, Carpenter and Patterson, Fee and Mason, Michigan, Reliable, and Viking. Anvil numbers are used for reference.
- B. Substitutions: Refer to Division 01.

2.2 HANGERS

- A. Anvil Figure #260 MSS Type 1, clevis hangers for:
 - 1. Non-insulated steel and galvanized piping 2" through 24" diameter
 - 2. Non-insulated PVC piping
- B. Anvil Figure #260 clevis hangers with Figure 167, MSS Type 40 galvanized insulation protection shields (sized for supporting insulation having a compressive strength of 4 psi). Support piping on outside of insulation. Size hangers so that pipe insulation passes through them without interruption.
 - 1. Heating water piping above 160 degrees F. 4" diameter and less.
 - 2. Chilled water piping
 - 3. All other insulated piping
- C. Anvil Figure CT-69, MSS Type 10 with adjustable wrought tubing ring hanger, copper plated for:
 - 1. Non-insulated copper tubing with no longitudinal movement
- D. Anvil Figure #171, MSS Type 41 with pipe roller, Anvil Figure #16x protection saddle and Anvil Figure 167, MSS Type 40 galvanized insulation protection shields (sized for supporting insulation having a compressive strength of 4 psi, at 8 foot intervals). Support piping on outside of insulation. Size hangers so that pipe insulation passes through them without interruption. Use these for:
 - 1. Heating water piping above 160 degrees F. 6" diameter and larger.

- E. Anvil Figure #CT-121, MSS Type 8, riser clamps (at floor slab penetrations) to support:
 - 1. Copper pipe risers
- F. Anvil Figure #261, MSS Type 8, galvanized riser clamps (at floor slab penetrations) to support:
 - 1. Steel pipe risers
 - 2. PVC pipe risers
 - 3. Polypropylene risers
- G. Anvil Powerstrut Trapeze Hangers: Where three or more lines of pipe run parallel, support them with trapeze hangers.
- H. Except for copper hangers, all other hangers and supports shall be hot-dipped galvanized.

2.3 INSERTS

- A. Concrete Insert: Anvil Figure #281, MSS Type 18, universal concrete inserts, adequately sized and correctly positioned to support full load operating systems.
- B. Concrete Insert, Wedge Type: Anvil Figure #281, 1/4" to 7/8"
- C. Lightweight Concrete Insert: Anvil Figure #285
- D. Continuous Concrete Insert: Anvil Powerstrut Figure #PS-349 pre-galvanized

2.4 EXPANSION ANCHORS

- A. Hilti Kwik-bolt, zinc-plated, metal expansion anchor.
- B. Anchor to meet U.L., ICBO-4627 and FM listings.

2.5 HANGER RODS

- A. Provide mild steel all-thread rods with maximum loads as follows:
 - 1. 3/8" - 300 lbs
 - 2. 1/2" - 600 lbs
 - 3. 5/8" - 1,200 lbs
 - 4. 3/4" - 2,000 lbs
 - 5. 1" - 5,000 lbs

2.6 CLAMPS

- A. C-Clamps: Anvil Figure #92, MSS Type 23.
 - 1. Use these for attaching hangers to steel beams. Do not weld hanger rods to structural steel members.
- B. Malleable Beam Clamps: Anvil Figure #218, MSS Type 30: Use these for attaching hangers to bar joists. Attach clamps to top chord of bar joists only. Confirm with structural engineer for maximum loading and restrictions.

PART 3 - EXECUTION

3.1 PIPE HANGERS

- A. Support pipes on specified hangers so that equipment, pumps, and fittings do not bear weight or stresses from vibration and swaying of pipe. Support pipe risers at regular intervals in pipe shafts at least once at each floor level or a maximum of 12'-0" apart. Do not use perforated metal, strap iron, or band iron. Do not make offsets in hangers.
- B. Maximum allowable spacing of pipe hangers is listed below. Space hangers and brackets at closer intervals where necessary to maintain levels, slopes, and drainage, or to prevent sagging or swaying of pipe.
- C. Steel and Galvanized Pipe - Water
 - 1. 1/4" to 1-1/2" - 7' 0" O.C.
 - 2. 2" to 2-1/2" - 10' 0" O.C.
 - 3. 3" to 4" - 12' 0" O.C.
 - 4. 5" and above - 14'0" O.C.
- D. Steel and Galvanized Pipe - Vapor
 - 1. 1/4" to 1-1/2" - 8' 0" O.C.
 - 2. 2" to 2-1/2" - 13' 0" O.C.
 - 3. 3" and above - 15' 0" O.C.
- E. Copper Pipe - Water
 - 1. 1/4" to 1-1/4" - 5'0" O.C.
 - 2. 2" to 2-1/2" - 8'0" O.C.
 - 3. 3" and above - 10'0" O.C.
- F. Copper Pipe - Vapor
 - 1. 1/4" to 1" - 5'0" O.C.
 - 2. 1-1/4" to 2" - 8'0" O.C.
 - 3. 2-1/2" to 4" - 10' 0" O.C.
 - 4. 5" and above -15' 0" O.C.
- G. Sway Bracing
 - 1. Provide sway bracing and additional supports to meet the seismic bracing requirements.

END OF SECTION

SECTION 23 05 48 - VIBRATION ISOLATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Vibration isolators, pipe supports, and equipment anchors, of appropriate sizes and weight loading to meet the specified deflection requirements, in accordance with instructions of isolator manufacturer.
- B. Vibration isolation for all Division 22 and 23 systems as noted below. Provide all miscellaneous items (angle iron, bolts, rods, etc.) required for a complete system. Contractor and vendors shall thoroughly coordinate all vibration isolation systems.
- C. Coordination of installation with other trades (placement of anchor bolts in concrete slabs, etc.)

1.2 RELATED REQUIREMENTS

- A. Section 01 45 33 - Code-Required Special Inspections
- B. Section 03 30 00 - Cast-in-Place Concrete
- C. Division 22: Plumbing

1.3 MANUFACTURER RESPONSIBILITIES

- A. Manufacturer of vibration isolation and seismic control products shall have the following responsibilities:
 - 1. Manufacturer of vibration isolation shall have the following responsibilities:
 - a. Determine vibration isolation and restraint sizes and locations for mechanical and plumbing equipment.
 - b. Determine vibration isolation sizes and locations for mechanical and plumbing equipment.
 - c. Provide isolation systems for all plumbing and mechanical of equipment (vibration isolated and non-isolated) and systems (piping and ductwork).
 - d. Provide installation instructions and drawings.
- B. Vibration isolation specialist shall coordinate his work with that of other trades to verify that equipment speeds, in revolution per minute (rpm), are based upon actual equipment installed at the project site.
- C. Verify that equipment rpm and spring deflection selected are arranged so that resonance is avoided.
- D. Exact mounting sizes, dimensions and quantity of isolators and static deflection required shall be determined by the isolator manufacturer based upon equipment that will be furnished and installed by the contractor under this Contract.

1.4 SUBMITTALS

- A. Submit product data and related information noted below in accordance with the provisions of Division 01.

- B. Contractor's Certification: Vibration isolator submittals shall include a certification, signed by an officer representing the Contractor and stipulating that the submittal prepared by the manufacturer has been reviewed, and checked on an item by item basis against each piece of mechanical equipment, piping, ductwork and panel shown or specified in the Contract Documents, which requires vibration isolation and/or support.
- C. Manufacturer's Certification: The manufacturer or manufacturers (if there are more than one) shall each certify that the selections of vibration isolation equipment are based upon the drawings and specifications, and that each piece of mechanical equipment has been examined for rotational speed, equipment type, mounting location, and supporting span between column centers, and that an appropriate isolator has been selected.
- D. Product Data: Furnish manufacturer's product data covering each isolator type for style, characteristic, and finish. Isolator quantities, dimensions, deflections, capacities and types shall remain the responsibility of the manufacturer and the contractor.
- E. Shop Drawings: Provide layout drawings, drawn to a scale of not less than 1/8-inch to 1-foot, showing the proposed layout of equipment and piping systems and the location and type of each vibration isolation and restraint device. Carefully examine other sections requiring coordinated shop drawings, including but not limited to Section 23 31 13, "Sheetmetal Ductwork", Section, "Sheetmetal - Special Ductwork", and prepare restraint/isolation shop drawings to the same scale showing the location of each vibration isolation equipment base, pipe hanger, flexible connection, and isolator restraint device.

1.5 QUALITY ASSURANCE

- A. Responsibility for Products: Select deflection for spring isolators in accordance with recommendations in the current issue of ASHRAE Handbook of Fundamentals, unless noted otherwise on drawings.
- B. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with not less than 10 years of documented experience.
 - 1. Member of Vibration Isolation and Seismic Control Manufacturers Association (VISCMA).

1.6 STORAGE AND PROTECTION

- A. Storage: Store vibration isolation equipment indoors in the manufacturer's original shipping containers. Preclude the entrance of construction dirt and debris. Vibration isolation equipment and bases, which show signs of rust, cement or concrete fouling, dirt and construction debris shall be disassembled and cleaned, approved or removed from the project site and replaced with new.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Amber Booth, Kinetics Noise Control, Korfund Company, Mason Industries, Vibration Eliminator Co., or Vibration Mountings & Controls.
- B. Furnish vibration isolators by single manufacturer.
- C. Substitutions: Not permitted.

2.2 PRODUCTS

- A. Type 1: Mason Super "W", 2 layers of 3/4" neoprene pad with 16 ga. galvanized shim.
- B. Type 2: Mason BR, two neoprene elements housed in a ductile iron casting.
- C. Type 3: Mason SLF, free standing spring isolator, 1/4" neoprene non-skid pad, leveling bolt, spring diameter no less than 0.8 of compressed height at rated load, minimal additional travel to solid equal to 50% or rated deflection.
- D. Type 4: Mason SLR, restrained spring isolator, vertical limit stops, internal isolation pad.
- E. Type 6: Mason 30N, spring and double neoprene hanger, 1-1/4" neoprene element at top of housing, spring seated in neoprene cup at bottom of housing, designed to allow 30 degrees arc from side to side of hanger rod.
- F. Type 10: Mason BMK rectangular steel frame form for concrete inertia base, 1/2" reinforcing bars on 6" centers, both ways.
- G. Type 11: Mason RSC, spring isolation curb for roof mounted equipment, heavy gauge Z section sheet metal base that supports adjustable and removable restrained spring mounts, top section to be continuous rail support for equipment; springs to rest on 1/4" neoprene pads; hardware shall be plated and springs furnished with rust resistant finish; curb to be waterproofed using continuous galvanized flexible counter flashing, joined at corners with EDAM bellows; spring locations to have removable, waterproof access ports.
- H. Type 12: Mason BBS flexible stainless steel braided hose; minimum lengths as follows:
 - 1. 1/2" - 1-1/2" : 12"
 - 2. 2" - 4" : 18"
 - 3. 6" - 10" : 24"
 - 4. 12" - 16" : 32"
- I. Type 13: Mason HS spring hanger, spring seated in neoprene cup.
- J. Type 14: Mason WF steel frame base, with motor slide rail.
- K. Type 15: Mason SafeFlex flexible rubber pipe connection, peroxide cured EPDM with Kevlar tire cord reinforcement, raised face rubber flanges with encased solid steel rings.
 - 1. 14" diameter and below: Mason SFDEJ twin sphere with reinforcing ring; minimum pressure rating of 250 psi at 170 degrees F. and 215 psi at 250 degrees F.
 - 2. 16" diameter and above: Mason SFEJ single sphere; minimum pressure rating of 180 psi at 170 degrees F. and 150 psi at 250 degrees F.
 - 3. Control rods; Mason CR with 1/2" thick Neoprene washer bushings.

2.3 MATERIALS AND EQUIPMENT

- A. Materials and equipment shall conform to the respective specifications and other requirements specified below:
 - 1. Squarehead bolts and heavy hexagon nuts, ANSI B18.2.1 and ANSI B18.2.2, and ASTM A 307 or ASTM A 576.

2. Sway Brace Material used for members shown on mechanical drawings, except for pipes, shall be structural steel conforming with ASTM A 36. Steel pipes shall conform to ASTM A 501.

PART 3 - EXECUTION

3.1 VIBRATION CONTROL

- A. Size vibration control equipment in accordance with weight distribution, pull or the imposed torque as shown on equipment shop drawings. Minimum static deflections may be revised subject to prior approval.
- B. Provide revised vibration control equipment to match revised or substituted equipment.
- C. Install vibration control equipment in accordance with the manufacturer's installation instructions and as specified.
- D. Install equipment on vibration isolation curbs to provide watertight seal.

3.2 APPLICATIONS

- A. Equipment: Use the vibration and restraint types listed above on the following applications:
 1. A/C units, indoor, not internally isolated
 - a. Type 3
 - b. Type 5
 2. Fans, Floor mounted
 - a. Slab on grade: Type 3
 - b. Upper floors: Type 3, 10
 3. Fans, suspended
 - a. Type 6, 14
- B. Ductwork
 1. All ductwork that is suspended such that the distance from the top of the duct to the point of attachment to structure above is 12" or less does not need to be seismically restrained.
- C. Piping
 1. Provide Type 6 vibration isolation on following piping:
 - a. Closest two hangers on piping at air handling units and blower coil units.
 - b. HVAC water piping within 20 pipe diameters each side of HVAC pumps.
- D. Use hold down clamps to attach multiple pipes to trapeze hangers.

3.3 ANCHORING

- A. Installation: Installation shall comply with manufacturer's published recommendations and shall be installed so that isolators are plumb and are operating at a manner for which they were designed.
- B. Unless otherwise specified, all equipment shall be securely bolted to isolators, steel bases or concrete inertia bases.

3.4 ANCHOR BOLTS

- A. If the size and number of the anchor bolts are not shown on the drawings then anchor bolts shall conform to the schedule for the various equipment weights or the manufacturer's installation recommendations, whichever is the most stringent.

3.5 MISCELLANEOUS EQUIPMENT

- A. The following specific items of equipment to be furnished under this contract shall be manufactured and assembled, and constructed so as to be capable of withstanding the horizontal equivalent static force of 0.11 times the operating weight of the equipment, at vertical center of gravity of the equipment without causing permanent deformation, dislocations, separation of components, or other damage, which would render the equipment inoperative for significant periods of time following an earthquake.
 - 1. Air-Handling Units

3.6 INSTALLATION

- A. Set anchor bolts when concrete is placed.
- B. Install isolators in accordance with recommendations of isolator manufacturer and equipment manufacturer.
- C. Isolate mechanical equipment as indicated.
- D. Remove all debris from under equipment, and thoroughly clean steel bases, inertia bases and check for free movement.

END OF SECTION

SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. HVAC systems testing and balancing requirements.

1.2 REFERENCE STANDARDS

- A. AABC - Associated Air Balance and Control
- B. NEBB - National Environmental Balancing Bureau

1.3 SCOPE OF WORK

- A. Perform test and balance in accordance with AABC or NEBB Standards.
- B. Water systems: Adjusted to deliver design flow rates and pressure requirements.
- C. Air and water balance shall be performed by qualified personnel experienced in this field.
- D. The air balance procedure followed and forms used shall agree with AABC or NEBB Standards.
- E. Make changes to pulleys, belts, dampers, impellers, and similar equipment to obtain design conditions as required by TAB procedures.
- F. The Architect, Engineer, Owner, or Owner's Representative may request a recheck, resetting, or verification of an air or water related item within 90 days of the completion of work. The work shall be provided at no additional cost.

PART 2 - PRODUCTS

2.1 NOT APPLICABLE

PART 3 - EXECUTION

3.1 PROCEDURES

- A. On completion of work, submit three copies of the complete report to include the following:
 - 1. Current certification documentation of all TAB equipment used.
 - 2. Current certification of TAB personnel responsible for the work.
 - 3. Dates, time, all personnel, and operating status of cooling and heating systems.
 - 4. A description of the procedure used for air and water balance.

3.2 AIR SYSTEMS

- A. Balance supply, return, and exhaust air outlets within 10% of design while still maintaining required pressure relationships.
- B. On each fan system, measure and report:

1. Design and actual fan RPM. Fan suction and discharge pressure. Fan total static pressure, and pressure drop across components. Design and actual supply, return, exhaust, and outside air CFM.
 2. Actual and motor nameplate voltage and amperage on fans.
 3. Design and actual entering and leaving air temperatures, heating and cooling (dry bulb and wet bulb) of the supply, return, exhaust, and outside air.
- C. For diffusers and grilles, measure, adjust, and report:
1. Design and actual CFM and FPM at each supply, return, and exhaust outlet.

3.3 WATER SYSTEMS

- A. For water systems, measure, adjust and report:
1. Design and actual GPM.
 2. Discharge and suction head for each pump.
 3. Actual and motor nameplate voltage for each pump.
 4. Design and actual GPM and entering/leaving temperatures of heating water through each heat exchanger.
 5. Design and actual water temperature difference and water pressure drop through air tempering coils at air terminal units, air handling units, and duct mounted reheat coils.

END OF SECTION

SECTION 23 07 00 - HVAC INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Pipe insulation
- B. HVAC equipment insulation
- C. Ductwork insulation

1.2 RELATED REQUIREMENTS

- A. Section 23 05 53 - Identification for HVAC Piping and Equipment
- B. Section 23 21 13 - Hydronic Piping
- C. Section 23 21 14 - Hydronic Specialties
- D. Section 23 31 13 - Sheetmetal Ductwork

1.3 DEFINITIONS

- A. Exposed - Equipment, ducts and piping in areas which will be visible without removing ceilings or opening access panels.
- B. Concealed - Installed above ceiling, in walls or chases.
- C. Outdoors - Exposed to the weather or ambient conditions.
- D. Underground - Buried.

1.4 REFERENCE STANDARDS

- A. ASTM C553 - Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications; 2013.
- B. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation; 2014.
- C. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material); 2012.
- D. ASTM C1290 - Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts; 2011.
- E. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation; 2013.
- F. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form; 2013.

- G. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation; 2012.
- H. ASTM C552 - Standard Specification for Cellular Glass Thermal Insulation; 2013.
- I. ASTM C578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation; 2013.
- J. SMACNA (DCS) - HVAC Duct Construction Standards; Sheet Metal and Air Conditioning Contractors' National Association; 2005.

1.5 SUBMITTALS

- A. Provide product data and required information under the provisions of Division 01.
- B. Submit manufacturer's product data and installation procedures for review. Product data shall identify specific thermal characteristics, list of materials and thickness for each service.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: ISO 9001-2000 certified.
- B. Fire-Test Response Characteristics: Testing in accordance with ASTM E84. Insulation and related materials, adhesives, coatings, sealers, jackets and tapes, shall have a fire-test response characteristic of: Flame spread rating of 25 or less; Smoke development of 50 or less.
- C. Materials shall meet the requirements of NFPA 90A.

PART 2 - PRODUCTS

2.1 PIPE AND EQUIPMENT INSULATION

- A. Materials for Pipe and Equipment: Provide factory premolded insulation for pipe, pipe fittings, and valves.
- B. Fitting insulation: Same thickness and material as adjoining pipe insulation.
- C. Cellular Glass (Foamglas):
 - 1. Acceptable manufacturers: Pittsburgh Corning "Foamglas"; minimum "R" value of 2.63.
 - 2. Mastic: Water based, Foster 30-80 or equal
 - a. Outside Applications: Foster Vapor Safe 30-80, Childers Chil Low CP-38 or Vimasco 749. Co. Coatings must meet MIL 19565C and be QPD listed. Permeance shall be 0.013 perms or less at 43 mils dry per ASTM E 96.
 - b. Inside applications: Foster Vapor Fas 30-65, Childers CP-34 or Vimasco 739. Permeance shall be 0.03 perms or less at 45 mils dry per ASTM E 96."
 - 3. Use on the following services:
 - a. Chilled water piping located in central plants and outdoors , 2" and less pipe, 1-1/2" thick; 2-1/2" and greater, 2" thick.
 - b. At hanger and support points as specified herein.
- D. Flexible Tubular Elastomeric:
 - 1. Provide fire-retardant closed-cell slip-on flexible type; minimum "R" value of 2.57

2. Acceptable manufacturers: Aeroflex "Aerocel", Armacell "AP/Armaflex", or K-Flex "Insul-Tube".
 3. Use on the following services:
 - a. Moisture condensate drains: 1/2" thick.
- E. Fiberglass Pipe Insulation:
1. Acceptable manufacturers: Johns-Manville "Micro-Lok 850, CertainTeed, Knauf, or Owens Corning.
 2. Jacket: ASJ fiberglass reinforced kraft paper with aluminum foil; minimum R value of 3.6.
 3. Use on the following services:
 - a. Chilled water piping: 1-1/2" thick.
 - b. Heating water piping:
 - 1) Pipe sizes 1 1/2" and less: 1-1/2" thick.
 - 2) Pipe sizes 2" and greater: 2" thick.
 - 3) Insulate all run outs to coil connections including valves, control valves, fittings and connections regardless of the piping size or length of the run out.

2.2 DUCTWORK INSULATION

- A. Blanket Type Duct Insulation:
1. Acceptable manufacturers: CertainTeed, Johns-Manville, Knauf, or Owens Corning.
 2. Provide with Foil Reinforced Kraft (FSK) vapor barrier, providing the minimum "R" value and pound per cubic foot (PCF) density shown below.
 3. Use on the following:
 - a. Unlined supply air ductwork in an unconditioned space, including concealed above ceiling: 2.2", 0.75 PCF, installed "R" value of 6.0.
 - b. Unlined supply air ductwork serving low temperature systems including operating rooms and cath labs: 3.0", 0.75 PCF, installed "R" value of 8.3. Overlapping layers with offset seams is acceptable to meet the "R" value indicated.
 - c. Unlined, exposed supply air ductwork: 2.2", 0.75 PCF, installed "R" value of 6.0.
 - d. Unlined make-up air ductwork: 1.5", 0.75 PCF, installed "R" value of 4.2.
 - e. Unlined ductwork supplying outside air: 2.2", 0.75 PCF, installed "R" value of 6.0.
 - f. Unlined return air ductwork installed in an unconditioned space, including concealed above ceiling: 2.2", 0.75 PCF, installed "R" value of 6.0.
 - 1) Insulation may be omitted from exposed low pressure return air ductwork in area served by the ductwork, except where the exposed ductwork is in rooms with doors/openings to the exterior.
 - g. Unlined exhaust air ductwork installed in an unconditioned space, including concealed above ceiling: 1.5", 0.75 PCF, installed "R" value of 4.2.
 - 1) Insulation may be omitted from exposed low pressure return air ductwork in area served by the ductwork, except where the exposed ductwork is in rooms with doors/openings to the exterior.
 - 2) Insulation may be omitted except where exhaust ductwork is installed in a plenum directly below the roof.
 - h. Unlined relief air ductwork within equipment rooms: 1-1/2" thick.
 - i. Reheat coils, including reheat coils at terminal boxes: 2.2", 0.75 PCF, installed "R" value of 6.0.

2.3 MATERIALS FOR FITTINGS, VALVES, AND SPECIAL COVERINGS

- A. For all services, use full thickness premolded insulation for pipe fittings, elbows, tees, valves, and couplings 2-1/2 and larger. Finish shall be as specified under Products above or as

specified below. PVC fitting covers may be used over the premolded insulation for chilled water and heating water systems.

- B. PVC fitting covers with full thickness fiberglass inserts may be used on piping fittings elbows and valves 2" and less for chilled water and heating water systems.
- C. For tanks, heat exchangers and large pipes in systems operating over 60 degrees F. When exposed-to-view inside building or in equipment rooms, cover insulation with a smoothing coat of Keane Powerhouse cement, one layer of white colored woven glass fabric embedded and finished with Foster GPM mastic.
- D. For pipe fittings, valves, strainers, and other irregular surfaces, in chilled water or refrigerant systems operating below 60 degrees F, when inside building or in equipment rooms, cover insulation with white colored woven glass fabric embedded in white vapor barrier coating, Foster 30-35 or equal.
- E. For any service when above grade exposed-to-the-weather outside building or in tunnels or manholes, cover straight pipe insulation with 0.016" thick smooth, aluminum jacket equivalent to Childers and cover fittings with factory formed covers equivalent to Ell jacs. Install jacket seams on bottom of pipe.
- F. For any service, except for steam and steam condensate, when below grade direct buried, cover straight pipe and fitting insulation with equivalent of Pittsburgh Corning "Pittwrap" or "Pittcoat No. 300 with PC Fabric 79". Valves in systems operating above 60 degrees F and installed in valve boxes shall not be insulated, however the valves shall be painted with rust-resistant product equivalent to Rustoleum.
- G. For flexible tubular elastomeric pipe and fitting insulation when exposed-to-view inside building or exposed to the weather, finish with two coats of fire retardant self-extinguishing vinyl lacquer type highly flexible coating equivalent to Armstrong "Armaflex Finish", custom color blended to match surrounding surfaces.
- H. For externally insulated sheet metal ducts when above grade exposed-to-the-weather outside building, slope ductwork and insulation to allow drainage and prevent ponding of water on top of ductwork. Cover duct insulation with glass mesh embedded and adhered to insulation using air drying weatherproof plastic fabricated cutback asphalt adhesive and finish with two coats of gray color flexible fire retardant protective coating having proven ability to withstand a wide range of temperatures without cracking or crazing and be highly resistant to damage by bumping and abrasion. Product shall be Johns-Mansville, Insulkote, or equivalent.
- I. Use prefabricated removable insulated, valve jackets on all valves in steam and steam condensate piping. Insulated jackets shall cover the entire valve including flanges and bonnet.
 - 1. Acceptable manufacturers: Auburn Manufacturing, Inc. (AMI) or ThermaXX.
 - 2. Inner lining: AMI GL2025-XX-9383 heat treated fiberglass cloth (<450F).
 - 3. Insulating material: AMI AM1000 needled fiberglass mat (<1000F).
 - 4. Outer cover: AMI AGL2025 aluminum foil laminated fiberglass cloth.
 - 5. Fastener: AMI GLR fiberglass draw string.
- J. Provide steel insulation shields on steam piping as specified in Section 23 05 29 when roller hangers are utilized.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

- A. Deliver and store insulation materials in manufacturers containers and keep free from dirt, water, chemical and mechanical damage.
- B. Complete piping and ductwork pressure testing prior to applying insulation.
- C. Apply insulation in workmanlike manner by experienced, qualified, workmen.
- D. Surfaces shall be clean and dry when covering is applied. Covering to be dry when installed and before and during application of any finish, unless such finish specifically requires a wetted surface for application.
- E. Adhesives, cements and mastics shall be compatible with materials applied and shall not attack materials in either wet or dry state.
- F. Stop duct coverings, including jacket and insulation, at fire penetrations of fire or smoke rated partitions, floors above grade and roofs. "Fan-out" or extend jacketed insulation at least 2" beyond angle frames of fire dampers and secure to wall. Maintain vapor barrier.

3.2 BLANKET TYPE DUCT INSULATION

- A. Apply jacketed blanket type glass fiber covering to ducts pulled snug but not so tight as to compress corners more than 1/4". Use insulation having 2" tab, or cut insulation long enough to allow for "peel-off" of insulation from jacket to effect a minimum overlap of 2". Staple lap with flare type staples on 1" centers. Cover standing seams, stiffeners, and braces with same insulation blanket, using 2" jacket lap and staple lap as herein before outlined. Cover and seal all staples with Foster 30-80 reinforced with glass cloth. Do not use pressure sensitive tape.
- B. Secure jacket to covering using equivalent of Foster No. 85-20 or Childers CP-82 adhesive.
- C. For ducts 24" or wider, mechanically fasten insulation to duct bottom, using weld pins having self-locking, metal discs, locating fasteners on not over 12" centers laterally and longitudinally. Seal pins as above.
- D. For ducts up to 24" deep, mechanically fasten insulation to duct sides, using one row of pins, plates or discs located on not over 12" centers longitudinally and equidistant laterally between duct top and bottom. For ducts 24" deep and greater, apply fasteners as before only using minimum of two rows.

3.3 INSTALLATION OF PIPE AND EQUIPMENT COVERING

- A. Where glass fiber or flexible tubular elastomeric insulation is used on piping sized 2" and larger, insert a section of foamglass or calcium silicate insulation, at hanger or support points, between pipe and metal shield for full length of shield, to prevent crushing of insulation. Where insulation passes through pipe hangers and across trapeze supports, 12" long metal saddles shall be used. Insulation thickness to be same as adjoining glass fiber insulation. On cold pipe, vapor barrier should be carried through the hanger and sealed. Saddles shall be used where rigid foamglass inserts are not acceptable. Pipe saddles shall cover 180 degrees of the pipe.

- B. Foamglass insulation shall be strictly applied as follows:
1. Both the circumferential and longitudinal joints shall be buttered with fire-resistive pliable sealer. Voids and cracks shall be filled with sealer. Mastic shall be Foster 30-80 or equal. Secure insulation with 3/4" wide x 0.010" thick aluminum bands on 8" centers.
 2. The circumferential joints shall be staggered.
 3. Fittings, valves, flanges, traps, and air vents shall be insulated with the same thickness of insulation using factory fabricated fitting sections or pre-molded insulated fittings.
 4. Block type insulation shall be adhered by stick-clips or bands, in addition to the sealer, as required to provide support for the insulation.
 5. Finish above furred ceilings and in chases shall be the bare insulation.
 6. Finish in equipment rooms and elsewhere where exposed-to-view shall be white ASJ.
 7. Finish where exposed-to-the-weather shall be Childers, or equal, .016 inch thick aluminum jacket on piping and Ell jacs, or equal, pre-formed aluminum covering on fittings.
 8. Finish on underground insulation shall be Pittsburgh Corning Pittwrap as recommended by manufacturer.
- C. Apply flexible tubular elastomeric insulation to pipe and fittings with all joints tightly fitted and sealed with adhesive.
- D. Apply semi-rigid high temperature, fiberglass board insulation as recommended by the manufacturer.
- E. Apply flexible high temperature blanket type in two steps. First, cover fitting with 1/2" thick matt only; then apply finished envelope containing 2" thick matt material. Secure envelope using stainless steel or monel bands, hooks washers, and lacing.
- F. Heat Traced Piping: Insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size large enough to enclose pipe and heat tracer. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

END OF SECTION

SECTION 23 09 13 - INSTRUMENTATION AND CONTROL DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Provide input and output control devices to integrate with direct digital control and building automation system.
- B. Furnish instrumentation control devices as an integral part of the Building Automation Section specified in Section 23 09 23.

1.2 RELATED REQUIREMENTS

- A. Section 23 05 00 - Common Work Results for HVAC
- B. Section 23 09 23 - Building Automation and Direct Digital Controls
- C. Section 23 20 00 - HVAC Piping
- D. Section 23 31 13 - Sheetmetal Ductwork
- E. Section 23 36 00 - Air Terminal Units
- F. Division 26: Electrical

1.3 SUBMITTALS

- A. Submit product data and schedules for all input/output devices.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Provide products and components by manufacturers listed. Where manufacturers are not listed, provide component that complies with specifications.
- B. Manufacturers listed must meet performance and material specifications of product or component. Listing of a manufacturer as an acceptable manufacturer does not grant permission to deviate from the specification requirements.

2.2 INPUT DEVICES

- A. General Requirements
 - 1. Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements.
- B. Temperature Sensors
 - 1. Acceptable Manufacturers: Automated Logic, Johnson Controls, Setra, or Siemens.
 - a. Substitutions: Not permitted.
 - 2. General Requirements:

- a. Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.
 - b. The temperature sensor shall be of the resistance type, and shall be either two-wire 1000 ohm nickel RTD, or two-wire 1000 ohm platinum RTD.
 - c. Accuracy values indicated include errors associated with the sensor, lead wire, and analog to digital conversion.
3. Room Temperature Sensors
- a. Refer to temperature sensor legend, schedules, floor plans, and control sequences for specific room temperature sensor requirements in each zone.
 - b. Room sensors shall be constructed for either surface or wall box mounting.
 - c. Room sensors shall have the following options when specified:
 - 1) Local setpoint adjustment providing a +/- 3 degree (adjustable) range.
 - 2) Timed override request push button with LED status for activation of after-hours operation.
 - 3) Flush mounting (sensor only, no local adjustment)
 - 4) Integral LCD display and keypad with the following capabilities:
 - (a) Display room and outside air temperatures.
 - (b) Display room setpoint.
 - (c) Password selectable adjustment of setpoint and override modes.
4. Stand Alone Thermostats
- a. Stand alone, heavy-duty electric thermostats shall be provided for unit heaters, cabinet unit heaters, and ventilation fans, when equipment is not indicated to be connected to the BAS. Thermostats shall be provided with concealed adjustment and function to cycle the equipment fan, electric coil, and/or control valves as applicable to maintain the space temperature setpoint. Finish of covers for all room-type instruments shall match and, unless otherwise indicated or specified, covers shall be manufacturer's standard finish.
5. Thermo Wells
- a. When thermo wells are required, the sensor and well shall be supplied as a complete assembly, including wellhead and Greenfield fitting.
 - b. Thermo wells shall be pressure rated and constructed in accordance with the system working pressure.
 - c. Thermo wells and sensors shall be mounted in a threadolet or 1/2" NPT saddle and allow easy access to the sensor for repair or replacement.
 - d. Thermo wells shall be constructed of 316 stainless steel.
6. Outside Air Sensors
- a. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.
 - b. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate that surrounds the sensor element.
 - c. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.
7. Duct Mount Sensors
- a. Duct mount sensors shall mount in an electrical box through a hole in the duct, and be positioned so as to be easily accessible for repair or replacement.
 - b. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.
 - c. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.
8. Averaging Sensors
- a. Provide at the following locations:
 - 1) Heating coils and cooling coils at air handling units and fan coil units.

- 2) Ductwork greater in any dimension than 48 inches and/or where air temperature stratification exists.
 - b. For plenum applications, such as mixed air temperature measurements, a string of sensors mounted across the plenum shall be used to account for stratification and/or air turbulence. The averaging string shall have a minimum of 4 sensing points per 12-foot long segment.
 - c. Capillary supports at the sides of the duct shall be provided to support the sensing string.
9. Low Limit Temperature Sensors
- a. Provide vapor charged sensing element that reacts to coldest 14" of sensor length.
 - b. Sensor shall have field adjustable setpoint.
- C. Humidity Sensors
1. Acceptable Manufacturers: Johnson Controls, Mamac, or Veris Industries.
 - a. Substitutions: Not permitted.
 2. The sensor shall be a solid-state type, relative humidity sensor of the Bulk Polymer Design. The sensor element shall resist service contamination.
 3. The humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2-wire isolated loop powered, 4-20 mA, 0-100% linear proportional output.
 4. The humidity transmitter shall meet the following overall accuracy, including lead loss and Analog to Digital conversion. 3% between 20% and 80% RH @ 77 Deg F unless specified elsewhere.
 5. Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with sealite fittings and stainless steel bushings.
 6. A single point humidity calibrator shall be provided, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.
 7. Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.
- D. Differential Pressure Transmitters
1. Acceptable Manufacturers: Automated Logic, Johnson Controls, Mamac, Setra, or Siemens.
 - a. Substitutions: Not permitted.
 2. General Air and Water Pressure Transmitter Requirements:
 - a. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.
 - b. Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.
 - c. Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device, and shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing Contractor and Owner permanent, easy-to-use connection.
 - d. A minimum of a NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.
 3. Differential Pressure Transmitters: (chilled water and hot water systems)
 - a. Provide self-contained, variable capacitance type differential pressure transmitters at chillers, boilers and air handling units to measure system and equipment differential pressures.
 - b. Installed by the contractor where indicated on the drawings including system DPs at AHU coils and across chillers. Wiring terminals and electronics shall be in separate

- compartments, so the electronics remain sealed during installation. Reverse polarity protection shall be included to keep wiring mishaps from damaging the transmitter. Wiring installed by the contractor between the control system and the transmitter(s) shall be Belden 9320, two wire, shielded twisted cable, and shall not be included in conduit containing AC circuit wiring.
- c. Design range shall be as required by system. External zero and span adjustments, over-pressure to 2,000 PSI, and no humidity effects.
 - d. Minimum accuracy shall be 0.25% of calibrated span. Includes combined effects of linearity, hysteresis and repeatability. Stability shall be 0.25% of upper range limit for six months. No internal mechanical linkages shall be used in the transmitter(s).
 - e. Low Differential Water Pressure Applications (0" - 20" w.c.)
 - 1) The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of flow meter differential pressure or water pressure sensing points.
 - 2) The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
 - (a) .01-20" w.c. input differential pressure range.
 - (b) 4-20 mA output.
 - (c) Maintain accuracy up to 20 to 1 ratio turndown.
 - (d) Reference Accuracy: +0.2% of full span.
 - f. Medium to High Differential Water Pressure Applications (Over 21" w.c.)
 - 1) The differential pressure transmitter shall meet the low pressure transmitter specifications with the following exceptions:
 - (a) Differential pressure range 10" w.c. to 300 PSI.
 - (b) Reference Accuracy: +1% of full span (includes non-linearity, hysteresis, and repeatability).
 - 2) Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.
4. Building Differential Air Pressure Applications (-1" to +1" w.c.)
- a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.
 - b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
 - 1) -1.00 to +1.00 w.c. input differential pressure ranges. (Select range appropriate for system application)
 - 2) 4-20 mA output.
 - 3) Maintain accuracy up to 20 to 1 ratio turndown.
 - 4) Reference Accuracy: +0.2% of full span.
5. Building Low Range Differential Air Pressure Applications (0" to 5" w.c.)
- a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.
 - b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
 - 1) (0.00 - 1.00" to 5.00") w.c. input differential pressure ranges. (Select range appropriate for system application.)

- 2) 4-20 mA output.
 - 3) Maintain accuracy up to 20 to 1 ratio turndown.
 - 4) Reference Accuracy: +0.2% of full span.
6. Building Medium Range Differential Air Pressure Applications (5" to 21" w.c.)
- a. The pressure transmitter shall be similar to the Low Air Pressure Transmitter, except that the performance specifications are not as severe. Differential pressure transmitters shall be provided that meet the following performance requirements:
 - 1) Zero & span: (c/o F.S./Deg. F): .04% including linearity, hysteresis and repeatability.
 - 2) Accuracy: 1% F.S. (best straight line) Static Pressure Effect: 0.5% F.S. (to 100 PSIG.
 - 3) Thermal Effects: <+.033 F.S./Deg. F. over 40 Deg. F. to 100 Deg. F. (calibrated at 70 Deg. F.).
 - b. Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.
7. Multi-point Monitors (MPM)
- a. Acceptable Manufacturers: Critical Room Control, Paragon Controls, Inc., Phoenix Controls, or TSI Pressura.
 - 1) Substitutions: Not permitted.
 - b. Provide wall mounted monitors as scheduled, indicated on floor plans, or described in controls sequences to display and allow setpoint adjustment of differential pressure, temperature, humidity, air change rates, and/or door switch status.
 - c. Provide external temperature and humidity sensors as required to obtain specified MPM input signals.
 - d. Pressure range: -0.20000 to +0.20000" w.c.
 - e. Resolution: 5% of reading.
 - f. Accuracy: +/- 10% of reading +/-0.00001" w.c.
 - g. Display update: 0.5 seconds.
 - h. Alarm contacts: Contacts close in alarm conditions.
 - i. Analog Output: 0-10vDC or 4-20mA
 - j. Ability to accept pressure measurement from two rooms.
 - k. RS-485 communication capability for interface with Building Automation System.
- E. Power Monitoring Devices
1. Acceptable manufacturers: Veris Industries.
 - a. Substitutions: Refer to Division 01.
 2. Current Measurement (Amps)
 - a. Current measurement shall be by a combination current transformer and a current transducer. The current transformer shall be sized to reduce the full amperage of the monitored circuit to a maximum 5 Amp signal, which will be converted to a 4-20 mA DDC compatible signal for use by the Facility Management System.
 - b. Current Transformer - A split core current transformer shall be provided to monitor motor amps.
 - 1) Operating frequency - 50 - 400 Hz.
 - 2) Insulation - 0.6 Kv class 10Kv BIL.
 - 3) UL recognized.
 - 4) Five amp secondary.
 - 5) Select current ration as appropriate for application.
 - 6) Acceptable manufacturers: Veris Industries

- c. Current Transducer - A current to voltage or current to mA transducer shall be provided. The current transducer shall include:
 - 1) 6X input over amp rating for AC inrushes of up to 120 amps.
 - 2) Manufactured to UL 1244.
 - 3) Accuracy: +.5%, Ripple +1%.
 - 4) Minimum load resistance 30kOhm.
 - 5) Input 0-20 Amps.
 - 6) Output 4-20 mA.
 - 7) Transducer shall be powered by a 24VDC regulated power supply (24 VDC +5%).

- F. Smoke Detectors
 - 1. Ionization type air duct detectors shall be furnished as specified elsewhere in Division 28. for installation under Division 23. All wiring for air duct detectors shall be provided under Division 28, Fire Alarm System. Coordinate interface with BAS and Fire Alarm System.

- G. Status and Safety Switches
 - 1. General Requirements
 - a. Switches shall be provided to monitor equipment status, safety conditions, and generate alarms at the BAS when a failure or abnormal condition occurs. Safety switches shall be provided with two sets of contacts and shall be interlock wired to shut down respective equipment.
 - 2. Current Sensing Switches
 - a. Acceptable manufacturers: Veris Industries.
 - 1) Substitutions: Refer to Division 01.
 - b. The current sensing switch shall be self-powered with solid-state circuitry and a dry contact output. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip point range.
 - c. Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.
 - d. Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.
 - 3. Air Filter Status Switches
 - a. Acceptable manufacturers: Automated Logic, Cleveland Controls, Johnson Controls, or Siemens.
 - 1) Substitutions: Refer to Division 01.
 - b. Differential pressure switches used to monitor air filter status shall be of the automatic reset type with SPDT contacts rated for 2 amps at 120VAC.
 - c. A complete installation kit shall be provided, including: static pressure tops, tubing, fittings, and air filters.
 - d. Provide appropriate scale range and differential adjustment for intended service.
 - 4. Air Flow Switches
 - a. Acceptable manufacturers: Automated Logic, Cleveland Controls, Johnson Controls, or Siemens.
 - 1) Substitutions: Refer to Division 01.
 - b. Differential pressure flow switches shall be bellows actuated mercury switches or snap acting micro-switches with appropriate scale range and differential adjustment for intended service.
 - c. Acceptable manufacturers: Johnson Controls, Cleveland Controls

5. Air Pressure Safety Switches
 - a. Acceptable manufacturers: Automated Logic, Cleveland Controls, Johnson Controls, or Siemens.
 - 1) Substitutions: Refer to Division 01.
 - b. Air pressure safety switches shall be of the manual reset type with SPDT contacts rated for 2 amps at 120VAC.
 - c. Pressure range shall be adjustable with appropriate scale range and differential adjustment for intended service.
6. Differential Pressure / Water Flow Switches
 - a. Acceptable manufacturers: Johnson Controls (model P74).
 - 1) Substitutions: Refer to Division 01.
 - b. Switch shall contain heavy duty pressure elements and be used to measure and relay the pressure difference between two sources or across the inlet/outlet of equipment.
 - c. Device shall be an automatic reset device and shall provide a control output at the differential pressure setpoint.
7. Low Temperature Limit Switches
 - a. Acceptable manufacturers: Johnson Controls (model A70).
 - 1) Substitutions: Refer to Division 01.
 - b. The low temperature limit switch shall be of the manual reset type with Double Pole/Single Throw snap acting contacts rated for 16 amps at 120VAC.
 - c. The sensing element shall be a minimum of 15 feet in length and shall react to the coldest 18-inch section. Element shall be mounted horizontally across duct in accordance with manufacturers recommended installation procedures.
 - d. For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required to provide full protection of the air stream.

2.3 OUTPUT DEVICES

A. Actuators

1. Acceptable manufacturers: Johnson Controls or Mamac.
 - a. Substitutions: Refer to Division 01.
2. General Requirements
 - a. Damper and valve actuators shall be electronic and/or pneumatic, as specified in the System Description section.
3. Electronic Damper Actuators
 - a. Electronic damper actuators shall be direct shaft mount.
 - b. Modulating and two-position actuators shall be provided as required by the sequence of operations. Damper sections shall be sized Based on actuator manufacturer's recommendations for face velocity, differential pressure and damper type. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers, as required. All actuators (except terminal units) shall be furnished with mechanical spring return unless otherwise specified in the sequences of operations. All actuators shall have external adjustable stops to limit the travel in either direction, and a gear release to allow manual positioning.
 - c. Modulating actuators shall accept 24 VAC or VDC power supply, consume no more than 15 VA, and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA, and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal and may be used to parallel other actuators and provide true position indication. The feedback signal of one

damper actuator for each separately controlled damper shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.

- d. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Isolation, smoke, exhaust fan, and other dampers, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop associated fan. Two-position actuators, as specified in sequences of operations as "quick acting," shall move full stroke within 20 seconds. All smoke damper actuators shall be quick acting.
4. Electronic Valve Actuators
- a. Electronic valve actuators shall be manufactured by the valve manufacturer.
 - b. Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.
 - c. Modulating and two-position actuators shall be provided as required by the sequence of operations. Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required application. The valve actuator shall be sized Based on valve manufacturer's recommendations for flow and pressure differential. All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations. The spring return feature shall permit normally open or normally closed positions of the valves, as required. All direct shaft mount rotational actuators shall have external adjustable stops to limit the travel in either direction.
 - d. Modulating Actuators shall accept 24 VAC or VDC and 120 VAC power supply and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal, and may be used to parallel other actuators and provide true position indication. The feedback signal of each valve actuator (except terminal valves) shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.
 - e. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Butterfly isolation and other valves, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated pump or chiller.
- B. Control Dampers
1. The BAS Contractor shall furnish all automatic dampers. All automatic dampers shall be sized for the application by the BAS Contractor or as specifically indicated on the Drawings.
 2. All dampers used for throttling air flow shall be of the opposed blade type arranged for normally open or normally closed operation, as required. The damper is to be sized so that, when wide open, the pressure drop is a sufficient amount of its close-off pressure drop to shift the characteristic curve to near linear.
 3. All dampers used for two-position, open/close control shall be parallel blade type arranged for normally open or closed operation, as required.
 4. Damper frames and blades shall be constructed of either galvanized steel or aluminum. Maximum blade length in any section shall be 60". Damper blades shall be 16-gauge minimum and shall not exceed eight (8) inches in width. Damper frames shall be 16-gauge minimum hat channel type with corner bracing. All damper bearings shall be made of reinforced nylon, stainless steel or oil-impregnated bronze. Dampers shall be tight closing, low leakage type, with synthetic elastomer seals on the blade edges and flexible stainless steel side seals. Dampers of 48"x48" size shall not leak in excess of 8.0 cfm per square foot when closed against 4" w.g. static pressure when tested in accordance with AMCA Std. 500.

5. Airfoil blade dampers of double skin construction with linkage out of the air stream shall be used whenever the damper face velocity exceeds 1500 FPM or system pressure exceeds 2.5" w.g., but no more than 4000 FPM or 6" w.g. Acceptable manufacturers are Johnson Controls D-7250 D-1250 or D-1300, Ruskin CD50, and Vent Products 5650.
6. One piece rolled blade dampers with exposed or concealed linkage may be used with face velocities of 1500 FPM or below. Acceptable manufacturers are: Johnson Controls D-1600, Ruskin CD36, and Vent Products 5800.
7. Multiple section dampers may be jack-shafted to allow mounting of piston pneumatic actuators and direct connect electronic actuators. Each end of the jackshaft shall receive at least one actuator to reduce jackshaft twist.

C. Control Relays

1. Control Pilot Relays
 - a. Acceptable manufacturers: Johnson Controls or Lectro.
 - 1) Substitutions: Refer to Division 01.
 - b. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.
 - c. Mounting Bases shall be snap-mount.
 - d. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.
 - e. Contacts shall be rated for 10 amps at 120VAC.
 - f. Relays shall have an integral indicator light and check button.
2. Lighting Control Relays
 - a. Lighting control relays shall be latching with integral status contacts.
 - b. Contacts shall be rated for 20 amps at 277 VAC.
 - c. The coil shall be a split low-voltage coil that moves the line voltage contact armature to the ON or OFF latched position.
 - d. Lighting control relays shall be controlled by:
 - 1) Pulsed Tri-state Output - Preferred method.
 - 2) Pulsed Paired Binary Outputs.
 - 3) A Binary Input to the Facility Management System shall monitor integral status contacts on the lighting control relay. Relay status contacts shall be of the "dry-contact" type.
 - e. The relay shall be designed so that power outages do not result in a change-of-state, and so that multiple same state commands will simply maintain the commanded state. Example: Multiple OFF command pulses shall simply keep the contacts in the OFF position.

D. Control Valves

1. Acceptable manufacturers: Johnson Controls.
 - a. Substitutions: Refer to Division 01.
2. All automatic control valves shall be fully proportioning and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All valves shall operate in sequence with another valve when required by the sequence of operations. All control valves shall be sized by the control manufacturer, and shall be guaranteed to meet the heating and cooling loads, as specified. All control valves shall be suitable for the system flow conditions and close against the differential pressures involved. Body pressure rating and connection type (sweat, screwed, or flanged) shall conform to the pipe schedule elsewhere in this Specification.
3. Chilled water control valves shall be modulating plug, ball, and/or butterfly, as required by the specific application. Modulating water valves shall be sized per manufacturer's recommendations for the given application. In general, valves (2 or 3-way) serving variable flow air handling unit coils shall be sized for a pressure drop equal to the actual coil pressure drop, but no less than 5 PSI. Valves (3-way) serving constant flow air handling

unit coils with secondary circuit pumps shall be sized for a pressure drop equal to 25% the actual coil pressure drop, but no less than 2 PSI. Mixing valves (3-way) serving secondary water circuits shall be sized for a pressure drop of no less than 5 PSI. Valves for terminal reheat coils shall be sized for a 2 PSIG pressure drop, but no more than a 5 PSI drop.

4. Ball valves shall be used for hot and chilled water applications, water terminal reheat coils, radiant panels, unit heaters, package air conditioning units, and fan coil units except those described hereinafter.
 5. Modulating plug water valves of the single-seat type with equal percentage flow characteristics shall be used for all special applications as indicated on the valve schedule. Valve discs shall be composition type. Valve stems shall be stainless steel.
 6. Butterfly valves shall be acceptable for modulating large flow applications greater than modulating plug valves, and for all two-position, open/close applications. In-line and/or three-way butterfly valves shall be heavy-duty pattern with a body rating comparable to the pipe rating, replaceable lining suitable for temperature of system, and a stainless steel vane. Valves for modulating service shall be sized and travel limited to 50 degrees of full open. Valves for isolation service shall be the same as the pipe. Valves in the closed position shall be bubble-tight.
- E. Control Valves, Segmented Ball Valves
1. Acceptable manufacturers: Fisher, Kele, Nelis-Jamesbury, or Valve Solutions, Inc.
 - a. Substitutions: Refer to Division 01.
 2. High performance segmented V-Ball control valve: Carbon steel body, stainless steel V-notch ball and shaft, low friction bearings and a low friction graphite ball set.; ANSI Class 150 or 300 flanges as required by application.
 3. Rated ANSI Class VI leakage rate, -20 degrees F. to 450 degree F. temperature range and minimum 285 PSI allowable shutoff pressure drop at -20 to 100 F.
 4. Rotation: 90 degrees; rangeability: 300 to 1 with equal percentage control characteristic; valve shall accommodate standard electric actuators.
 5. Warranty: Valve and linkage, 3 year warranty from date of installation.
- F. Electronic Signal Isolation Transducers
1. Acceptable manufacturers: Advanced Control Technologies.
 - a. Substitutions: Refer to Division 01.
 2. A signal isolation transducer shall be provided whenever an analog output signal from the BAS is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input signal from a remote system.
 3. The signal isolation transducer shall provide ground plane isolation between systems.
 4. Signals shall provide optical isolation between systems.
- G. External Manual Override Stations
1. External manual override stations shall provide the following:
 - a. An integral HAND/OFF/AUTO switch shall override the controlled device pilot relay.
 - b. A status input to the Facility Management System shall indicate whenever the switch is not in the automatic position.
 - c. A Status LED shall illuminate whenever the output is ON.
 - d. An Override LED shall illuminate whenever the HOA switch is in either the HAND or OFF position.
 - e. Contacts shall be rated for a minimum of 1 amp at 24 VAC.
- H. Electronic/Pneumatic Transducers
1. Acceptable manufacturers: Johnson Controls or Mamac.
 - a. Substitutions: Refer to Division 01.

2. Electronic to Pneumatic transducers shall provide:
 - a. Output: 3-15 PSIG.
 - b. Input: 4-20 mA or 0-10 VDC.
 - c. Manual output adjustment.
 - d. Pressure gauge.
 - e. External replaceable supply air filter.

2.4 MISCELLANEOUS DEVICES

A. Local Control Panels

1. All control panels shall be factory constructed, incorporating the BAS manufacturer's standard designs and layouts. All control panels shall be UL inspected and listed as an assembly and carry a UL 508 label listing compliance. Control panels shall be fully enclosed, with perforated sub-panel, hinged door, and slotted flush latch. Provide common keying for all new panels and match keying when existing panels are present.
2. Control panels shall consist of the DDC controller(s), display module as specified and indicated on the plans, and I/O devices-such as relays, transducers, and so forth-that are not required to be located external to the control panel due to function. Where specified the display module shall be flush mounted in the panel face unless otherwise noted.
3. All I/O connections on the DDC controller shall be provide via removable or fixed screw terminals.
4. Low and line voltage wiring shall be segregated. All provided terminal strips and wiring shall be UL listed, 300-volt service and provide adequate clearance for field wiring.
5. All wiring shall be neatly installed in plastic trays or tie-wrapped.
6. A 120 VAC duplex convenience receptacle and required transformers shall be provided in each enclosure.

B. Power Supplies

1. DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75% of the rated capacity of the power supply.
2. Input: 120 VAC +10%, 60Hz.
3. Output: 24 VDC.
4. Line Regulation: +0.05% for 10% line change.
5. Load Regulation: +0.05% for 50% load change.
6. Ripple and Noise: 1 mV rms, 5 mV peak to peak.
7. An appropriately sized fuse and fuse block shall be provided and located next to the power supply.
8. A power disconnect switch shall be provided next to each power supply.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Actuation / Control Type

1. Primary Equipment
 - a. Controls shall be provided by equipment manufacturer as specified herein.
 - b. All damper and valve actuation shall be electric.
2. Air Handling Equipment
 - a. All air handlers shall be controlled with a HVAC-DDC Controller
 - b. All damper and valve actuation shall be electric.
3. Terminal Equipment:

- a. Terminal Units (ATU, UV, etc.) shall have electric damper and valve actuation.
 - b. All Terminal Units shall be controlled with HVAC-DDC Controller.
- B. HVAC Input Devices - General
1. All Input devices shall be installed per the manufacturer recommendation.
 2. Locate components of the BAS in accessible local control panels wherever possible.
 - a. The mechanical contractor shall install all in-line devices such as temperature wells, pressure taps, air flow stations, etc.
 3. Flow Measuring Devices shall be installed in strict compliance with ASHRAE and ASME guidelines affecting non-standard approach conditions.
 4. Outside Air Sensors
 - a. Sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air conditions accurately.
 - b. Sensors shall be installed with a rain proof, perforated cover.
 5. Water Differential Pressure Sensors
 - a. Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device.
 - 1) Differential pressure transmitters shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines.
 - b. The transmitters shall be installed in an accessible location wherever possible.
 6. Medium to High Differential Water Pressure Applications (Over 21" w.c.)
 - a. Air bleed units, bypass valves and compression fittings shall be provided.
 7. Building Differential Air Pressure Applications (-1" to +1" w.c.)
 - a. Transmitters exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.
 - b. The interior tip shall be inconspicuous and located as shown on the drawings.
 8. Air Flow Measuring Stations
 - a. Install air flow measuring stations in accordance with manufacturer's instructions at the locations indicated on the plans including clear distances to adjacent fittings, elbows, inlets, or other interference. A written report shall be submitted to the Engineer if any discrepancies exist or if installation cannot be completed per the manufacturer's recommendations.
 - b. Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.
 9. Duct Temperature Sensors
 - a. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
 - b. The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.
 - c. For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.
 - d. The sensor shall be mounted to suitable supports using factory approved element holders.
 10. Space Sensors
 - a. Mounted per ADA requirements.
 11. Averaging and Low Temperature Limit Switches
 - a. Install as indicated in the control diagram.
 - b. Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by at least 1 foot of sensor.
 - c. For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to obtain full coverage.

12. Air Differential Pressure Status Switches
 - a. Install with static pressure tips, tubing, fittings, and air filter.
 13. Water Differential Pressure Status Switches
 - a. Install with shut off valves for isolation.
- C. HVAC Output Devices
1. All output devices shall be installed per the manufacturer's recommendation. The mechanical contractor shall install all in-line devices such as control valves, dampers, air flow stations, pressure wells, etc.
 2. Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke. When any pneumatic actuator is sequenced with another device, pilot positioners shall be installed to allow for proper sequencing.
 3. Control Dampers: Shall be opposed blade for modulating control of air flow. Parallel blade dampers shall be installed for two position applications.
 4. Control Valves: Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 PSI. The maximum pressure drop for steam applications shall be 7 PSI.
 5. Electronic Signal Isolation Transducers: Whenever an analog output signal from the BAS is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input a signal from a remote system, provide a signal isolation transducer. Signal isolation transducer shall provide ground plane isolation between systems. Signals shall provide optical isolation between systems

3.2 TRAINING

- A. The BAS contractor shall provide the following training services:
1. One day of on-site orientation by a system technician who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the BAS software layout and naming conventions, and a walk through of the facility to identify panel and device locations.

END OF SECTION

SECTION 23 21 13 - HVAC PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Piping and pipe fittings for:
 - 1. Chilled Water Piping
 - 2. Heating Water Piping

1.2 RELATED REQUIREMENTS

- A. Section 23 05 00 - Common Work Results for HVAC
- B. Section 23 21 16 - Hydronic Piping Specialties
- C. Section 23 05 23 - General Duty Valves for HVAC
- D. Section 23 07 00 - HVAC Insulation

1.3 REFERENCE STANDARDS

- A. ASME B1.1 - Unified Inch Screw Threads; 2008.
- B. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300; 2011.
- C. ASME B16.5 - Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard; 2013.
- D. ASME B16.9 - Factory Made Wrought Buttwelding Fittings; 2012.
- E. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; 2012.
- F. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings; 2013.
- G. ASME B18.2 - Square, Hex, Heavy Hex, and Askew Head bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws; 2013.
- H. ASME B31.1 - Power Piping; 2014.
- I. ASME B31.3 - Process Piping; 2012.
- J. ASME B31.9 - Building Services Piping; 2014 (ANSI/ASME B31.9).
- K. ASTM A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings; 2010.
- L. ASTM A21.51 - American National Standard for Ductile-Iron Pipe, Centrifugally Cast, for Water; 2002.
- M. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2012.

- N. ASTM A106/A106M - Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service; 2013.
- O. ASTM A193 - Standard Specification for alloy Steel and Stainless Steel Bolting Materials for High Temperature Service; 2014.
- P. ASTM A194 - Standard Specification for Carbon and Alloy Steel Nuts for bolts for High Pressure or High Temperature Service, or Both; 2014.
- Q. ASTM A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod; 2014.
- R. ASTM A563 - Standard Specification for Carbon and Alloy Steel Nuts; 2014.
- S. ASTM A449 - Standard Specification for Quenched and Tempered Steel bolts and Studs; 2004.
- T. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2009.
- U. AWWA C110/A21.10 - American National Standard for Ductile-Iron and Gray-Iron Fittings, 3 In. Through 48 In. (75 mm Through 1200 mm), for Water and Other Liquids; American Water Works Association; 2012.
- V. AWWA C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast, for Water; American Water Works Association; 2009 (ANSI/AWWA C151/A21.51).
- W. MSS SP-25 - Standard Marking System for Valves, Fittings, Flanges, and Unions; 2013.

1.4 SUBMITTALS

- A. Submit product data for review in accordance with the requirements of Division 01 for piping and fittings. Submittal data shall include but not be limited to:
 - 1. Manufacturer of pipe.
 - 2. Tests or listings by recognized testing laboratory that certifies material composition is in accordance with ANSI/ASTM requirements.
 - 3. Product data for pipe and fittings to be used on each piping system.
 - 4. Welding procedures for steel pipe.
 - 5. Solder and brazing product data and installation procedures for copper pipe.

PART 2 - PRODUCTS

2.1 STEEL PIPE

- A. Black steel: Electric resistance welded or seamless, ASTM A53 or ASTM A106 Grade B. Mill wrap uninsulated underground steel pipe with Republic X-Tru-Coat or equal.
 - 1. Through 10" standard weight Schedule 40
 - 2. 12" pipe and larger: standard weight with 0.375" wall thickness
- B. Provide for the following services:
 - 1. Chilled water supply and return piping, 1-1/4" diameter and larger. (Contractor option: copper up to 2" diameter; see "COPPER PIPE" below.)
 - 2. Chilled water supply and return piping, 2-1/2" diameter and larger.
 - 3. Heating water supply and return piping, 2-1/2" diameter and larger.

- C. Schedule 40, seamless: ASTM A53, Grade B. Provide for the following services:
 - 1. Steam piping
 - 2. Steam relief vent piping
- D. Schedule 80, seamless: ASTM A53 or ASTM A106, Grade B. Provide for the following services:
 - 1. Steam Condensate piping
 - 2. Boiler blowdown piping
 - 3. Pumped condensate piping
- E. Schedule 40, A53 or A106 galvanized pipe for:
 - 1. Cooling Coil condensate drain piping. (Contractor option: Copper; see "COPPER PIPE" below.)
 - 2. Drain piping from equipment 1-1/2" diameter and smaller.

2.2 STEEL PIPE FITTINGS

- A. Flanges, Fittings, and Unions: Mark in accordance with MSS-SP-25.
- B. Fittings:
 - 1. 2-1/2" and larger: Class 150, wrought steel, butt welded fittings, ASME B16.9
 - 2. 2" and Smaller
 - a. Water Service: Class 150, malleable iron, screwed.
 - b. Condensate: Class 150 malleable iron, A53 screwed, ASME B16.3
- C. Flanges, 2-1/2" and larger: Class 150, A53 wrought forged steel, slip-on or weld neck, ASME/ANSI B16.5. Flange faces shall match equipment or mating flanges (i.e. flat-faced flanges shall be used adjacent to equipment with integral flat-faced flanges, such as pumps, control valves, etc.)
- D. Gaskets:
 - 1. Inorganic fibers, 1/16 or 1/8 inch thick, reinforced EPDM binder, 550 deg F (continuous) and 700 psig operation, Garlock 5507 or equal:
 - a. Chilled water
 - b. Heating water
 - 2. Spiral wound "chevron" metallic gaskets, flexible graphic filler, class 150 and 300 service, Flexitallic LS, CG or equal
 - a. Steam
- E. Unions, 2" and smaller: Material as specified under fittings, screwed with brass seat.
- F. Branch connections from mains or headers, 2-1/2" and larger: Welded tees or welding outlets, Bonney Forge Weldolets or Threadolets. Use forged outlets only if branch line is at least one pipe size smaller than main or header.
- G. Galvanized steel pipe fittings: Same as above, except galvanized coated.
 - 1. Provide drainage pattern type fittings for drain piping.
- H. Bolting Materials: Torque all bolts to 50% of yield strength or per equipment manufacturer's recommendation, whichever is lower. Use anti-seize lubricant on all bolt threads. Same finished carbon steel bolts and hex nuts, ASTM A307. Threads and Dimensions: ASME/ANSI B1.1 and B18.2.

1. Systems 210 degrees F and less: Use ASTM A449 studs or bolts and ASTM-A563 Grade B hex nuts
2. Systems above 210 degrees F: Use ASTM-A193 Grade B7 studs or bolts and ASTM-A194 Grade 2 Heavy Hex Nuts
3. Use galvanized bolts and nuts on piping outside the building, inside tunnels, and inside manholes.

I. Thread Lubricant: Similar to Crane "Formula 425".

2.3 COPPER PIPE

- A. Conform to ASTM B-88 specification for wrought seamless copper.
- B. Type L, hard for:
 1. HVAC reheat water pipe, 1" and smaller; Contractor option for copper or steel pipe 1-1/4" to 2".
 2. HVAC chilled water pipe, 2" and smaller.
- C. Type M, hard for:
 1. For non-pressurized drain piping.
 2. Fan coil unit condensate piping.
 3. Cooling coil condensate piping.

2.4 COPPER PIPE FITTINGS

- A. Sweat type, wrought copper, ASTM B62, with dimensions conforming to ASTM/ANSI B16.22 and sweep patterns for copper tubing.
- B. Dielectric Connections:
 1. Provide at junction of copper pipe and equipment with steel piping systems within the temperature limitations of the product.
 2. Dielectric insulating unions, and insulating flange unions, as manufactured by CTS Fabrication USA (1-1/2" thru 8").
 3. Provide copper solder joint to plated female iron pipe for sizes 1/2" through 2".
 4. Provide insulating flange unions, malleable female iron pipe thread to copper solder joint flange unions for sizes 2-1/2" through 4".
 5. Provide Dielectric transition fittings, Victaulic Series 647 for sizes 1/2" to 4".
 6. Brass fittings and valves may not be used for dielectric union locations.
- C. Unions: Brass ground joint, 250 lb. working pressure.
- D. Nipples: Brass.

2.5 MISCELLANEOUS PIPE ACCESSORIES

- A. Escutcheons: Chrome pipe escutcheons, slip-on or split type where pipe passing through finished walls or ceiling may be visible.
- B. Exposed Metal Pipe and Trim: Chrome plated.
- C. Control System Connectors: Crane No. 386, 1" steel half couplings, or 1" female pipe thread connectors.

- D. Install 18 gauge sheetmetal or galvanized steel pipe saddles to protect insulation.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Clean inside of pipe before installation. Keep installed piping clean, and protect ends from foreign matter by capping or plugging them.
- B. Install pipe so that it does not interfere with opening of doors or apparatus, access to equipment, or to electrical equipment.
- C. Do not install pipes in such a way that they will apply torque to pumps. After pumps have been installed and pumps have been operated, recheck and realign pumps if necessary.
- D. Run pipes in straight lines and square with building. Install risers plumb. Make offsets only where indicated and where necessary.
- E. Install branch connections using separate tee or lateral fittings for each branch. Do not combine branches into "bullhead tee" arrangement.
- F. Do not install water pipes in electric rooms, tele/data and IDF rooms, transformer rooms, audio/visual rooms or elevator equipment rooms. Fire protection piping runouts serving only these rooms shall be installed in these rooms.
- G. Do not install piping above electrical equipment such as starters, variable frequency motor controllers, motor control centers, or disconnects. Maintain code required clearance above, below and to sides of electrical equipment.
- H. Provide flanges or unions throughout the pipe systems at all equipment. Make provisions for servicing and removal of equipment without dismantling piping.
- I. In so far as possible, drainage piping shall not be installed overhead, whether exposed or above ceiling, in operating rooms, delivery rooms, nurseries, food preparation or serving areas, or in rooms listed above. Where unavoidable, provide drain troughs or other means to carry away leakage.
 - 1. Grading Pipes for Drainage:
 - 2. Slope cooling coil condensate drains at 1/8" per foot.
- J. Slope steam pipes and steam condensate drain pipes at 1/4" per 10 feet. Do not raise condensate pipe except at ends of main drips.
- K. Piping Expansion:
 - 1. Install piping to allow thermal expansion and contraction without injury to piping, equipment or structure.
 - a. Use loops or expansion joints where necessary and where detailed.
 - b. Provide pipe guides.
- L. Branch Lines:
 - 1. Where possible branch lines shall come off top of mains to prevent sediment, welding slag, or pipe burrs from entering the branch lines and causing valve leakage or failure.

3.2 PIPE JOINTING

A. Preparing Pipe Ends:

1. Machine cut pipe ends square.
2. Ream pipe ends, after cutting, to full diameter.
3. Where pipe is to be threaded, secure pipe in pipe stand, die cut, full depth, right hand threads. Threads to be taper type.
4. All threaded pipe joints to have suitable pipe sealant applied to threads prior to assembly of joint. Joints shall be leak proof.
5. Where pipe is to be welded, die-cut end of butt joints at 30 degree taper. Weld should have a full penetration with no bubbles or holes. Remove all slag.

B. Welded Steel Piping:

1. Where welded piping is specified, make welds by oxy-acetylene process or electric process in accordance with ASME/ANSI B31.1.
 - a. Welding Rods: Grade recommended for purpose by manufacturer's and identification.
2. Line welds, single V-butt type:
 - a. Mill or machine bevel pipe at 37 1/2 degrees to within 1/16" of inside wall, except that in field limited amount of pipe may be flame beveled.
 - b. Pipe with a wall thickness of 3/16" or less need not be beveled but may be welded by melting down into building up over abutting ends.
 - c. Separate abutting ends of joints before welding to permit complete fusion to bottom without overlapping.
 - d. Tack in two or more points to maintain alignment, and fusion weld.
3. Make all welds of sound weld metal, thoroughly fused into ends of pipe, and to bottom of vee.
 - a. Build in excess of pipe wall to give reinforcement to one fourth pipe wall thickness.
 - b. Weld metal shall present a gradual increase in thickness from surface of pipe to center of weld.
 - c. Minimum weld width: Two and one half times thickness of pipe wall.
4. Use welding ells at turns in welded lines
5. Do not weld pipe couplings in place of welding fittings for any branch connections.
6. Weld-o-lets and thread-o-lets:
 - a. Scribe and cut openings in main pipes for welded branches accurately taking care to remove all of plugs and cuttings from main pipe.
 - b. Full weld fillet welds for full depth of fillet, with additional beads to form well rounded connection as recommended by weld-o-let manufacturer.
7. Cut openings into pipe for welded connections accurately to give matched intersections.
8. Make welded fittings of same material with same pressure and temperature rating as pipe with which they are used.
9. Make flanged connections to control valves, pump suction and specialties with ANSI standard welding neck flanges. All other flange connections may be made with slip-on flanges provided they are seal welded on inside.
10. Fuse all fillet welds for flanges or fittings into pipe and plate for minimum distance of 1-1/2 times pipe wall thickness and depth weld on 1-1/4 times pipe wall thickness.

C. Soldered and Brazed Joints:

1. Make Type L and M copper pipe joints with suitable flux and 95/5, lead free solder.

D. Bracing Joints:

1. Provide braces and bridle rods as required to reinforce joints.

2. If mechanical lock type couplings are used, then prepare pipe ends and make joints in accordance with pipe coupling manufacturer's printed instructions.
3. Where large pipes underground are subject to shock because of sudden changes in liquid flow rate, provide concrete "kicker" blocks at joints, fittings, and changes of pipe direction. Provide "kicker" blocks in accordance with applicable pipe industry trade or research organization recommendations.
 - a. For example, for ductile iron pipe follow recommendations of Ductile Iron Pipe Research Association.

3.3 ESCUTCHEONS

- A. Provide chrome plated escutcheons where uninsulated pipes penetrate walls or ceilings of finished spaces.

3.4 STRAINERS

- A. Install strainers so the strainer basket can be removed without spilling water on motors and electrical equipment.

3.5 AIR VENTING

- A. Provide manually operated air vents at high points in vertical risers and at water coils to eliminate air from systems.
- B. Air vents are required at reheat coils. See piping details on drawings.
- C. Use ball valves for manual air vents.

3.6 VALVE ACCESS

- A. Locate ceiling/wall access panels at shut-off and control valves for proper access and operation. Furnish and install access doors in accordance with Section 23 05 00 and other Divisions as applicable.

3.7 CONTROL SYSTEM CONNECTORS

- A. Weld connectors at points indicated, and at other points where necessary for installation of thermometers, sensors, and automatic controls.

3.8 TESTING

- A. Before piping is concealed or insulated, recheck it for leaks.
- B. Rework or replace defective and leaking joints, and joints which are otherwise unsatisfactory. Peening, caulking, and doping are not permitted.

END OF SECTION

SECTION 23 31 13 - SHEETMETAL DUCTWORK

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Rectangular Metal Ducts
- B. Round Ducts

1.2 RELATED REQUIREMENTS

- A. Division 07 - Firestopping
- B. Division 09 - Painting and Coating
- C. Section 23 01 30.51 - HVAC Air Duct Cleaning
- D. Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment
- E. Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC
- F. Section 23 07 00 - HVAC Insulation
- G. Section 23 33 00 - Air Duct Accessories
- H. Section 23 33 19 - Duct Silencers
- I. Section 23 3600 - Air Terminal Units
- J. Section 23 3700 - Air Outlets and Inlets

1.3 REFERENCE STANDARDS

- A. ASHRAE Handbook - Fundamentals; 2013.
- B. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2013.
- C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2014.
- D. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; National Fire Protection Association; 2012.
- E. NFPA 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems; National Fire Protection Association; 2012.
- F. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations; National Fire Protection Association; 2014.
- G. SMACNA 1972 - HVAC Air Duct Leakage Test Manual; Sheet Metal and Air Conditioning Contractors' National Association; 2012, 2nd Edition.

- H. SMACNA 1966 - HVAC Duct Construction Standards; Sheet Metal and Air Conditioning Contractors' National Association; 2005.
- I. SMACNA 1767 - Kitchen Ventilation Systems and Food Service Equipment Fabrication & Installation Guidelines; 2001.
- J. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.
- K. UL 1978 - Grease Ducts; Current Edition, Including All Revisions.
- L. UL 2221 - Tests of Fire Resistive Grease Duct Enclosure Assemblies; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A. Submit material/product data as described in Division 01.
- B. Shop Drawings: Provide shop drawings of sheet metal shop ductwork, as follows:
 - 1. Draw to a scale not less than 1/4-inch to one foot
 - 2. Provide sheet sizes equal to Contract Drawings
 - 3. Show duct sizes
 - 4. Show fitting details
 - 5. Show lighting and ceiling diffusers
 - 6. Show bottom of duct elevation above finished floor
 - 7. Show all manual and motorized dampers and associated access doors.
 - 8. Show HVAC equipment, all air terminal units, and air quantities.
- C. Coordinated Shop Drawings: Provide coordinated shop drawings for sheet metal work in mechanical equipment rooms, and other congested areas listed.
 - 1. Draw to a scale of 1/2 inch to 1 foot.
 - 2. Provide sheet sizes to match Contract Drawings.
 - 3. Show duct sizes.
 - 4. Show bottom duct elevations from finished floor.
 - 5. Show lighting, equipment, maintenance and operating clearances, HVAC piping, plumbing piping, medical gas piping, pneumatic tube system, conduit 3" and larger, and columns and beams with mounting heights.
 - 6. Show construction details of all fittings and connections to equipment.
 - 7. Show construction details of plenums and casing.
- D. Coordinated Shop Drawings shall be completed for all areas prior to installation of the major trades. The coordinated shop drawings are not required to be submitted except as noted above. A coordinated shop drawing attempt shall be submitted with any request to the owner or design team to assist with overhead coordination conflicts.
- E. Certifications: Provide a duct schedule, certified by an officer of the sheet metal fabrication subcontractor, that the ductwork conforms to SMACNA standards. For each sheet metal system furnished on the project include:
 - 1. System name
 - 2. Duct material
 - 3. Duct gauge
 - 4. SMACNA rectangular reinforcement number

5. SMACNA intermediate reinforcement number
6. SMACNA transverse reinforcement number
7. Rod diameter and type
8. Sealant type
9. Attachment method
10. Duct system design pressure

F. Field Conditions

1. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturer.
2. Maintain temperature within acceptable range during and after installation of duct sealants.

1.5 QUALITY ASSURANCE

- A. Provide an installed duct system which will supply the air quantities indicated by the drawings and have the lowest possible friction loss with the least possible leakage loss. System static pressure loss for each system shall not exceed that which is indicated in the equipment schedule as external static pressure or in the fan schedule as static pressure and shall include the losses of all accessories. Friction losses shall be minimized by reduction in the number of offsets and elbows by pre-planning the duct system installation and coordination with other trades to prevent interferences. Maintain access to accessories requiring maintenance, service, and inspection. Radius elbows are preferred for turns to minimize friction, noise, and vibrations.
- B. Provide and/or construct materials, ductwork, joints, transformations, splitters, dampers, and access doors as specified herein for the sheet metal ductwork as shown on drawings.
- C. SMACNA Manual: Sheet Metal Tradesman shall have access on the construction site to "HVAC Duct Construction Standards". Comply with applicable provisions of the SMACNA Manual and more stringent requirements of this specification.
- D. Quality control involves not only the general performance requirements for air ducts, but also quality workmanship which includes layout pre-planning so that offsets, rises, falls, elbows, fittings, etc., are minimized or eliminated. General performance requirements for ducts include:
 1. Dimensional stability (shape deformation and strength)
 2. Containment of the air being conveyed (leakage control). See Part 3 of this specification for leakage testing.
 3. Vibration (fatigue and appearance)
 4. Noise (generation, transmission, or attenuation)
 5. Exposure (to damage, weather, temperature extremes, flexure cycles, wind, corrosive atmospheres, biological contamination, flow interruption or reversal, underground or other encasement conditions, combustion, or other in-service conditions)
 6. Support (alignment and position retention)
 7. Seismic restraint
 8. Thermal conductivity (heat gain or loss and condensation control)
- E. Provide galvanized duct materials which meet applicable requirements of local and state codes, whichever is the most stringent.
- F. Support ductwork in accordance with applicable requirements of local and state codes and details on drawings.
- G. Emboss fittings with material gauge, manufacturer, and type material.

- H. Sealers, liners, pre-insulated jackets and flexible ducts shall comply with a flame spread rating of 25 or less and a smoke developed rating of not over 50.

PART 2 - PRODUCTS

2.1 MATERIAL

- A. Sheet metal ductwork, angles, bar slips, hangers, and straps: Galvanized, prime quality steel sheets.
- B. Screws: Cadmium plated.
- C. Joint Sealers: water resistant, mildew and mold resistant.
 - 1. Suitable for indoor and outdoor use, fiber reinforced, with UV inhibitors.
 - 2. Surface burning characteristics: Flame spread of zero and smoke developed of zero when tested in accordance with ASTM E84.
 - 3. Suitable for use with flexible ducts and UL listed.
 - 4. Acceptable Products:
 - a. Carlisle Hardcast VersaGrip 181, Design Polymerics DP1020, or Ductmate FIBERseal.
 - b. Substitutions: Not permitted.
 - 5. Pressure sensitive tape is not acceptable.
- D. Duct Sealing:
 - 1. All longitudinal and transverse joints, seams and duct sidewall penetrations, regardless of pressure classification, shall be sealed with duct sealer. Follow SMANCA Table 1-2, Seal Class A for all supply, return, and exhaust ductwork.
 - 2. See Leakage Testing of Installed Systems requirements in Part 3.
- E. Sheetmetal accessories: As specified in Section 23 23 00.

2.2 PRESSURE CLASSIFICATION

- A. Ductwork where maximum dimension is less than 97" shall be constructed based on applicable pressure classification in accordance with SMACNA Manual including sheetmetal gauge, reinforcement gauge and spacing.
- B. Construct the following for 1" pressure classification, Table 1- 4:
 - 1. Supply ductwork downstream of air terminal units
 - 2. Low pressure supply ductwork to reheat coils
 - 3. Low pressure supply, return, and outside air ductwork at fan coil units
- C. Construct the following for 2" pressure classification, Table 1- 5:
 - 1. Return ductwork
 - 2. Exhaust ductwork
 - 3. Make-up air ductwork
- D. Construct the following for 6" w.g. pressure classification Table 1-8:
 - 1. Supply ductwork and plenums downstream of supply fans up to air terminal units

2.3 RECTANGULAR DUCTWORK

- A. Transverse Joints:
1. "S" and drive construction for 1" and 2" w.g. pressure classification.
 - a. Provide duct gauge and reinforcing angles in accordance with Table 1-11
 2. Duct Connection System: Connection system as manufactured by Ductmate or Nexus shall incorporate gasketed joints, metal cleats and bolted corners. Minimum metal gauge shall be 24 gauge. Connection systems may be used for all pressure classifications.
 3. For pressure classifications above 2", use double "S" joint up to 30" and companion angle or manufacturer's connection system above 30".
- B. Longitudinal Seams: Pittsburgh Lock
- C. Transitions:
1. Do not exceed 1" in 7" of slope for increase-in-area transitions.
 2. Do not exceed 1" in 4" of slope for decrease-in-area transitions, 1" in 7" is preferable.
 3. Do not exceed 45 degrees on the entering or leaving side for angle of transitions at connections to equipment without the use of approved turning vanes.
- D. Elbows:
1. Fabricate ells using one of the following specifications: The fabrication methods are listed in order of preference. Use radius elbows where ever possible. Use square elbows only when available space prevents the use of radius elbows.
 - a. Unvaned, long radius elbow with the throat radius equal to 3/4 of the width of the duct and with a full heel radius.
 - b. Six inch throat radius with full radius, single thickness vanes and full heel radius. Maximum unsupported length of vanes shall be 36". Securely fasten vanes to runners. Secure vanes in stable position. Construct vane edges to project tangents parallel to duct sides.
 - c. Square elbows with airfoil, double thickness turning vanes.
 2. Turning vanes:
 - a. Acceptable manufacturers: Aero Dyne
 - b. Substitutions: Not permitted.
 - c. True airfoil design; smoothly-rounded entry nose with extended trailing edge. Generated sound power level shall not exceed 54 decibels in band 4 at 2000 FPM in a 24"x24" duct.
 - d. Fabricate assemblies with Aero Dyne Co. side rails; install vanes on design centers of 2.4 inches across the full diagonal dimension of the elbow.
 - e. Submit Aero Dyne product and performance data for review.
- E. Branch Connections:
1. Pressure classification 2" and less:
 - a. Rectangular branch from rectangular main: 45 degree entry with all corners closed as shown in Figure 2-8
 - b. Round branches: Spin-in fitting without scoop.
 - c. Parallel flow branches: See Figure 2-7.
 - d. Space duct joints to avoid cutting them for branch take offs and outlet collars.
 2. Pressure classification above 2":
 - a. Round branches: Conical round fittings only.
 - b. Rectangular branch from rectangular main: 45 degree entry with all corners closed as shown in Figure 2-8

- c. Parallel flow branches: See Figure 2-7.
- d. Space duct joints to avoid cutting them for branch take offs and outlet collars.

2.4 ROUND DUCTWORK

- A. Applicable for pressure classification above 2".
- B. Round Duct (Spiral Pipe) and Fittings:
 - 1. Manufactured from galvanized steel meeting ASTM A653/A653M. Construction shall be in accordance with SMACNA HVAC Duct Construction Standards.
 - 2. Use appropriate seams made to eliminate leakage based on pressures for which system has been designed. Longitudinal seam duct to have fusion welded butt seam.
 - 3. Fittings and couplings shall have minimum gauges specified by SMACNA Manual.
 - 4. Fittings shall have continuous welds along all seams. Divided flow fittings shall be manufactured as separate fittings, not as tap collars welded into spiral duct sections.
 - 5. Ninety degree tees (conical) and 45 degree laterals (wye) up to and including 12" diameter tap size to have radiused entrance into the tap, produced by machine or press forming. Entrances to be free of weld build-up, burrs, or irregularities.
 - 6. Elbows in diameters 3" thru 8" shall be two section stamped elbows. Other elbows shall be gored construction with all seams continuous welded. Fabricate to center line radius of 1.5 times the cross sectional diameter. Elbows, not die-stamped, shall be fabricated as follows:
 - a. Less than 30 degree angle: minimum 2 gores
 - b. Between 30 thru 60 degrees: minimum 3 gores
 - c. Over 60 degrees: minimum 5 gores
 - 7. Two piece mitered elbows shall not be used.
 - 8. Tees shall be conical. Saddle taps or straight tees shall not be used.
 - 9. The leading edge of all vanes in ducts over 20" diameter shall be hemmed with 1/2" foldback. Turning vanes in ducts over 24" shall be reinforced by stays or sectional construction to limit unsupported length to 24". Vanes shall be a minimum of 20 gauge.
 - 10. Reduction of divided flow fittings to conical span section in the 36 common reductions in sizes 4" thru 22".
 - 11. Spun bellmouth connections are to be used at each round take-off from plenum.
 - 12. Galvanized areas damaged by welding to be coated with corrosion resistant aluminum paint.
- C. Couplings for Round Medium-Pressure Duct (over 2" w.g.):
 - 1. Pipe-to-pipe joints shall be sleeve couplings, reinforced by rolled beads.
 - 2. Pipe-to-fitting joints shall be slip-fit of projecting collar fitting into pipe.
 - 3. Insertion length of sleeve coupling and fitting collar shall be 2" minimum.

PART 3 - EXECUTION

3.1 INSTALLATION, APPLICATION, ERECTION

- A. Do not exceed 45 degrees for easement transition angle.
- B. Seal all transverse and longitudinal joints and seams and duct wall penetrations with approved sealer in accordance with manufacturer's directions regardless of pressure class.
- C. Counterflash ductwork penetrating roof.

- D. Support round ducts from building structure with galvanized steel hangers in accordance with SMACNA. Secure hangers to masonry portion of building by means of inserts or other acceptable anchors.
- E. Secure hangers to steel structure members by means of C-clamps. Vertical risers, and other duct runs where methods of support specified above are not applicable, shall be supported by angle brackets as shown in SMACNA manual.
- F. Where appropriate based on duct weight, support rectangular ducts by minimum, 1" x 18 gauge, galvanized band iron or minimum 3/8" galvanized rod hangers attached to reinforcing angles and spaced same as reinforcing angles. Design hangers, reinforcing angles and other components to support weight of duct and insulation. Secure hangers to concrete beam or slab by adequately sized inserts, anchor shield and bolt, toggle bolt, or expansion bolt.
- G. Attach hangers to ductwork using sheet metal screws.
- H. Space hangers approximately 8' along the duct for ducts under 60". For ducts over 60" and larger and heavier sections, such as welded duct and sound absorbers, space hangers at approximately 4' intervals.
- I. Hangers and bracing used with ductwork shall be galvanized.
- J. Provide smooth insulation finish around damper operating quadrants, splitter adjusting clamps, access doors, and similar operating devices. Provide metal collar equivalent in depth to insulation thickness. Access door locks and damper handles shall be free from mastic or sealant.
- K. In addition to the requirements above, add supplemental bracing as necessary to prevent sagging and drumming, and/or vibration.

3.2 CLEANING

- A. Clean mechanical system thoroughly to assure all foreign matter and dirt is removed.

3.3 AIR MOVING EQUIPMENT OPERATION DURING CONSTRUCTION

- A. The use of new or existing air handling units, fans, or other permanent air moving equipment during construction is prohibited unless approved by the owner in writing. If approved for use during construction, the following procedures shall be followed:
 - 1. The contractor shall protect the interior of all ductwork, air handling units, and other equipment from the accumulation of dirt and dust and other contaminants. If the permanent equipment cannot be adequately protected, temporary air moving/ conditioning equipment and distribution systems shall be utilized as required for finishing trades.
 - 2. Provide all specified filters in equipment to be operated as well as temporary filters on all return and exhaust air grilles, open ductwork, and transfer openings in the work area.
 - 3. The contractor shall remove all filters used during construction and replace them with new filters prior to test and balance work and prior to substantial completion.
 - 4. If the ductwork and/or equipment is found to be contaminated at any point during construction, an independent NADCA certified contractor shall be retained to clean the ductwork and/or equipment at the contractors expense. Refer to Section 23 01 30.51.
 - 5. System operating temperatures shall be maintained to avoid condensation on ductwork and equipment surfaces. New or existing insulation found damaged shall be replaced.

6. Coordinate use of air handling equipment with ICRA plan, if applicable. Maintain required pressure relationships in construction areas adjacent to occupied areas.

3.4 LEAKAGE TESTING OF INSTALLED SYSTEMS

- A. Test duct for leakage in accordance with SMACNA HVAC Air Duct Leakage Test Manual. Use prescribed test kit containing test blower, two U-tube manometers and calibrated curve attached to the orifice tube assembly.
- B. Pressure testing shall include taps/take-offs to air terminal units in medium pressure ductwork and taps/take-offs to air devices in supply, return, and exhaust ductwork.
- C. Pressurize all installed duct systems for each pressure class to maximum pressure for fabrication classification. The leakage amount shall not exceed the allotted amount for the pressure class or the allotted amount for that portion of the system as follows:
 1. 1" Pressure Class - Leakage Class 6; Max. Leakage Factor - 6.0 CFM/100 SF
 2. 2" Pressure Class - Leakage Class 6; Max. Leakage Factor - 9.4 CFM/100 SF
 3. 1" and 2" Pressure Class exhaust ductwork connected to or serving fume hoods, bio-safety cabinets, chemical or hazardous storage rooms, smoke removal/purge systems, laboratory spaces, isolation rooms, bronchoscopy rooms, and nuclear medicine rooms shall be construction and tested as follows:
 - a. 1" Pressure Class - Leakage Class 3; Max. Leakage Factor - 3.0 CFM/100 SF
 - b. 2" Pressure Class - Leakage Class 3; Max. Leakage Factor - 4.7 CFM/100 SF
 4. 6" Pressure Class - Leakage Class 3; Max. Leakage Factor - 9.6 CFM/100 SF
- D. All ductwork shall be leak tested first before being enclosed in a shaft or above other inaccessible areas.
- E. Correct leaks found in excess of allowable limits. Retest until acceptable leakage is witnessed.
- F. Have test results available for review on a progressive and final basis. Include all test results in project closing file along with name, signature, and date of independent witness to testing. Test results shall show preliminary and final test results and include all calculations used to determine system compliance with the maximum specified leakage rate.

3.5 AIR TEST AND BALANCE

- A. Prepare the system for tests as specified in Section 23 05 93 and correct deficiencies found by the Test and Balance firm.
- B. Duct dimensions shown on drawings indicate inside clear dimensions. Make calculation allowances for duct requiring internal sound lining, or insulation to provide "inside clear" (IC) dimensions.

END OF SECTION

SECTION 23 33 00 - AIR DUCT ACCESSORIES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Backdraft dampers - metal.
- B. Duct access doors.
- C. Duct test ports.
- D. Fire dampers.
- E. Smoke dampers.
- F. Combination fire and smoke dampers.

1.2 RELATED REQUIREMENTS

- A. Division 07: Firestopping.
- B. Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment.
- C. Section 23 31 13 - Sheetmetal Ductwork.
- D. Section 23 36 00 - Air Terminal Units: Pressure regulating damper assemblies.

1.3 REFERENCE STANDARDS

- A. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; National Fire Protection Association; 2012.
- B. SMACNA 1966 - HVAC Duct Construction Standards; 2005.
- C. UL 181 - Factory-Made Air Ducts and Air Connectors; 2013.
- D. UL 33 - Heat Responsive Links for Fire-Protection Service; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.
- E. UL 555 - Standard for Fire Dampers; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.
- F. UL 555S - Standard for Leakage Rated Dampers for Use in Smoke Control Systems; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.
- G. AMCA 511 - Certified Ratings Program-Product Rating Manual for Air Control Devices; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A. Refer to Division 01 for submittal procedures.

- B. Product Data: Submit manufacturer's product data for review. Include electrical characteristics and connection requirements where applicable.
- C. Project Record Drawings: Record actual locations of volume dampers, rated dampers, access doors, and test holes.

PART 2 PRODUCTS

2.1 BACKDRAFT DAMPERS - METAL

- A. Acceptable manufacturers: Louvers & Dampers, Nailor Industries, or Ruskin Company.
 - 1. Substitutions: Refer to Division 01.
- B. Multi-Blade, Parallel Action Gravity Balanced Backdraft Dampers: Galvanized steel, with center pivoted blades of maximum 6 inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; counter-balance adjustment device to permit setting for varying differential static pressure.

2.2 FIRE DAMPERS

- A. Acceptable manufacturers: Air Balance, Greenheck, Ruskin, or Nailor.
 - 1. Substitutions: Not permitted.
- B. Fabricate in accordance with NFPA 90A, UL 555, and as indicated.
- C. Material: Galvanized steel or 304 stainless steel to match adjacent ductwork.
- D. Dampers shall be curtain or multi-leaf type, 1-1/2 hour rated, suitable for horizontal or vertical mounting. Blades for curtain type dampers shall be stored out of the airstream.
- E. Dampers shall meet Class 1 leakage rates and be dynamic rated for closure against airflow up to 2000 FPM in low pressure systems and up to 4000 FPM in medium pressure systems.
- F. Dampers shall have a UL 555 differential pressure rating of 4 in. wg.
- G. Provide damper with fusible link causing the damper to lock in the closed position at 165 degrees F.
- H. Provide manufacturer's round to horizontal duct adapter as required.
- I. Maximum pressure drop shall be as follows:
- J. Damper pressure drop shall not exceed 0.05 in. wg. at 1500 FPM or 0.10 in wg. at 2000 FPM.
- K. Dampers shall bear the AMCA Certified Ratings Seal for Air Performance in accordance with AMCA 511.

2.3 SMOKE DAMPERS

- A. Acceptable manufacturers: Air Balance, Greenheck, Ruskin, or Nailor
 - 1. Substitutions: Not permitted.

- B. Fabricate in accordance with NFPA 90A, UL 555S, and as indicated.
- C. Dampers: Single or multi-blade type, 1-1/2 hour rated, automatically operated by 120V electric actuator mounted outside the airstream unless noted otherwise. Actuator shall be adequately sized to open the damper within 15 seconds.
- D. Dampers shall be meet Class 1 leakage rates and be dynamic rated for closure against airflow up to 2000 FPM in low pressure systems and up to 4000 FPM in medium pressure systems.
- E. Provide two-position actuator. Damper shall fail normally closed.
- F. Provide manufacturer's round to horizontal duct adapter as required.
- G. Damper pressure drop shall not exceed 0.15 in. wg. at 1500 FPM or 0.25 in. wg. at 2000 FPM.
- H. Dampers shall bear the AMCA Certified Ratings Seal for Air Performance in accordance with AMCA 511.

2.4 COMBINATION FIRE AND SMOKE DAMPERS

- A. Acceptable manufacturers: Air Balance, Ruskin, Greenheck, or Nailor.
 - 1. Substitutions: Not permitted.
- B. Fabricate in accordance with NFPA 90A, UL 555, UL 555S, and as indicated.
- C. Dampers: Single or multi-blade type, 1-1/2 hour rated, automatically operated by 120V electric actuator mounted outside the airstream unless noted otherwise. Actuator shall be adequately sized to open the damper within 15 seconds.
- D. Dampers shall be meet Class 1 leakage rates and be dynamic rated for closure against airflow up to 2000 FPM and 4" w.g. in low pressure systems and up to 4000 FPM and 6" w.g. in medium pressure systems.
- E. Provide two-position actuator and with resetable link with open/closed indicator causing the damper to close at 165 degrees F. Damper shall fail normally closed.
- F. Provide manufacturer's round to horizontal duct adapter as required.
- G. Damper pressure drop shall not exceed 0.15 in. wg. at 1500 FPM or 0.25 in. wg. at 2000 FPM.
- H. Dampers shall bear the AMCA Certified Ratings Seal for Air Performance in accordance with AMCA 511.

2.5 SLEEVES FOR RATED DAMPERS

- A. Unless otherwise required by the authority having jurisdiction, sleeves for fire dampers, smoke dampers and combination fire and smoke dampers shall be provided by the damper manufacturer and be of rigid type construction recommended in Schedule 2 of SMACNA Publication for "Fire Damper and Heat Stop Guide for Air Handling Systems". Use 16 gauge for ducts 24" or less in diameter or either rectangular dimension and 14 gauge for ducts over 24". Provide minimum 18" long sleeves. Coordinate required length with wall thicknesses.

- B. Install 1-1/2"x1-1/2"x1/8" angle bar on four sides of sleeves and both sides of wall. Fasten angles to sleeve only. Do not fasten to the wall.

2.6 DUCT ACCESS DOORS

- A. Acceptable manufacturers: Ruskin, SEMCO, Greenheck, Ward Industries, or DuctMate.
 - 1. Substitutions: Refer to Division 01.
- B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards and as indicated.
- C. Fabrication: Rigid and close-fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ducts, provide minimum 1 inch thick insulation with minimum 24 gauge sheet metal cover on each side.
 - 1. Less Than 12 inches Square: Secure with sash locks.
 - 2. Up to 18 inches Square: Provide two hinges and two sash locks.
 - 3. Up to 24 x 48 inches: Three hinges and two compression latches with outside and inside handles.
 - 4. Larger Sizes: Provide an additional hinge.
 - 5. Latches shall permit easy removal of access door while maintaining positive closing and minimum leakage. Provide continuous sponge rubber gaskets for all doors.
- D. Provide insulated doors in ductwork for access to service equipment such as airflow measuring stations (each side), casing mounted coils (each side), control dampers, duct mounted coils (each side), duct mounted smoke detectors, humidifiers, rated dampers, and elsewhere as noted on drawings.
- E. Size access doors as follows:
 - 1. Duct sizes under 12": Door sized sufficient to service equipment or replace fusible link.
 - 2. Duct sizes 12" to 20": 12"x12" door.
 - 3. Duct sizes 20" to 36": 18"x18" door.
 - 4. Duct sizes above 36": 24"x24" door.
- F. Provide reinforced wire glass view windows (min. 12"x12") in access doors at humidifiers.
- G. Mount doors in rigid frame of at least 22 gauge formed galvanized steel or aluminum.
- H. Use angle iron bracing as required to make the door frame a rigid assembly.
- I. In accordance with NFPA 90A, identify each access door with minimum 1/2" high printed or stenciled letters as 'Fire Damper', 'Smoke Damper', or 'Combination Fire/Smoke Damper'.

2.7 DUCT TEST PORTS

- A. Temporary Test Port: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps. Repair insulation and vapor barrier.
- B. Permanent Test Port: Factory fabricated, air tight flanged fittings with screw cap equal to Carlisle PTP-1. Provide extended neck fittings to clear insulation.

2.8 FLEXIBLE DUCT

- A. Acceptable manufacturers: Thermaflex M-KE

1. Substitutions: Refer to Division 01.
- B. Characteristics of flexible duct to air terminals:
1. Approved as UL 181 Class 1 air duct with a minimum rated air velocity of 4,000 feet per minute and pressure rated for a minimum of 4-inches water gauge positive pressure and 1-inch water gauge negative pressure.
 2. Composed of a Chlorinated Polyethylene (CPE) liner duct permanently bonded to a coated spring steel wire helix.
 3. Fire-retardant, low permeability outer vapor barrier of fiberglass reinforced film laminate with a permanence of not greater than 0.05 perms when tested in accordance with ASTM E 96 Procedure A.
 4. Flame spread less than 25, smoke developed rating less than 50.
 5. Insulated with 1/2" thick fiberglass insulation.
 6. Provide a minimum of three feet of flexible duct upstream of diffusers. Do not exceed six feet of length.
 7. Flexible duct shall meet standards of local building code.
 8. The duct shall have passed an impact test equal to the UL 181 standard, conducted by a nationally recognized testing laboratory except it shall use a 25-pound weight dropped from a height of 10 feet. The inner and outer surfaces shall not have ruptured, broken, torn, ripped, collapsed or separated. The helix shall rebound to a cross-sectional elliptical area not less than 80 percent of the original test sample diameter.
- C. The use of flex duct shall be limited to flexible air connector applications.
- D. Seal off the insulation jacket at its ends and at joints with mastic, hardcast, or similar material. Replace flex if jacket is punctured.
- E. Complete insulation coverage up to the diffuser neck connection.
- F. Do not route flexible duct through corridor walls or fire or smoke rated partitions, barriers, or walls.
- G. No bends shall be made in flexible duct with the center line radius less than one and one-half duct diameter and only one bend may occur per four foot length of duct material.

2.9 FLEXIBLE DUCT CONNECTIONS

- A. Acceptable manufacturers: Carlisle, Durodyne, or Elgen.
1. Substitutions: Refer to Division 01.
- B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards and as indicated.
- C. Flexible Duct Connections: Fabric crimped into metal edging strip.
1. Fabric: NFPA 90A compliant, UL listed fire-retardant neoprene coated woven glass fiber fabric, minimum 28 oz. density.
 - a. Net Fabric Width: Approximately 3 inches wide.
 2. Metal: 3 inches wide, 24 gauge, 0.0239 inch thick galvanized steel. Provide aluminum or stainless steel metal as required to match ductwork material.

2.10 VOLUME CONTROL DAMPERS

- A. Acceptable manufacturers: Louvers & Dampers, Greenheck, McGill Airflow, Ruskin, or SEMCO.
1. Substitutions: Refer to Division 01.

- B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards and as indicated.
- C. Splitter Dampers:
 - 1. Material: Same gauge as duct to 24 inches size in either direction, and two gauges heavier for sizes over 24 inches.
 - 2. Blade: Fabricate of single thickness sheet metal to streamline shape, secured with continuous hinge or rod.
 - 3. Operator: Minimum 1/4 inch diameter rod in self aligning, universal joint action, flanged bushing with set screw .
- D. Single Blade Dampers: Fabricate for duct sizes up to 6 x 30 inch.
 - 1. Fabricate for duct sizes up to 6 x 30 inch.
 - 2. Blade: 22 gauge, minimum.
 - 3. Frame: 18 gauge, minimum.
- E. Multi-Blade Damper: Fabricate of opposed blade pattern with 3V or airflow shaped blades and maximum blade sizes 8 x 72 inch. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.
 - 1. Blade: 18 gauge, 0.0478 inch, minimum.
- F. End Bearings: Except in round ducts 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon, thermoplastic elastomer, or sintered bronze bearings.
- G. Quadrants:
 - 1. Provide locking, indicating quadrant regulators on multi-blade dampers.
 - 2. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.
 - 3. Where rod lengths exceed 30 inches provide regulator at both ends.

2.11 MISCELLANEOUS PRODUCTS

- A. Duct Opening Closure Film: Mold-resistant, self-adhesive film to keep debris out of ducts during construction equal to Carlisle Dynair Duct Protection Film. Use to cover all open ends of stored or hung ductwork during construction.
 - 1. Thickness: 2 mils.
 - 2. High tack water based adhesive.
 - 3. UV stable light blue color.
 - 4. Elongation before break: 325 percent, minimum.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install accessories in locations specified and as shown on drawings in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA HVAC Duct Construction Standards. Refer to Section 23 31 13 for duct construction and pressure class.
- B. Provide insulated doors in ductwork for access to service equipment such as airflow measuring stations (each side), casing mounted coils (each side), control dampers, duct mounted coils

(each side), duct mounted smoke detectors, humidifiers, rated dampers, and elsewhere as noted on drawings.

- C. Provide insulated access doors in kitchen exhaust ducts for cleaning and inspection in accordance with NFPA 96.
- D. Provide duct test holes where indicated and required for testing and balancing purposes.
- E. Provide fire dampers, combination fire and smoke dampers, and smoke dampers at locations indicated, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
- F. Provide graphic representation of each individual smoke damper and combination fire/smoke damper location and status in the building automation system floor plans. Include unique ID to for each damper.
- G. At equipment supported by vibration isolators, provide flexible duct connections immediately adjacent to the equipment.
- H. Provide balancing dampers at all points on supply, return, and exhaust systems where branches are taken from larger ducts.
- I. Use splitter dampers only where indicated.
- J. Where diffusers or grilles and registers are not provided with volume dampers, install spin-in fitting with balance damper in duct run-out.
- K. Provide all screws, bolts, nuts, inserts, and material required for attaching sheetmetal to duct, walls, floors, and ceilings.

3.2 TESTING

- A. Check work for satisfactory installation and performance.
- B. Insure that adequate access does in fact exist for rated dampers, that damper blade movement is not restricted, and that damper operator motors are not hindered in operation by proximity to walls or other objects.
- C. Check duct connections at access doors for air leakage or condensation. Correct deficiencies found.

END OF SECTION

SECTION 23 34 16 - CENTRIFUGAL IN-LINE FANS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Forward curved, backward inclined, and airfoil type centrifugal fans.

1.2 RELATED REQUIREMENTS

- A. Section 23 05 00 - Common Work Results for HVAC
- B. Section 23 05 13 - Common Motor Requirements for HVAC Equipment
- C. Section 23 05 48 - Vibration Isolation
- D. Division 26: Electrical

1.3 REFERENCE STANDARDS

- A. AMCA 99 - Standards Handbook
- B. AMCA 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating
- C. AMCA 211 - Laboratory Methods of Testing Fans for Rating Purposes
- D. AMCA 300 - Test Code for Sound Rating Air Moving Devices
- E. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices
- F. ANSI/AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings

1.4 SUBMITTALS

- A. Submit manufacturer's product data for review in accordance with the provisions of Division 01.
- B. Fan curves shall include entire range of RPM curves, scheduled operating point, brake horsepower, motor horsepower, and sound performance data.

1.5 QUALITY ASSURANCE

- A. Certify fans performance in accordance with AMCA Certified Air and Sound Rating Criteria, Standard 210, 211, and 301.
- B. Sound Power data: Rated in accordance with AMCA 300.

1.6 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data as specified in Division 01.
- B. Include instructions for lubrication, motor, spare parts list, and wiring diagrams.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site under provisions of Division 01.
- B. Store and protect products under provisions of Division 01.
- C. Protect motors, shafts, and bearings from weather and construction dust.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Acme, Chicago Blower, Clarage (Twin City), Greenheck, Loren Cook, PennBarry, or Trane.
- B. Substitutions: Refer to Division 01.

2.2 EQUIPMENT REQUIREMENTS

- A. Wheels and Housings: Wheel diameters and outlets areas sized in accordance with AMCA Standards. Fans shall be statically and dynamically balanced. Housing shall contain access doors or removable access panels for maintenance.
- B. Drive arrangements: Conform with AMCA Standard AS2404, and as shown on drawings. Sheave shall be adjustable, cast iron, machined, keyed, security attached and sized for 150% of the horsepower at its rated maximum speed.
- C. Housing Constructions: Galvanized steel with slip joint inlets and outlets. Rivet blades to galvanized steel shroud.
- D. Painting: Factory applied, rust-resistant paint. Provide standard factory color unless noted otherwise.
- E. Shaft: Solid hot rolled steel, ground and polished for a smooth bearing fit.
- F. Mount relubricable anti-friction, self-aligning pillow block ball bearings on Class I fans and spherical roller type bearings on Class II and III fans. Position bearing supports to directly oppose drive belt tensions and transmit loads to the fan base.
- G. Bearings to have a minimum AFBMA L-50 life in excess of 200,000 hours for operating conditions.
- H. Provide lifetime lubricated and sealed bearings in fans and motors above ceilings.
- I. Mount motor: Adjustable slide rail on a steel isolation base.
- J. Provide fan type, capacity, direction of rotation, discharge direction, and arrangement as shown on drawings. Provide steel fan base for Arrangement 9 and 10 fans. Provide fan base for Arrangement 3 fans under Section 23 05 48 - Vibration Isolation. Prime-coat paint bases.
- K. Provide spark-proof constructed fans with explosion proof motors where scheduled.

- L. Provide fans noted on drawings with an asphaltum finish, or a bitumastic finish inside and to the housing and wheel, inlet bell, and vanes as scheduled.
- M. Provide OSHA approved expanded metal belt guards with aligned opening for checking fan shaft speed.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install fans in locations shown on drawings and in accordance with manufacturer's instructions.
- B. Connect fans to ductwork only by means of flexible connections.
- C. Fans for outdoor mounting shall be completely weatherproofed, with a fan motor and drive weather cover, and receive a second factory coat of paint.

3.2 TEST AND ACCEPTANCE

- A. Start-up and checkout fan for proper motor phasing, alignment, and vibration free operation. Improperly aligned fans to be connected. Change unmatched belts.
- B. Test fans in accordance with Section 23 05 00.
- C. Demonstrate system operation to Owner's maintenance personnel and instruct them in operational requirements.
- D. Verify that, where applicable, fans are interlocked with supply (and exhaust) fans as required by control drawings.

END OF SECTION

SECTION 23 36 00 - AIR TERMINAL UNITS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Dual duct terminal units.

1.2 RELATED REQUIREMENTS

- A. Section 23 05 00 - Common Work Results for HVAC.
- B. Section 23 05 13 - Common Motor Requirements for HVAC Equipment
- C. Section 23 05 23 - General Duty Valves for HVAC
- D. Section 23 05 29 - Hangers for HVAC Piping
- E. Section 23 05 53 - Identification for HVAC Piping and Equipment
- F. Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC
- G. Section 23 07 00 - HVAC Insulation
- H. Section 23 09 13 - Instrumentation and Control Devices for HVAC
- I. Section 23 21 13 - Hydronic Piping
- J. Section 23 21 14 - Hydronic Specialties
- K. Section 23 31 13 - Sheetmetal Ductwork
- L. Section 23 33 00 - Air Duct Accessories
- M. Section 26 27 17 - Equipment Wiring: Electrical characteristics and wiring connections.

1.3 REFERENCE STANDARDS

- A. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilation Systems; National Fire Protection Association; 2012.
- B. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.
- C. Acoustical Liner: Meet requirements of NFPA 90A, UL 181, and ASTM C665 as specified.
- D. Air Diffusion Council, ADC Standard 1062R2, Air Diffusing Equipment Test Code.
- E. Air Moving and Conditioning Association, AMCA Standard 210, Test Code for Air Moving Devices.
- F. SMACNA HVAC Duct Construction Standards; Current Edition.

1.4 SUBMITTALS

- A. Submit product data and required information in accordance with the provisions of Division 01.
- B. Product Data: Provide data indicating configuration, general assembly, materials used in fabrication, access door location and size, insulation thickness, density, and R-value. Include specific performance ratings that indicate unit ID, airflow setpoints, coil performance, air pressure drop, NC rating, and electrical characteristics and connection requirements.
- C. Manufacturer's Installation Instructions: Indicate support and hanging details, and service clearances required.
- D. Project Record Documents: Record actual locations of units.
- E. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists.
- F. Substitutions: Refer to Division 1.
- G. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.6 WARRANTY

- A. See Division 01 for additional warranty requirements.
- B. Provide five year manufacturer warranty for air terminal units.

1.7 GUARANTEE

- A. Manufacturer guarantees resultant noise levels to be within NC rating published by manufacturer.

PART 2 PRODUCTS

2.1 DUAL DUCT AIR TERMINAL UNITS

- A. Acceptable Manufacturers:
 - 1. Anemostat, Environmental Technologies (JCI), Krueger, Metalaire, Nailor, Price, Titus, and Trane.
- B. Basic Assembly:
 - 1. Casings: Minimum 22 gauge galvanized steel.
 - 2. Lining:

- a. Insulation shall comply with the requirements of UL 181, NFPA 90A, and ASTM C665.
 3. Provide insulated gasketed access panel on bottom of terminal unit for access to and inspection of internal air valves. Adjacent duct insulation shall not block access door(s).
 4. Leakage: Maximum 1% of maximum rated airflow at 1" wg. inlet static pressure.
 5. Multi-point, multi-axis flow ring or cross sensor at box inlets.
 6. Provide integral flow taps and calibration chart on each unit.
 7. Factory calibrate sensor and controller for maximum, minimum, heating, and unoccupied design airflow according to the air terminal unit schedule. Terminal units scheduled for constant volume operation shall be provided with controls capable of variable volume operation.
 8. Factory mount, wire, connect, calibrate, setup and test DDC controllers, pressure transducers, and electronic damper actuators furnished to box manufacturer under Section 23 09 13. Damper actuators integral with terminal unit may be furnished by terminal unit manufacturer and operation coordinated with DDC controller.
 9. Control transformer: Provide and factory mount 120V / 24V control circuit transformer for each terminal unit sized to handle all box controls. Provide safety devices including toggle disconnect switch and primary and secondary fusing.
- C. Actuator / Controls: Electronic
1. Configuration: Air volume damper assembly inside unit casing. Locate control components inside protective metal shroud with removable cover.
 2. Volume Damper: Construct of galvanized steel with peripheral gasket and self lubricating bearings; maximum damper leakage: 2 percent of design air flow at 3 inches rated inlet static pressure. Damper positions shall be indicated on the end of the shaft on the outside of the casing.
 3. Provide separate actuators for each volume damper, unless noted otherwise.
 4. Controller to provide consistent air delivery within 5% of nominal airflow down to 25% of unit rated CFM, independent of changes in system static pressure or either inlet damper position.
- D. Attenuator:
1. Where indicated, attenuators shall be provided as required to reduce the discharge and radiated NC levels to 35 or less based on selections made at 3.0" w.c. inlet static pressure.
 2. The attenuator lining shall match the specified air terminal unit lining.
 3. Provide attenuator on all air terminal units in the following spaces: _____.
- E. Heating Water Coil:
1. Selection criteria:
 - a. Unless noted otherwise, coils shall be selected at the scheduled heating water supply temperature to meet the scheduled performance criteria in the following priority: total capacity (BTUH), leaving air temperature, heating water return temperature.
 - b. Coils rows shall be selected to obtain the performance closest to the scheduled values while meeting the scheduled capacity and without exceeding the leaving air temperature.
 2. Construction:
 - a. Fins: Aluminum, maximum 10 fins per inch.
 - b. Tubes: 1/2 inch, 5/8 inch, or 7/8 inch seamless, copper tubes mechanically expanded into the fin collars; arranged for counter-flow of heating water.
 - c. Water velocity maximum 8 feet per second with water pressure loss not greater than indicated on the drawings.
 - d. Rows: Provide coil rows scheduled or as required to achieve scheduled performance.
 3. Coils shall be ARI certified and leak tested at 300 PSIG under water.

4. Casing shall be minimum 22 gauge galvanized steel.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide ceiling access doors or locate units above easily removable ceiling components.
- C. Support units independently from structure. Do not support from adjacent ductwork.
- D. Connect to ductwork in accordance with Section 23 31 13.
- E. Provide insulation and engraved equipment nameplate as specified.
- F. Provide insulation in accordance with Section 23 07 13 and Section [].
- G. Verify that electric power is available and of the correct characteristics.
- H. Coordinate control installations with temperature controls vendor.

3.2 CLEANING, TESTING, STARTUP, AND DEMONSTRATION

- A. Clean and test units in accordance with Section 23 05 00.
 1. Include flushing of connected piping and cleaning of water control valves.
- B. Start-up units, check for proper operation as a system with air handling unit, fan, and connected ductwork.
- C. Check for clear access to control panel, isolation valves, control valves, balancing valves, and access panels. Verify required working clearance for control panels.
- D. Prepare units for Test and Balance as required by Section 23 05 93, correct any deficiencies found and retest.
- E. Demonstrate operation of units as a complete system to maintenance personnel and instruct them in the operation, adjustment and repair of the system.
- F. Check connections to insure they are tight and without noticeable leakage. Correct any deficiencies found.

END OF SECTION

SECTION 23 37 00 - AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Diffusers.
- B. Registers/grilles.

1.2 RELATED REQUIREMENTS

- A. Section 23 05 00 - Common Work Results for HVAC
- B. Section 23 33 00 - Air Duct Accessories
- C. Section 23 31 13 - Sheetmetal Ductwork
- D. Section 23 31 14 - Sheetmetal - Special Ductwork

1.3 SUBMITTALS

- A. Product Data: Submit product data for review. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.
- B. Samples: Submit two of each required air outlet and inlet type upon request.
- C. Project Record Documents: Record actual locations of air outlets and inlets.

1.4 QUALITY ASSURANCE

- A. Test and rate air outlet and inlet performance in accordance with ASHRAE Std 70.
- B. Test and rate louver performance in accordance with AMCA 500-L.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Anemostat, Carnes, Krueger, Metalaire, Nailor, Price, or Titus unless noted otherwise.
- B. Substitutions: Refer to Division 01.
- C. Air devices shall meet these specifications and the requirements noted in the Air Distribution Device Schedule. Titus model numbers are not inclusive of all listed requirements.

2.2 SUPPLY DIFFUSERS

- A. Type S1 (based on Titus TMS)

1. Square, 3-cone louvered face ceiling diffuser, four way directional blow. For diffusers noted on drawings to be 2 or 3 way blow, provide blank off plates in diffuser. Provide panel, face and neck size scheduled.
 2. Material: Steel with baked acrylic finish.
 3. Color: White.
 4. Borders and mounting: Coordinate ceiling device frame type with architectural ceiling type.
 5. Dampers: Provide ceiling diffusers complete with opposed blade volume dampers where diffuser is installed in inaccessible ceiling and spin-in fitting manual volume damper at branch ductwork tap is not accessible.
 6. Accessories: None.
- B. Type S6 (based on Titus TLF-AA without HEPA filter)
1. Acceptable manufacturers:
 - a. Anemostat, Nailor, Precision Air Products, Price, or Titus.
 - b. Substitutions: Not permitted.
 2. Square or rectangular laminar flow diffuser with 6" deep backpan and integral internal baffle for evenly distributing air over the entire perforated face of the diffuser. The face shall be secured in place by quarter-turn fasteners for quick removal and sanitizing. Throw for terminal velocities of 75, 50, and 30 feet/minute along with corresponding pressure drop shall be provided with submittal data. Provide panel, face and neck size scheduled.
 3. Material: Aluminum with continuously welded seams and baked acrylic finish.
 4. Color: White.
 5. Borders and mounting: Coordinate ceiling device frame type with architectural ceiling type.
 6. Dampers: Furnish with integral manual volume damper adjustable through the face of the diffuser.
 7. Accessories: Safety chain.

2.3 RETURN AND EXHAUST GRILLES

- A. Type R1 / E1 (based on Titus 50F)
1. Square or rectangular frame with perforated 1/2" x 1/2" x 1/2" grid. Provide frame and face size scheduled with minimum 3" deep fabricated steel backpan with centered ductwork connection equal to neck size scheduled. The visible surface of the backpan shall be painted flat black, unless noted otherwise. Provide panel, face and neck size scheduled.
 2. Material: Aluminum frame and grid with baked acrylic finish.
 3. Color: White.
 4. Borders and mounting: Coordinate ceiling device frame type with architectural ceiling type.
 5. Dampers: Provide ceiling grille complete with opposed blade volume dampers where diffuser is installed in inaccessible ceiling and spin-in fitting manual volume damper at branch ductwork tap is not accessible.
 6. Accessories: None.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install accessories in accordance with manufacturer's published recommendations as well as applicable sections of SMACNA manual and other standards set forth in Part 1.

- C. Provide all screws, bolts, nuts, inserts, and material required for attaching sheet metal to duct, walls, floors, and ceilings.
- D. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.
- E. Where diffusers or grilles and registers are not provided with volume dampers, install spin-in fitting with balancing damper in duct runout.

3.2 TESTING

- A. Check work for satisfactory installation and performance.
- B. Check duct connections at air inlets and outlets air leakage or condensation. Correct conditions found.

3.3 INSPECTION

- A. Air inlets and outlets shall be clean and free from scratches and dents. Repair or replace damaged devices as required.

END OF SECTION

