SECTION 23 0400 - GENERAL CONDITIONS FOR MECHANICAL TRADES

PART 1 GENERAL

1.1 RELATED REQUIREMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to all Divisions 23 Sections.

B. This section applies to certain sections of Division 26, "Electrical," and this section applies to all sections of Division 23, "Mechanical" of this project specification unless specified otherwise in the individual sections.

C. The Drawings of other trades (Architectural, Food Service, Structural, Landscape, Civil, Mechanical, Fire Protection and Plumbing) shall be examined for coordination and familiarity of work with other Contractors. Any duplication or omission of provisions in this project should be brought to the attention of the Owners prior to Bidding.

1.2 DESCRIPTION

A. The General Conditions and Supplementary General Conditions are a part of this Division and are to be considered a part of this Contract.

B. Where items of the General Conditions and Supplementary General Conditions are repeated in other Sections of the Specifications, it is merely intended to qualify or to call particular attention to them. It is not intended that any other parts of the General Conditions and Supplementary General Conditions shall be assumed to be omitted if not repeated therein. This Section applies equally and specifically to all Contractors supplying labor and/or equipment and/or materials as required under each Section of this Division. Where conflicts exist between the drawings and the specifications or between this section of the specifications and other sections, the more stringent or higher cost option shall apply.

1.3 INTENT

A. It is the intent of the Specifications and Drawings to call for finished work, tested and ready for operation. Provide all parts necessary for the intended use, fully complete and operational, and installed in professional manner in accordance with the design intent.

B. Any apparatus, appliance, material or work not shown on drawings but mentioned in the specifications, or vice versa, or any incidental accessories necessary to make the work complete and ready for operation as determined by good trade practice even if not particularly specified, shall be furnished, delivered and installed under their respective Divisions without any additional expense to the Owner.

C. Minor details not usually shown or specified but necessary for proper installation and operation shall be included in the work as though they were hereinafter shown or specified.

D. Work under each Section shall include giving written notice to the Owner and Engineer of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules or regulations of authorities having jurisdiction; and any necessary items of work omitted. In the absence of such written notice, it is mutually agreed that work under each Section includes the cost of all required items for the accepted, satisfactory functioning of the entire system without extra compensation.

1.4 DEFINITIONS

A. No Exceptions Taken – reviewed and determined to be in general conformance with contract documents.

B. “Approved equal” mean any product which in the opinion of the Engineer is equal in quality, arrangement, appearance, and performance to the product specified.

C. Directed: Terms such as "directed," "requested," "authorized," "selected," "approved," "required," and "permitted" mean "directed by the Engineer," "requested by the Engineer," and similar phrases.

D. “Finished” refers to all rooms and areas to be specified to receive architectural treatment as indicated on the drawings. All rooms and areas not covered, including underground tunnels and areas above ceilings shall be considered not finished, unless otherwise noted.

E. “Furnish” or “supply” shall mean purchase, deliver to, and off-load at the job site, ready to be installed including where appropriate all necessary interim storage and protection.

F. Indicated: The term "indicated" refers to graphic representations, notes, or schedules on the Drawings, other paragraphs or schedules in the Specifications, and similar requirements in the Contract Documents. Where terms such as "shown," "noted," "scheduled," and "specified" are used, it is to help the reader locate the reference; no limitation on location is intended.

G. “Install” shall mean set in place complete with all mounting facilities and connections as necessary ready for normal use or service.

H. “Product” shall mean any item of equipment, material, fixture, apparatus, appliance or accessory installed under this Division.

I. “Provide” shall mean furnish (or supply) and install as necessary.

J. Regulation: The term "Regulations" includes laws, ordinances, statutes, and lawful orders issued by authorities having jurisdiction, as well as rules, conventions, and agreements within the construction industry that control performance of the Work.

K. Remove: The term “remove” means “to disconnect from its present position, remove from the premises and to dispose of in a legal manner.”

L. Special Warranties: The term “Special Warranties” are written warranties required by or incorporated in the Contract Documents, either to extend time limits provided by standard warranties or to provide greater rights for the Owner.

M. Standard Product Warranties: The term “Standard Product Warranties” are preprinted written warranties published by individual manufacturers for particular products and are specifically endorsed by the manufacturer to the Owner.

N. “Subcontractor” means specifically the subcontractor working under this Division. Other Contractors are specifically designated “Plumbing Subcontractor”, “General Contractor” and so on. Note: Take care to ascertain limits of responsibility for connecting equipment which requires connections by two or more trades.

O. Substitutions: Requests for changes in products, materials, equipment, and methods of construction proposed by the Contractor are considered requests for "substitutions."

P. “Wiring” shall mean cable assembly, raceway, conductors, fittings and any other necessary accessories to make a complete wiring system.

1.5 CONTRACT DOCUMENTS

A. The two dimensional drawings govern the construction. They show the design intent and are part of the Contract Documents. BIM models are not part of contract documents. They are developed for convenience only.

B. Drawings are diagrammatic and indicate the general arrangement of systems and work included in the Contract. Consult the Architectural Drawings and Details for exact location of fixtures and equipment; where same are not definitely located, obtain this information from the Architect. (Do not scale the drawings)

C. Work under each Section shall closely follow Drawings in layout of work; check Drawings of other Divisions to verify spaces in which work will be installed. Maintain maximum headroom; where space conditions appear inadequate, Owner and Engineer shall be notified before proceeding with installations.

D. The Owner may, without extra charge, make reasonable modifications in the layout as needed to prevent conflict with work of other trades and/or for proper execution of the work.

1.6 DISCREPANCIES IN DOCUMENTS

A. Where variances occur between the Drawings and Specifications or within either of the Documents, the item or arrangement of better quality, shall be included in the Contract price. The Owner and Engineer shall decide on the item and the manner in which the work shall be installed.

B. Where Drawings or Specifications conflict or are unclear, submit clarification request in writing before Award of Contract. Otherwise, Architect's interpretation of Contract Documents shall be final, and no additional compensation shall be permitted due to discrepancies or un-clarities thus resolved.

C. Where Drawings or Specifications do not coincide with manufacturers' recommendations or with applicable codes and standards, submit clarification request in form of an RFI before installation. Otherwise, make changes in installed work required for compliance with manufacturer instructions or codes and standards within Contract Price.

D. Where insufficient information exists in the documents to precisely describe a certain component or subsystem, or the routing of a component or its coordination with other building elements, where notification required by Paragraph (B) above has not been submitted, provide the specific component or subsystem with all parts necessary for the intended use, fully complete and operational, and installed in professional manner either concealed or exposed in accordance with the design intent.

E. Where discrepancies exist between the mechanical, plumbing, fire protection, and electrical drawings in regards to what trade owns disconnects or starters, the discrepancy shall be brought to the Architect’s attention in accordance with paragraph (B) above. If the scope is not resolved prior to the Award of Contract, Division 26 shall provide such items.

1.7 SURVEYS AND MEASUREMENTS

A. Before submitting their Bid, the Contractors shall visit the site and become thoroughly familiar with all existing conditions under which work will be installed. This Contract includes all modifications of existing systems required for the installation of new equipment. This Contract includes all necessary offsets, transitions and modifications required to install all new equipment in existing spaces. All new and existing equipment and systems shall be fully operational under this Contract before the job is considered complete. The Contractors shall be held responsible for any assumptions he makes, any omissions or errors he makes as a result of his failure to become fully familiar with the existing conditions at the site and the Contract Documents.

B. The Contractor shall base all measurements, both horizontal and vertical, from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at the site and check the correctness of same as related to the work.

C. Should the Contractor discover any discrepancies between actual measurements and those indicated which prevent following good practice or which interfere with the intent of the Drawings and Specifications, the Engineer will be notified and work will not proceed until instructions from the Engineer are received.

1.8 CODES AND STANDARDS

A. Reference Standard Compliance

1. Where equipment or materials are specified to conform to industry and technical society reference standards of the organizations such as American National Standards Institute (ANSI), American Society for Testing and Materials (ASTM), National Electrical Manufacturers Association (NEMA), and Underwriters Laboratories Inc. (UL), submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance.

2. Independent Testing Organization Certificate: In lieu of the label or listing indicated above, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Engineer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

B. Wherever Codes and/or Standards are mentioned in these Specifications, the latest applicable edition or revision of the local building or life safety code shall be followed.

C. The following Standards shall be used where referenced by the following abbreviations:

AABC	Associated Air Balance Council
ACGIH	American Conference of Governmental Industrial Hygienists
ADC	Air Diffusion Council
AGA	American Gas Association
AIA	American Institute of Architects
AMCA	Air Moving and Conditioning Association
ANSI	American National Standards Institute
API	American Petroleum Institute
ARI	Air Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers

ASME	American Society of Mechanical Engineers
ASPE	American Society of Plumbing Engineers
ASSE	American Society of Sanitary Engineers
ASTM	American Society of Testing and Materials
AWS	American Welding Society
AWWA	American Water Works Association
CGA	Compressed Gas Association
CSA	Canadian Standards Association
CISPI	Cast Iron Soil Pipe Institute
EJMA	Expansion Joint Manufacturing Association
EPA	Environmental Protection Agency
FM	Factory Mutual
FSSC	Federal Specification
HIS	Hydraulic Institute Standards
IEEE	Institute of Electrical and Electronics Engineers
IRI	Industrial Risk Insurers
ISO	Insurance Services Office
MCAA	Mechanical Contractors Association of America
NBS	National Bureau of Standards
NEBB	National Environmental Balancing Bureau
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NOFI	National Oil Fuel Institute
NSC	National Safety Council
NSF	National Sanitation Foundation
OSHA	Occupational Safety and Health Administration
PDI	Plumbing and Drainage Institute

SBI	Steel Boiler Industry (Division of Hydronics Institute)
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
STI	Steel Tank Institute
UL	Underwriters' Laboratories

D. All materials furnished and all work installed shall comply with the rules and recommendations of the NFPA, the requirements of the local utility companies, the recommendations of the fire insurance rating organization having jurisdiction and the requirements of all Governmental departments having jurisdiction.

E. The Contractor shall include in the work, without extra cost to the Owner, any labor, materials, services, apparatus and Drawings in order to comply with all applicable laws, ordinances, rules and regulations, whether shown on Drawings and/or specified or not.

1.9 PERMITS AND FEES

A. The Contractor shall give all necessary notices, obtain all permits; and pay all Government and State sales taxes and fees where applicable, and other costs, including utility connections or extensions in connection with the work, file all necessary Drawings, prepare all documents and obtain all necessary approvals of all Governmental and State departments having jurisdiction, obtain all required certificates of inspection for his work, and deliver a copy to the Owner and Engineer before request for acceptance and final payment for the work.

1.10 EQUIPMENT EQUIVALENTS AND SUBSTITUTIONS

A. Certain manufacturers of material, apparatus or appliances are indicated in the drawings and specifications for this project. These items have been used as the basis of design, and as a convenience in fixing the minimum standard of quality, finish and design that is required. If the Contractors uses an "approved equal" alternative to the basis of design, and if the features of that alternative have an impact on other components of the Project, the Contractor shall include the necessary adjustments in those components, whether for architectural, structural, mechanical, electrical, fire protection, or any other elements, plus any adjustments for difference in performance.

B. Where no specific make of material, apparatus or appliance is mentioned, any first-class product made by a reputable manufacturer may be submitted for Architect and Engineer review.

C. Where the Contractor proposes to use an item that is different from the basis of design in the Drawings and specifications, and that will require the redesign of the structure, partitions, foundations, piping, wiring or any other component of the mechanical, electrical, or architectural layout, the Contractor shall provide the necessary redesign of those components.

D. Where the Contractor proposes to deviate (provide an equivalent or request for substitution) from the basis of design scheduled equipment or materials as hereinafter specified or shown on the drawings, they are required to submit a requested for substitution in writing. The Contractor shall state in their request whether it is a substitution, equivalent or a non approved equivalent to that specified and the amount of credit or extra cost involved. A copy of said request shall be included in the Base Bid with manufacturer's equipment cuts. The Base Bid shall be based on using the materials and equipment as specified with no exceptions.

E. If an alternative or substitute item results in a difference in quantity and arrangement of structure, piping, ductwork, valves, pumps, insulation, wiring, conduit, and equipment from that specified or indicated on the Drawings, the Contractor shall furnish and install any such additional equipment required by the system, at no additional cost to the Owner including any costs added to other trades due to the equivalent change from the basis of design detailed in the drawings or included within the specifications.

F. Equipment, material or devices submitted for review as a "substitution" shall meet the following requirements:

G. Substitution Request Submittal: Requests for substitution will be considered if received in writing 14 days before the bid date. Requests received later than 14 days before the bid date may be considered or rejected at the discretion of the Engineer/Owner. Once the Contractor submits a complete request for substitution as determined by the engineer, the engineer reserves the right to request the time necessary to evaluate the request for substitution and review it with the Owner.

H. Identify the product, or the fabrication or installation method to be replaced in each request. Include related Specification Section and Drawing numbers. Provide complete documentation showing compliance with the requirements for substitutions, and the following information, as appropriate:

a. Product Data, including Drawings and descriptions of products, fabrication and installation procedures.

b. Samples, where applicable or requested.

c. A detailed comparison of significant qualities of the proposed substitution with those of the Work specified. Significant qualities may include elements such as size, weight, durability, performance and visual effect.

d. Coordination information, including a list of changes or modifications needed to other parts of the Work and to construction performed by the Owner and separate Contractors that will become necessary to accommodate the proposed substitution.

e. A statement indicating the substitution's effect on the Contractor's Construction Schedule compared to the schedule without approval of the

substitution. Indicate the effect of the proposed substitution on overall Contract Time.

f. Cost information, including a proposal of the net change, if any in the Contract Sum.

g. Certification by the Contractor that the substitution proposed is equal-to or better in every significant respect to that required by the Contract Documents, and that it will perform adequately in the application indicated. Include the Contractor's waiver of rights to additional payment or time that may subsequently become necessary because of the failure of the substitution to perform adequately.

h. Engineer's Action: Within one week of receipt of the request for substitution, the Engineer will notify the Contractor of acceptance or rejection of the proposed substitution. If a decision on use of a proposed substitute cannot be made or obtained within the time allocated, use the product specified by name. Acceptance of a product substitution will be in the form of an Addendum.

i. Other Conditions: The Contractor's substitution request will be received and considered by the Engineer when one or more of the following conditions are satisfied, as determined by the Engineer; otherwise requests will be returned without action except to record noncompliance with these requirements.

1) The request is directly related to an "or equal" clause or similar language in the Contract Documents.

2) The specified product or method of construction cannot be provided within the Contract Time. The request will not be considered if the product or method cannot be provided as a result of failure to pursue the Work promptly or coordinate activities properly.

3) A substantial advantage is offered the Owner, in terms of cost, time, energy conservation or other considerations of merit, after deducting offsetting responsibilities the Owner may be required to bear. Additional responsibilities for the Owner may include additional compensation to the Engineer for redesign and evaluation services, increased cost of other construction by the Owner or separate Contractors, and similar considerations.

1.11 SUBMITTAL PROCEDURES

A. Provide Submittals in accordance with the requirements of Division 1 and as indicated in the following.

B. Coordination: Coordinate preparation and processing of submittals with performance of construction activities. Transmit each submittal sufficiently in advance of performance of related construction activities to avoid delay.

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals and related activities that require sequential activity.

2. Coordinate transmittal of different types of submittals for related elements of the Work so processing will not be delayed by the need to review submittals concurrently for coordination. The Engineer reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.

C. Processing: Allow sufficient review time so that installation will not be delayed as a result of the time required to process submittals, including time for resubmittals.

1. Allow ten business days for initial review. Allow additional time if processing must be delayed to permit coordination with subsequent submittals. The Engineer will promptly advise the Contractor when a submittal being processed must be delayed for coordination.

2. If an intermediate submittal is necessary, process the same as the initial submittal.

3. Allow ten business days for reprocessing each submittal.

4. No extension of Contract Time will be authorized because of failure to transmit submittals to the Engineer sufficiently in advance of the Work to permit processing.

D. Submittal Preparation: Place a permanent label or title block on each submittal for identification. Indicate the name of the entity that prepared each submittal on the label or title block. Submittals shall be arranged in order of specification sections.

1. Include the following information on the label for processing and recording action taken.

a. Project name.

b. Date.

c. Name and address of Engineer.

d. Name and address of Contractor.

e. Name and address of subcontractor.

f. Name and address of supplier.

g. Name of manufacturer.

h. Number, title and paragraph of appropriate Specification Section.

i. Drawing number and detail references, as appropriate.

E. Submittal Transmittal: Package each submittal appropriately for transmittal and handling. Transmit each submittal from Contractor to Engineer using a transmittal form. Submittals received from sources other than the Contractor will be returned without action. On the transmittal, record relevant information and requests for data. On the form, or separate sheet, record deviations from Contract Document requirements, including minor variations and limitations. Include Contractor's certification that information complies with Contract Document requirements.

F. Except for submittals for record, information or similar purposes, the Engineer will review each submittal, mark to indicate action taken, and return promptly. Compliance with specified characteristics is the Contractor's responsibility.

G. Action Stamp: The Engineer will stamp each submittal with a uniform, self-explanatory action stamp. The stamp will be appropriately marked, to indicate the action taken.

1.12 SHOP DRAWINGS

A. Submit neatly prepared information, drawn to accurate scale. Highlight, encircle, or otherwise indicate deviations from the Contract Documents. Do not reproduce Contract Documents or copy standard information as the basis of Shop Drawings. Standard information prepared without specific reference to the Project is not considered Shop Drawings.

B. The Contractor shall submit for review detailed shop drawings of all equipment and material specified in each section and coordinated ductwork layouts. No material or equipment may be delivered to the job site or installed until the Contractor has received shop drawings for the particular material or equipment which have been properly reviewed. Shop drawings shall be submitted within 60 days after award of Contract before any material or equipment is purchased. The Contractor shall submit for review all shop drawings to be incorporated in the Mechanical Contract.

C. Provide shop drawings for all devices specified under equipment specifications for all systems. Shop drawings shall include manufacturers' names, catalog numbers, cuts, diagrams, dimensions, identification of products and materials included, compliance with specified standards, notation of coordination requirements, notation of dimensions established by field measurement and other such descriptive data as may be required to identify and accept the equipment. A complete list in each category (example: all fixtures), of all shop drawings, catalog cuts, material lists, etc., shall be submitted to the Engineer at one time. No consideration will be given to a partial shop drawing submittal.

D. When a submittal could involve more than one trade, e.g., valves, piping, etc., the submitted shall be separated by traded involved, ie. HVAC, plumbing, fire protection, etc.

E. Where multiple quantities or types of equipment are being submitted, provide a cover sheet (with a list of contents) on the submittal identifying the equipment or material being submitted.

F. The Contractor shall furnish all necessary templates, patterns, etc., for installation work and for the purpose of making adjoining work conform; furnish setting plans and shop details to other trades as required.

G. "No Exception Taken" rendered on shop drawings shall not be considered as a guarantee of measurements or building conditions. Where drawings are reviewed, review does not mean that drawings have been checked in detail; said approval does not in any way relieve the Contractor from his responsibility or necessity of furnishing material or performing work as required by the Contract Drawings and Specifications. Verify available space prior to submitting shop drawings. Review of shop drawings shall not apply to quantity of material.

H. After shop drawings have been reviewed, with no exceptions taken, no further changes will be allowed without the written consent of the Engineer.

I. Shop drawing submittal sheets which may show items that are not being furnished shall have those items crossed off to clearly indicate which items will be furnished.

J. Bidders shall not rely on any verbal clarification of the Drawings and/or Specifications. Any questions shall be referred to the Engineer in writing at least five (5) working days prior to Bidding to allow for issuance of an Addendum.

K. Do not use Shop Drawings without an appropriate final stamp indicating action taken in connection with construction.

L. All submittals shall be made in electronic PDF format with searchable OCR (Optical Character Recognition) format. This excludes scanned and faxed materials.

1.13 COORDINATION DRAWINGS AND BIM MODEL

A. Coordination drawings are required for all mechanical and electrical trades. The content and procedures described in Division 01 shall be followed, with the additional requirements specifically for the mechanical and electrical trades as described in this Section. If a BIM model is not used on this project, the below requirements shall be accomplished in CAD.

B. Prepare coordination drawings accordance with Division 01, at 1 to 1 (full) scale prepared at ¼" = 1' -0" detailing major elements, components, and systems of

mechanical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. The Contractor shall indicate the proposed locations of piping, conduit, ductwork, equipment, and materials. Include the following:

    a. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.

    b. Equipment connections and support details.

    c. Exterior wall and foundation penetrations.

    d. Fire-rated wall and floor penetrations.

    e. Sizes and locations of required concrete pads and bases.

C. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.

D. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.

E. Prepare reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, light fixtures, communication systems components, sprinklers, and other ceiling-mounted items.

F. The Contractor and each subcontractor shall sign and date each coordination drawing prior to submission.

G. Work shall not be performed until coordination drawings have been approved by the architect and engineer.

H. Electronic copies of the MEP floor plans and/or BIM model are available to use as a basis for preparing coordination drawings and can be provided by the Engineer. If the Contractor elects to obtain the Engineers electronic files an Electronic Drawing File Release Form must be submitted. This form must be signed by the Contractor, Owner, and Architect. Upon receipt of a signed copy of the Electronic Drawing File Release Form, the Engineer will provide copies of the electronic files for the Contractor's use. A copy of the Electronic Drawing File Release Form is appended to the end of this specification section

I. Review by Engineer of coordination drawings is limited to confirming that requirements for coordination and preparation of plans have been complied with by the Contractor and shall not diminish responsibility under this Contract for final coordination of installation

and maintenance clearances of all systems and equipment with Architectural, Structural, Mechanical, Electrical and other related work.

1.14 COORDINATION WITH OTHER DIVISIONS

A. All work shall be carried out in conjunction with other trades and full cooperation shall be given in order that all work may proceed with a minimum of delay and interference. Particular emphasis is placed on timely installation of major apparatus and furnishing other Contractors, especially the Contractor or Construction Manager, with information as to openings, chases, sleeves, bases, inserts, equipment locations, panels, etc., required by other trades.

B. The Contractors are required to examine all of the Project Drawings and mutually arrange work so as to avoid interference with the work of other trades. In general, ductwork, HVAC piping, sprinkler piping and drainage lines take precedence over water, gas and electrical conduits. The Engineer shall make final decisions regarding the arrangement of work which cannot be agreed upon by the Contractors.

C. Where the work of the Contractor will be installed in close proximity to or will interfere with work of other trades, the Contractors will cooperate in working out space conditions to make a satisfactory adjustment.

D. If the work under a Section is installed before coordinating with other Divisions or Sections or so as to cause interference with work of other Sections, the necessary changes to correct the condition shall be made by the Contractor causing the interference without extra charge to the Owner.

E. The two dimensional drawings are diagrammatic. They indicate general arrangements of mechanical systems and other work, and are intended to convey sufficient information for skilled contractors and tradespeople to furnish and install complete systems. They are not intended to be absolutely precise; they are not intended to specify or to show every offset, fitting, and component. The purpose of the drawings is to indicate a systems concept, the main components of the systems, and the approximate geometrical relationships. Based on the systems concept, the main components, and the approximate geometrical relationships, provide all other components and materials to make the systems fully complete, coordinated with other systems and the structure and space available, and operational. Similarly, the drawings do not show all offsets required for coordination nor do they show the exact routings and locations needed to coordinate with structure and other trades in order to avoid interferences and to meet ceiling heights and other Architectural requirements. Establish and provide offsets, changes in direction, and exact routings to coordinate all systems. Where conflicts or potential conflicts exist and engineering guidance is desired, submit a “Request for Information” (RFI).

F. Controls contractor shall coordinate and sequences of operation with all other trades as necessary to provide a complete and functioning system.

1.15 QUALITY CONTROL

A. Service Support: The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

B. Modification of References: In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears.

C. The Contractor shall furnish the services of an experienced superintendent who shall be constantly in charge of the installation of the work together with all skilled tradespeople, fitters, metal workers, welders, helpers and laborers required to unload, transfer, erect, connect, adjust, start, operate and test each system.

D. Unless otherwise specifically indicated on the Drawings or Specifications, all equipment and materials shall be installed with the acceptance of the Engineer and in accordance with the recommendations of the manufacturer. This includes the performance of such tests as the manufacturer recommends.

E. All labor for installation of mechanical systems shall be performed by experienced, skilled tradespeople under the supervision of a licensed journeyman foreman. All work shall be of a quality consistent with good trade practice and shall be installed in a neat, professional manner. The Engineer reserves the right to reject any work which, in their opinion, has been installed in a substandard, dangerous or unserviceable manner. The Contractor shall replace said work in a satisfactory manner at no extra cost to the Owner.

1.16 SHUTDOWNS

A. When installation of a new system requires the temporary shutdown of an existing operating system, the connection of the new system shall be performed at such time as designated by the Owner.

B. The Engineer and the Owner shall be notified in writing of the estimated duration of the shutdown period at least ten (10) days in advance of the date the work is to be performed.

C. Work shall be arranged for continuous performance whenever possible. The Contractor shall provide all necessary labor, including overtime if required, to assure that existing operating services will be shut down only during the time actually required to make necessary connections.

1.17 TEMPORARY UTILITIES

A. General: Provide new materials and equipment; if acceptable to the Engineer, undamaged previously used materials in serviceable condition may be used. Provide materials suitable for the use intended.

B. Conditions of Use: Keep temporary services and facilities clean and neat in appearance. Operate in a safe and efficient manner. Take necessary fire prevention measures. Do not overload facilities, or permit them to interfere with progress. Do not allow hazardous dangerous or unsanitary conditions, or public nuisances to develop or persist on the site.

C. First Aid Supplies: Comply with governing regulations.

D. Fire Extinguishers: Provide hand-carried, portable UL-rated, class "A" fire extinguishers for temporary offices and similar spaces. In other locations provide hand-carried, portable, UL-rated, class "ABC" dry chemical extinguishers, or a combination of extinguishers of NFPA recommended classes for the exposures.

E. Utilities: Engage the appropriate local utility company to install temporary service or connect to existing service. Where the company provides only part of the service, provide the remainder with matching, compatible materials and equipment; comply with the company's recommendations.

1. Use Charges: Cost or use charges for temporary facilities are not chargeable to the Owner or Engineer, and will not be accepted as a basis of claims for a Change Order.

F. Water Service: Install water service and distribution piping of sizes and pressures adequate for construction until permanent water service is in use.

G. Temporary Heat-Cool-Dehumidification: Provide temporary services required by construction activities, for curing or drying of completed installations or protection of installed construction from adverse effects of low temperatures or high humidity. Select safe equipment that will not have a harmful effect on completed installations or elements being installed. Coordinate temporary services to produce the ambient condition required and minimize consumption of energy. The building’s permanent HVAC systems shall not be used for these purposes.

H. Environmental Protection: Provide protection, operate temporary facilities and conduct construction in ways and by methods that comply with environmental regulations, and minimize the possibility that air, waterways and subsoil might be contaminated or polluted, or that other undesirable effects might result. Avoid use of tools and equipment which produce harmful noise. Restrict use of noise making tools and equipment to hours that will minimize complaints from persons or firms near the site.

I. Termination and Removal: Unless the Engineer requires that it be maintained longer, remove each temporary facility when the need has ended, or when replaced by authorized use of a permanent facility, or no later than Substantial Completion. Complete or, if necessary, restore permanent construction that may have been delayed because of interference with the temporary facility. Repair damaged Work, clean exposed surfaces and replace construction that cannot be satisfactorily repaired. Materials and facilities that constitute temporary facilities are property of the Contractor. The Owner reserves the right to take possession of Project identification signs.

1.18 Equipment Access

A. Appliances, controls devices, heat exchangers and HVAC system components that utilize energy shall be accessible for inspection, service, repair and replacement without disabling the function of a fire-resistance-rated assembly or removing permanent construction, other appliances, venting systems or any other piping or ducts not connected to the *appliance* being inspected, serviced, repaired or replaced. A level working space not less than 30 inches deep and 30 inches wide shall be provided in front of the control side to service an *appliance*.

1.19 PROJECT PHASING

A. Work under each Section shall include all necessary temporary connections, equipment, piping, heating, temperature control work, fire stopping, water heaters, labor, and material as necessary to accommodate the phasing of Construction as developed by the General Contractor or Construction Manager and approved by the Owner. All existing systems that pass-thru an area of the building shall remain operational during all phases of construction. No extra compensation shall be granted the Contractor for work required to maintain existing systems operational or to accommodate the construction phasing of the project.

1.20 PROTECTION OF MATERIALS AND EQUIPMENT

A. Work under each Section shall include protecting the work and material of all other Sections from damage by work or workpeople and shall include making good all damage thus caused.

B. The Contractor shall be responsible for work and equipment until the facility has been accepted by the Owner. Protect work against theft, injury or damage and carefully store material and equipment received on site which is not immediately installed. Close open ends of work with temporary covers or plugs during construction to prevent entry of foreign material.

C. Work under each Section includes receiving, unloading, uncrating, storing, protecting, setting in place and completely connecting equipment supplied under each Section. Work under each Section shall also include exercising special care in handling and

protecting equipment and fixtures, and shall include the cost of replacing any of the equipment and fixtures which are missing or damaged.

D. Equipment and material stored on the job site shall be protected from the weather, vehicles, dirt and/or damage by tradespeople or machinery. Insure that all electrical or absorbent equipment or material is protected from moisture during storage.

1.21 ADJUSTING AND TESTING

A. After all the equipment and accessories to be furnished are in place, they shall be put in final adjustment and subjected to such operating tests so as to assure the Engineer that they are in proper adjustment and in satisfactory, permanent operating condition.

B. Where requested by the Engineer, a factory-trained service representative shall inspect the installation and assist in the initial startup and adjustment to the equipment. The period of these services shall be for such time as necessary to secure proper installation and adjustments. After the equipment is placed in permanent operation, the service representative shall supervise the initial operation of the equipment and instruct personnel responsible for operation and maintenance of the equipment. The service representative shall notify the Contractor in writing that the equipment was installed according to manufacturer's recommendations and is operating as intended by the manufacturer.

1.22 CLEANING

A. The Contractor shall thoroughly clean and flush all piping, ducts and equipment of all foreign substances, oils, burrs, solder, flux, etc., inside and out before being placed in operation.

B. If any part of a system should be stopped or damaged by any foreign matter after being placed in operation, the system shall be disconnected, cleaned and reconnected wherever necessary to locate and/or remove obstructions. Any work damaged in the course of removing obstructions shall be repaired or replaced when the system is reconnected at no additional cost to the Owner.

C. During the course of construction, all ducts and pipes shall be capped in an acceptable manner to insure adequate protection against the entrance of foreign matter.

D. Upon completion of all work under the Contract, the Contractor shall remove from the premises all rubbish, debris and excess materials left over from his work. Any oil or grease stains on floor areas caused by the Contractor shall be removed and floor areas left clean.

E. Complete the following cleaning operations before requesting inspection for Certification of Substantial Completion.

1. Remove labels that are not permanent labels.

2. Clean transparent materials, including mirrors and glass in doors and windows. Remove glazing compound and other substances that are noticeable vision-obscuring materials. Replace chipped or broken glass and other damaged transparent materials.

3. Clean exposed exterior and interior hard-surfaced finishes to a dust-free condition, free of stains, films and similar foreign substances. Restore reflective surfaces to their original reflective condition. Leave concrete floors broom clean. Vacuum carpeted surfaces.

4. Wipe surfaces of mechanical and electrical equipment. Remove excess lubrication and other substances. Clean plumbing fixtures to a sanitary condition. Clean light fixtures and lamps.

F. Comply with regulations of authorities having jurisdiction and safety standards for cleaning. Do not burn waste materials. Do not bury debris or excess materials on the Owner's property. Do not discharge volatile, harmful or dangerous materials into drainage systems. Remove and dispose of ALL waste materials, packaging material, skids etc. from the site and dispose of in a lawful manner in accordance with municipal, state and federal regulations.

G. Where extra materials of value remaining after completion of associated Work have become the Owner's property, arrange for disposition of these materials as directed.

1.23 OPERATING AND MAINTENANCE

A. Upon completion of all work and tests, the Contractor shall furnish the necessary skilled labor and helpers for operating his system and equipment for a period specified under each applicable Section of this Division. During this period, the contractor shall fully instruct the Owner or the Owner’s representative in the operation, adjustment and maintenance of all equipment furnished. The Contractor shall give at least seven (7) days notice to the Owner and the Engineer in advance of this period.

B. The Contractor shall include the maintenance schedule for the principal items of equipment furnished under this Division.

C. The Contractor shall physically demonstrate procedures for all routine maintenance of all equipment furnished under each respective Section to assure accessibility to all devices.

D. An authorized manufacturer’s representative shall attest in writing that the equipment has been properly installed prior to startup of any major equipment. The following equipment will require this inspection: pumps; air conditioning equipment, controls, air handling equipment, compressors, boilers etc. These letters shall be bound into the operating and maintenance books.

E. Refer to individual trade Sections for any other particular requirements related to operating instructions.

F. Demonstration shall be recorded on USB Flash drive turned over to the Owner. Video recording shall be done in a professional manner with quality video (1080p resolution) and clear audible sound.

1.24 OPERATING AND MAINTENANCE MANUALS

A. Prepare operating and maintenance manuals in accordance with the requirements of Division 1 and as follows. The Contractor shall prepare up to six (6) copies of a complete maintenance and operating instructions manual, bound in booklet form. Organize operating and maintenance data into suitable sets of manageable size. Bind properly indexed data in individual heavy-duty 3-ring vinyl-covered binders, with pocket folders for folded sheet information and designation partitions with identification tabs. Mark appropriate identification on front and spine of each binder.

B. Manual shall include the following:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.

2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.

3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

4. Servicing and operating instructions including lubrication charts and schedules.

5. Emergency and safety instructions.

6. Spare parts list.

7. Copies of warranties.

8. Wiring diagrams.

9. Recommended "turn around" cycles.

10. Inspection procedures.

11. Approved Shop Drawings and Product Data.

12. Equipment Start-up Reports.

13. Temperature control diagrams and written sequences of operations.

14. Balance reports.

C. Include in the manual, a tabulated equipment schedule for all equipment. Schedule shall include pertinent data such as: make, model number, serial number, voltage, normal operating current, belt size, filter quantities and sizes, bearing number, etc. Schedule shall include maintenance to be done and frequency.

D. Maintenance and instruction manuals shall be submitted to the Owner at the same time as the seven (7) day notice is given prior to the instruction period.

1.25 ACCEPTANCES

A. The equipment, materials, quality, design and arrangement of all work installed under the Mechanical Sections shall be subject to the review of the Engineer.

B. Within 30 days after the awarding of a Contract, the Mechanical Contractor shall submit to the Engineer, for review, a list of manufacturers of equipment proposed for the work under the Mechanical Sections. The intent to use the exact manufacturers and models specified does not relieve the Contractor of the responsibility of submitting such a list.

C. If extensive or unacceptable delivery time is expected on a particular item of equipment specified, the Contractor shall notify the Owner and Engineer, in writing, within 30 days of award of the Contract. In such instances, equipment substitutions may be made pending acceptance by the Engineer or the Owner’s representative.

D. Where any specific material, process or method of construction or manufactured article is specified by reference to the catalog number of a manufacturer, the Specifications are to be used as a guide and are not intended to take precedence over the basic duty and performance specified or noted on the Drawings. In all cases, the Mechanical Contractor shall verify the duty specified with the specific characteristics of the equipment offered for review. Equipment characteristics are to be used as mandatory requirements where the Contractor proposes to use an acceptable equivalent.

E. If material or equipment is installed before it is reviewed and/or approved, the Contractor shall be liable for its removal and replacement at no extra charge to the Owner if, in the opinion of the Engineer, the material or equipment does not meet the intent of, or standard of quality implied by, the Drawings and Specifications.

F. Failure on the part of the Engineer to reject shop drawings or to reject work in progress shall not be interpreted as acceptance of work not in conformance with the Drawings and/or Specifications. Work not in conformance with the Drawings and/or Specifications shall be corrected whenever it is discovered.

1.26 RECORD DRAWINGS

A. General: Do not use record documents for construction purposes; protect from deterioration and loss in a secure, fire-resistive location; provide access to record documents for the Engineer's reference during normal working hours.

B. Maintain a clean, undamaged set of blue or black line white-prints of Contract Drawings and Shop Drawings. Mark the set to show the actual installation where the installation varies substantially from the Work as originally shown. Mark whichever drawing is most capable of showing conditions fully and accurately. Give particular attention to concealed elements that would be difficult to measure and record at a later date. Items to be indicated include but are not limited to:

1. Dimensional change
2. Revision to drawing detail
3. Location and depth of underground utility
4. Revision to pipe routing
5. Revision to electrical circuitry
6. Actual equipment location
7. Duct size and routing
8. Location of concealed internal utility
9. Changes made by Change Order
10. Details not on original Contract Drawing
11. Information on concealed elements which would be difficult to identify or measure later

C. Mark record sets with red erasable pencil; use other colors to distinguish between variations in separate categories of the Work.

D. Mark new information that is important to the Owner, but was not shown on Contract Drawings or Shop Drawings.

E. Note related Change Order numbers where applicable.

F. Organize record drawing sheets into manageable sets, bind with durable paper cover sheets, and print suitable titles, dates and other identification on the cover of each set.

G. Final record documents shall be prepared in the latest electronic version and on USB Flash drive of all drawings and a clean set of reproducible paper copies shall be turned over to the Owner at the completion of the work.

1.27 WARRANTIES AND BONDS

A. The following general administrative and procedural requirements for warranties and bonds required by the Contract Documents, including manufacturers standard warranties on products and special warranties are to be included:

1. General close-out requirements included in Division 1.

2. Specific requirements for warranties for the Work and products and installation that are specified to be warranted, are included in the individual Sections of Divisions-2 through -50.

3. Certifications and other commitments and agreements for continuing services to Owner are specified elsewhere in the Contract Documents.

B. Disclaimers and Limitations: Manufacturer's disclaimers and limitations on product warranties do not relieve the Contractor of the warranty on the Work that incorporates the products, nor does it relieve suppliers, manufacturers, and subcontractors required to countersign special warranties with the Contractor.

C. Separate Prime Contracts: Each prime Contractor is responsible for warranties related to its own Contract.

1.28 WARRANTY REQUIREMENTS

A. Related Damages and Losses: When correcting warranted Work that has failed, remove and replace other Work that has been damaged as a result of such failure or that must be removed and replaced to provide access for correction of warranted Work.

B. Reinstatement of Warranty: When Work covered by a warranty has failed and been corrected by replacement or rebuilding, reinstate the warranty by written endorsement. The reinstated warranty shall be equal to the original warranty with an equitable adjustment for depreciation.

C. Replacement Cost: Upon determination that Work covered by a warranty has failed, replace or rebuild the Work to an acceptable condition complying with requirements of Contract Documents. The Contractor is responsible for the cost of replacing or rebuilding defective Work regardless of whether the Owner has benefited from use of the Work through a portion of its anticipated useful service life.

D. Owner's Recourse: Written warranties made to the Owner are in addition to implied warranties, and shall not limit the duties, obligations, right and remedies otherwise available under the law, nor shall warranty periods be interpreted as limitations on time in which the Owner can enforce such other duties, obligations, rights, or remedies.

E. Rejection of Warranties: The Owner reserves the right to reject warranties and to limit selections to products with warranties not in conflict with requirements of the Contract Documents.

F. The Owner reserves the right to refuse to accept Work for the Project where a special warranty, certification, or similar commitment is required on such Work or part of the Work, until evidence is presented that entities required to countersign such commitments are willing to do so.

G. Submit written warranties to the Engineer prior to the date certified for Substantial Completion. If the Engineer's Certificate of Substantial Completion designates a commencement date for warranties other than the date of Substantial Completion for the Work, or a designated portion of the Work, submit written warranties upon request of the Engineer.

H. When a designated portion of the Work is completed and occupied or used by the Owner, by separate agreement with the Contractor during the construction period, submit properly executed warranties to the Engineer within fifteen days of completion of that designated portion of the Work.

I. When a special warranty is required to be executed by the Contractor, or the Contractor and a subcontractor, supplier or manufacturer, prepare a written document that contains appropriate terms and identification, ready for execution by the required parties. Submit a draft to the Owner through the Engineer for approval prior to final execution.

1. Refer to individual Sections of Divisions-2 through -50 for specific content requirements, and particular requirements for submittal of special warranties.

J. Form of Submittal: At Final Completion compile two copies of each required warranty and bond properly executed by the Contractor, or by the Contractor, subcontractor, supplier, or manufacturer. Organize the warranty documents into an orderly sequence based on the table of contents of the Project Manual.

K. Bind warranties and bonds in heavy-duty, commercial quality, durable 3-ring vinyl covered loose-leaf binders, thickness as necessary to accommodate contents, and sized to receive 8-1/2" by 11" paper.

1. Provide heavy paper dividers with celluloid covered tabs for each separate warranty. Mark the tab to identify the product or installation. Provide a typed description of the product or installation, including the name of the product, and the name, address and telephone number of the installer.

2. Identify each binder on the front and the spine with the typed or printed title "WARRANTIES AND BONDS," the Project title or name, and the name of the Contractor.

3. When operating and maintenance manuals are required for warranted construction, provide additional copies of each required warranty, as necessary, for inclusion in each required manual.

1.29 GUARANTEES

A. The Contractor shall guarantee all material and installation quality under these Specifications and the Contract for a period of one (1) year from the date of final acceptance by Owner. During this guarantee period, all defects developing through faulty equipment, materials or installation quality shall be corrected or replaced

immediately by this Contractor without expense to the Owner. Such repairs or replacements shall be made to the Engineer's satisfaction.

B. Contractor shall provide name, address, and phone number of all contractors and subcontractors and associated equipment they provided.

1.30 PROJECT CLOSE-OUT

A. Submit specific warranties, quality bonds, maintenance agreements, final certifications and similar documents in accordance with Division 01.

B. Deliver tools, spare parts, extra stock, and similar items.

C. Complete start-up testing of systems, including measuring and documenting all required startup checklist requirements documented in installation and maintenance instructions by the equipment manufacturer, and instruction of the Owner's operating and maintenance personnel. Discontinue or change over and remove temporary facilities from the site, along with construction tools, mock-ups, and similar elements.

D. Complete final clean up requirements, including touch-up painting. Touch-up and otherwise repair and restore marred exposed finishes.

E. Field Observation Procedures: On receipt of a request for an Engineers Field Observation, the Engineer will advise the Contractor of unfulfilled requirements. The Engineer will advise the Contractor of construction that must be completed or corrected before the certificate will be issued. Contractor shall submit written response to each corrective item including specific photos prior to final Engineering inspection.

1. The Engineer will repeat the Field Observation when requested and assured that the Work has been substantially completed.

2. Results of the completed list of unfulfilled items will form the basis of requirements for final acceptance.

END OF SECTION 23 0400

Electronic Drawing File Release Form

DELIVERY OF FILES FOR: _____

Project Name

In accepting and utilizing any drawings or other data on any form of electronic media generated and provided by the Design Professional, the Client covenants and agrees that all such drawings and data are instruments of service of the Design Professional, who shall be deemed the author of the drawings and data, and shall retain all common law, statutory law and other rights, including copyrights.

The Client further agrees not to use these drawings and data, in whole or in part, for any purpose or project other than the project which is the subject of this Agreement. The Client agrees to waive all claims against the Design Professional resulting in any way from any unauthorized changes or reuse of the drawings and data for any other project by anyone other than the Design Professional.

In addition, the Client agrees, to the fullest extent permitted by law, to indemnify and hold the Design Professional harmless from any damage, liability or cost, including reasonable attorneys' fees and costs of defense, arising from any changes made by anyone other than the Design Professional or from any reuse of the drawings and data without the prior written consent of the Design Professional.

Under no circumstances shall transfer of the drawings and other instruments of service on electronic media for use by the Client be deemed a sale by the Design Professional, and the Design Professional makes no warranties, either express or implied, of merchantability and fitness for any particular purpose.

_____ _____

Client's Signature Date

_____

Company - Title

_____ _____

Architects' Signature Date

_____

Firm - Title

_____ _____

Owner's Signature Date

_____

Company - Title

SECTION 23 0516 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Design of expansion systems and anchors

B. Flexible pipe connectors.

C. Expansion joints and compensators.

D. Pipe Alignment Guides

E. Swivel Joints

F. Pipe Anchors

1.2 RELATED REQUIREMENTS

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

B. Division 23 specifications

1.3 REFERENCE STANDARDS (follow the most currently adopted amended version)

A. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. ASME B16.5 - Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24 Inch Standard.

C. ASME B16.11 - Forged Fittings, Socket-welding and Threaded.

D. ASME B31.9 – Building Services Piping

E. ASME Section IX – Boiler and Pressure Vessel Code- Welding and Brazing Qualifications.

F. ASTM A269/A269M - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.

G. AWS D1.1 – Structural Welding Code- Steel.

H. EJMA (STDS) - EJMA Standards.

I. FM (AG) - FM Approval Guide.

J. ITS (DIR) - Directory of Listed Products.

K. UL (DIR) - Online Certifications Directory.

1.4 DESIGN REQUIREMENTS

A. Provide design, details, work and equipment required for expansion and contraction of hot water piping systems. Verify anchors, guides, and expansion joints provide and adequately protect system.

B. Provide structural work and equipment required for expansion and contraction of piping. Verify anchors, guides, and expansion joints provide and adequately protect system.

C. Expansion Compensation Design Criteria:
1. Installation Temperature: 50°F.
2. Hot Water Heating System Temperature: 210°F.
3. Refrigerant System Temperature: Refer to manufacturers design literature.
4. Safety Factor: 30%.

1.5 SUBMITTALS

A. Pipe Expansion Analysis, Design and Certification:
1. Provide pipe expansion and anchoring calculations for all refrigerant and hot water piping systems including connections to equipment and to the structure. Piping layouts and associated calculations must be stamped by a registered professional engineer with at least five years of pipe expansion experience, licensed in the state of the job location.
2. Analysis must indicate calculated dead loads, active expansion loads and capacity of materials utilized for connections to equipment and structure. Analysis must detail anchoring methods, bolt diameter, embedment and/ or welded length. All expansion and anchoring devices shall be designed to accept the forces as calculated.

B. Shop Drawings: Indicate layout of piping systems, including flexible connectors, expansion joints, expansion compensators, loops, offsets and swing joints. Indicate installed locations of flexible pipe connectors, expansion joints, anchors and guides.

C. Product Data:
1. Flexible Pipe Connectors: Indicate maximum temperature and pressure rating, face-to-face length, live length, hose wall thickness, hose convolutions per foot and per assembly, fundamental frequency of assembly, braid structure, and total number of wires in braid.
2. Expansion Joints: Indicate maximum temperature and pressure rating, and maximum expansion compensation.

D. Manufacturer's Instructions: Indicate manufacturer's installation instructions, special procedures, and external controls.

E. Maintenance Data: Include adjustment instructions.

F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. Extra Packing for Packed Expansion Joints: One set for each joint.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum five years' experience.

B. Installer: Company specializing in performing work of this section with minimum five years' experience.

C. Design expansion compensating system under direct supervision of a Professional Engineer experienced in design of this work and licensed in state which the work will occur.

PART 2 PRODUCTS

2.1 MANUFACTURERS:

A. Mason Industries

B. The Metraflex Company

C. UniSource Manufacturing

2.2 FLEXIBLE PIPE CONNECTORS - STEEL PIPING

A. Inner Hose: Bronze.

B. Exterior Sleeve: Single braided, stainless steel.

C. Pressure & Temperature Rating: 125 psi and 450°F.

D. Joint: Flanged.

E. Size: Use pipe sized units.

F. Maximum offset: 3/4 inch on each side of installed center line.

2.3 FLEXIBLE PIPE CONNECTORS - COPPER PIPING SERVING WATER SYSTEMS

A. Inner Hose: Bronze.

B. Exterior Sleeve: Braided bronze.

C. Pressure & Temperature Rating: 125 psi and 450°F.

D. Joint: Flanged.

E. Size: Use pipe sized units.

F. Maximum offset: 3/4 inch on each side of installed center line.

G. Application: Copper piping serving water-based systems.

2.4 FLEXIBLE PIPE CONNECTORS - COPPER PIPING SERVING REFRIGERANT SYSTEMS

A. Inner Hose: Stainless Steel.

B. Exterior Sleeve: Braided 304 Stainless Steel

C. Pressure Rating: 650 psi.

D. Joint: Brazed.

E. Size: Use pipe sized units.

F. Maximum offset: 3/4 inch on each side of installed center line.

G. Application: Refrigerant Piping.

H. Certifications: UL Listed for Refrigeration Service.

2.5 EXPANSION JOINTS - STAINLESS STEEL BELLOWS TYPE

A. Pressure & Temperature Rating: 125 psi and 400°F.

B. Maximum Compression: 1-3/4 inches.

C. Maximum Extension: 1/4 inch.

D. Joint: Flanged.

E. Size: Use pipe sized units.

F. Application: Steel piping 3 inches and under.

2.6 EXPANSION JOINTS - EXTERNAL RING CONTROLLED STAINLESS STEEL BELLOWS TYPE

A. Pressure & Temperature Rating: 125 psi and 400°F.

B. Maximum Compression: 15/16 inch.

C. Maximum Extension: 5/16 inch.

D. Maximum Offset: 1/8 inch.

E. Joint: Flanged.

F. Size: Use pipe sized units.

G. Accessories: Internal flow liner.

H. Application: Steel piping over 2 inches.

2.7 EXPANSION JOINTS - DOUBLE SPHERE, FLEXIBLE COMPENSATOR

A. Body: Multi-Layered Kevlar with EPDM.

B. Pressure & Temperature Rating, Sizes 3/4 Inch to 1-1/4" Inch: 150 psi and 210°F.

C. Pressure & Temperature Rating, Sizes 1-1/2 Inch to 12 Inch: 150 psi and 250°F.

D. Pressure & Temperature Rating, Sizes 14 Inch to 24 Inch: 105 psi and 250°F.

E. Maximum Compression: 1/2 inch.

F. Maximum Elongation: 3/8 inch.

G. Maximum Offset: 3/8 inch.

H. Maximum Angular Movement: 15 degrees.

I. Joint: Tapped steel flanges.

J. Size: Use pipe sized units.

K. Accessories: Control cables.

L. Application: Steel piping 2 inches and over.

2.8 EXPANSION JOINTS - TWO-PLY BRONZE BELLOWS TYPE

A. Construction: Bronze with anti-torque device, limit stops, internal guides.

B. Pressure & Temperature Rating: 125 psi and 400°F.

C. Maximum Compression: 1-3/4 inches.

D. Maximum Extension: 1/4 inch.

E. Joint: Soldered.

F. Size: Use pipe sized units.

G. Application: Copper piping.

2.9 EXPANSION JOINTS - LOW PRESSURE COMPENSATOR WITH TWO-PLY BRONZE BELLOWS

A. Working Pressure: 75 psi.

B. Maximum Temperatures: 250°F.

C. Maximum Compression: 1/2 inch.

D. Maximum Extension: 5/32 inch.

E. Joint: Soldered.

F. Size: Use pipe sized units.

G. Application: Copper or steel piping 3 inches and under.

2.10 EXPANSION JOINTS - STEEL WITH PACKED SLIDING SLEEVE

A. Working Pressure and Temperature: Class 150.

B. Joint: Flanged.

C. Size: Use pipe sized units.

D. Application: Steel piping 2 inches and over.

2.11 EXPANSION JOINTS - COPPER WITH PACKED SLIDING SLEEVE

A. Working Pressure: 125 psi.

B. Maximum Temperature: 250°F.

C. Joint: Flanged.

D. Size: Use pipe sized units.

E. Application: Copper or steel piping 2 inches and over.

2.12 EXPANSION LOOPS - HOSE AND BRAID

A. Provide flexible loops with two flexible sections of hose and braid, two 90 degree elbows, and 180 degree return with support bracket and air release or drain plug.

B. Provide flexible loops capable of movement in the x, y, and z planes. Flexible loops to impart no thrust loads to the building structure.

C. Flexible Connectors: Flanged, braided type with wetted components of stainless steel, sized to match piping.

1. Maximum Allowable Working Pressure & Temperature: 150 psig at 120°F.
2. Accommodate the Following:
   a. Axial Deflection in Compression and Expansion: To be determined by the Professional Engineer providing calculations.
   b. Lateral Movement: To be determined by the Professional Engineer providing calculations.
   c. Angular Rotation: 15 degrees.
   d. Force developed by 1.5 times specified maximum allowable operating pressure.
3. End Connections: Same as specified for pipe jointing.
4. End Connections: Flanged ductile iron; complying with ASME B16.1 Class 125.
5. End Connections: Threaded; complying with ASME B16.11.
6. Provide necessary accessories including, but not limited to, swivel joints.

2.13 EXPANSION JOINTS - EXTERNALLY PRESSURIZED EXPANSION JOINTS

A. Construction: Stainless steel with anti-torque device, limit stops, internal guides.

B. Maximum Allowable Working Pressure & Temperature: 150 psig at 700°F.

C. Maximum Axial Compression: 4 inches.

D. End Connections: Flanged by weld end.

E. Size: Use pipe sized units.

F. Application: Steel piping 2 inches and over.

2.14 PIPE ALIGNMENT GUIDES

A. Two piece welded steel with enamel paint, bolted, with spider to fit standard pipe, frame with four mounting holes, clearance for minimum 1 inch thick insulation, minimum 3 inches travel

2.15 SWIVEL JOINTS

A. Fabricated steel body, double ball bearing race, field lubricated, with rubber (Buna-N) o-ring seals.

2.16 PIPE ANCHORS

A. All-directional acoustical pipe anchor, consisting of two sizes of steel tubing separated by a minimum 1/2" thick 60 durometer neoprene. Vertical restraint shall be provided by similar material arranged to prevent vertical travel in either direction. Allowable loads on the isolation material should not exceed 500 PSI and the design shall be balanced for equal resistance in any direction.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with EJMA (Expansion Joint Manufacturers Association) Standards.

C. Install flexible pipe connectors on:
   1. Pipes connected to pumps.
   2. Refrigerant piping connections to equipment per recommendations of equipment manufacturer.
   3. Pipes connected to equipment supported by vibration isolation. Provide line size flexible connectors.

D. Install flexible connectors at right angles to displacement. Install one end immediately adjacent to isolated equipment and anchor other end. Install in horizontal plane unless indicated otherwise.

E. Rigidly anchor pipe to building structure. Provide pipe guides so movement is directed along axis of pipe only. Erect piping such that strain and weight is not on cast connections or apparatus.

F. Provide support and anchors for controlling expansion and contraction of piping. Provide loops, pipe offsets, and swing joints, or expansion joints where required.

G. For systems using grooved piping systems, provide with minimum one joint per inch pipe diameter instead of flexible connector supported by vibration isolation.

H. Provide piping expansion loops at all building expansion joints as indicated on drawings.

I. Provide piping expansion joints or expansion loops as indicated below:
   1. Provide and install pipe expansion joints or expansion loops at all conditions listed below and as required to minimize stress on the piping systems.
   2. Provide pipe guides at inlet and outlet of each expansion joint and expansion loop.
   3. Where expansion joints or loops are required, provide pipe anchors at ends of each straight length of run.
   4. Provide and install expansion joints, expansion loops, pipe guides and anchors per ASHRAE guidelines and manufacturer’s recommendations.

PIPING SYSTEM	PIPING MATERIAL	PIPE SIZE	Condition Requiring expansion joint or expansion loop (all conditions assume "offset leg" at end of runs are minimum 12'0" long)
Hot water supply and return (all temperatures)	Copper	Up to 3 inches	All straight sections of piping over 90' long. All straight sections of piping where "offset leg" is less than 12'0"
Hot water supply and return (all temperatures)	Steel	Up to 2 inches	All straight sections of piping over 140' long.
Hot water supply and return (all temperatures)	Steel	2" to 4"	All straight sections of piping over 90' long
Hot water supply and return (all temperatures)	Steel	5" to 8"	All straight sections of piping over 45' long

END OF SECTION 23 0516

SECTION 23 0517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Pipe sleeves.

B. Manufactured sleeve-seal systems.

1.2 RELATED REQUIREMENTS

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

B. Division 07 – Thermal and Moisture Protection.

C. Division 09 - Finishes.

D. Section 23 0523 - General-Duty Valves for HVAC Piping.

E. Section 23 0553 - Identification for HVAC Piping and Equipment: Piping identification.

F. Section 23 0716 - HVAC Equipment Insulation.

G. Section 23 0719 - HVAC Piping Insulation.

1.3 REFERENCE STANDARDS (follow the most currently adopted amended version)

A. ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type).

B. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems.

1.4 SUBMITTALS

A. Shop Drawings: Indicate pipe materials used, jointing methods, supports, floor and wall penetration seals. Indicate installation, layout, weights, mounting and support details, and piping connections.

B. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. Extra Valve Stem Packings: Two for each type and size of valve.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

B. Installer Qualifications: Company specializing in performing work of the type specified this section.
   1. Minimum three years experience.
   2. Approved by manufacturer.

C. Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store sleeve and sleeve seals in shipping containers, with labeling in place.

B. Provide temporary protective coating on cast iron and steel sleeves if shipped loose.

1.7 WARRANTY

A. Correct defective Work within a five year period after Date of Substantial Completion.

PART 2 PRODUCTS

2.1 PIPE SLEEVES

A. Materials
   1. Galvanized-Steel Sheet: 0.0239-inch 0.6-mm minimum thickness; round tube closed with longitudinal joint.
   2. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

2.2 MANUFACTURED SLEEVE-SEAL SYSTEMS

A. Manufacturers:
   1. Flexicraft Industries; PipeSeal.
   2. Metraflex
   3. Link-Seal
   4. Substitutions: See Division - 01 General Requirements.

B. Modular/Mechanical Seal:
   1. Synthetic rubber interlocking links continuously fill annular space between pipe and wall/casing opening.
   2. Provide watertight seal between pipe and wall/casing opening.
   3. Elastomer element size and material in accordance with manufacturer's recommendations.
   4. Glass reinforced plastic pressure end plates.

PART 3 EXECUTION

3.1 GENERAL

A. Lay out penetration and sleeve openings in advance, to permit provision in work. Coordinate work with architectural and structural work. Set sleeves and conduit in forms before concrete is poured. Provide remedial work where sleeves and conduits are omitted or improperly placed. Remedial work includes core drilling (see requirements below) for penetrations if walls are poured, or otherwise constructed, without required sleeves. Provide core drilling (see requirements below) of existing construction. Do not penetrate structural members without Structural Engineer's/Architect's written approval.

B. Sleeve installation shall meet NFPA-101 requirements, UL rated assemblies requirements, and materials requirements of these specifications. Submit a list of the UL listed details that the Contractor intends on using on this project in all rated assemblies.

C. Sleeves that penetrate outside walls, basement slabs, footings and beams shall be waterproof. Sleeves that penetrate floors shall be fireproof and waterproof.

D. Identify unused sleeves and slots for future installation. Fill slots, sleeves and other openings in floors or walls if not used. Fill spaces in openings after installation of pipe, duct, conduit or cable. Fill for floor penetrations shall prevent passage of water, smoke, fire, and fumes. Fill shall be fire resistant in fire floors and walls, and shall prevent passage of air, smoke and fumes.

E. Do not support piping risers or conduit on sleeves.

F. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 for materials.

G. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements. Verify final equipment locations for roughing-in.

3.2 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

B. Remove scale and foreign material, from inside and outside, before assembly.

3.3 APPLICATIONS

A. Provide sleeves when penetrating footings, floors, walls, partitions, and other building components as follows:
   1. Interior walls, partitions, and floors: galvanized-steel sheet, unless steel or brass sleeves are specified elsewhere.
   2. Below Grade Exterior Walls: Zinc coated or cast iron pipe with mechanical sleeve seals. Provide watertight space with link rubber or modular seal between sleeve and pipe on both pipe ends.

3. Above Grade Exterior Walls: steel pipe sleeve with mechanical sleeve seals.
4. Mechanical, Laundry, and Animal Room Floors above Basement: Galvanized steel pipe or black iron pipe with asphalt coating. Connect sleeve with floor plate except in mechanical rooms.
5. Concrete and masonry walls, concrete floor and roof slabs: galvanized-steel sheet
6. Floors with membrane waterproofing: stack sleeve fittings

3.4 INSTALLATION

A. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient.

B. Install piping to conserve building space, to not interfere with use of space and other work.

C. Install piping and pipe sleeves to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

D. Install sleeves that are large enough to provide 1/4 inch annular clear space between sleeve and pipe or pipe insulation. Sleeves for insulated pipe and duct in non-fire rated construction shall accommodate continuous insulation without compression. Sleeves and/or penetrations in fire rated construction shall be packed with fire rated material that shall maintain the fire rating of the wall. Seal ends of penetrations to provide continuous vapor barrier where insulation is interrupted.

E. Where pipes passing through openings are exposed in finished rooms, finishes of filling materials shall match and be flush with adjoining floor, ceiling, and wall finishes.

F. Inserts:
1. Provide inserts for placement in concrete formwork.
2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.

G. Structural Considerations:
1. Do not penetrate building structural members unless indicated.

H. Seal pipe including sleeve penetrations to achieve fire resistance equivalent to fire separation required.
1. Underground Piping: Mechanically expandable chloroprene inserts with bitumen sealed metal components.
2. Aboveground Piping:
   a. Pack solid using mineral fiber conforming to ASTM C592.
   b. Fill space with an elastomer caulk to a depth of 0.50 inch where penetrations occur between conditioned and unconditioned spaces.

3. All Rated Openings: Caulk tight with fire stopping material conforming to ASTM E814 in accordance with Division 07 to prevent the spread of fire, smoke, and gases.
4. Caulk exterior wall sleeves watertight with Mechanically expandable chloroprene inserts with mastic-sealed components.

I. Vertical Piping:
1. Sleeve Length: 1 inch above finished floor.
2. Provide sealant for watertight joint.
3. Blocked Out Floor Openings: Provide 1-1/2 inch angle set in silicon adhesive around opening.
4. Drilled Penetrations: Provide 1-1/2 inch angle ring or square set in silicone adhesive around penetration.

J. Clearances:
1. Provide allowance for insulated piping.
2. Wall, Floor, Floor, Partitions, and Beam Flanges: 1 inch greater than external; pipe diameter.
3. All Rated Openings: Caulked tight with fire stopping material conforming to ASTM E814 in accordance with Division 07 to prevent the spread of fire, smoke, and gases.

K. Manufactured Sleeve-Seal Systems:
1. Install manufactured sleeve-seal systems in sleeves located in grade slabs and exterior concrete walls at piping entrances into building.
2. Provide sealing elements of the size, quantity, and type required for the piping and sleeve inner diameter or penetration diameter.
3. Locate piping in center of sleeve or penetration.
4. Install field assembled sleeve-seal system components in annular space between sleeve and piping.
5. Tighten bolting for a water-tight seal.
6. Install in accordance with manufacturer's recommendations.

L. When installing more than one piping system material, ensure system components are compatible and joined to ensure the integrity of the system. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

3.5 CORE DRILLING

A. Core drilling shall be avoided in new construction. Set sleeves prior to installation of structure for passage of pipes, conduit and ducts. Where core drilling is unavoidable (e.g. when individual sleeves are not installed or incorrectly located) or required by renovation projects, locate required openings prior to coring and submit locations for review.

B. Coordinate openings with other Divisions.

C. Do not disturb existing systems. Protect areas from damage.

D. Thoroughly investigate existing conditions in vicinity of required opening prior to coring.

3.6 CLEANING

A. Upon completion of work, clean all parts of the installation.

B. Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.

END OF SECTION 23 0517

SECTION 23 0523 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Applications.

B. General requirements.

C. Angle valves.

D. Globe valves.

E. Ball valves.

F. Butterfly valves.

G. Check valves.

H. Gate valves.

I. Plug valves.

J. Chainwheels.

1.2 ABBREVIATIONS AND ACRONYMS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. PTFE: Polytetrafluoroethylene.

G. RS: Rising stem.

H. SWP: Steam working pressure.

I. TFE: Tetrafluoroethylene.

1.3 REFERENCE STANDARDS (follow the most currently adopted amended version)

A. API STD 594 - Check Valves: Flanged, Lug Wafer, and Butt-Welding.

B. ASME B1.20.1 - Pipe Threads, General Purpose (Inch).

C. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250;.

D. ASME B16.5 - Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard.

E. ASME B16.10 - Face-to-Face and End-to-End Dimensions of Valves.

F. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.

G. ASME B16.34 - Valves - Flanged, Threaded and Welding End.

H. ASME B31.1 - Power Piping.

I. ASME B31.9 - Building Services Piping.

J. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Welding, Brazing, and Fusing Qualifications.

K. ASTM A48/A48M - Standard Specification for Gray Iron Castings.

L. ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.

M. ASTM A216/A216M - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.

N. ASTM A395/A395M - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.

O. ASTM A536 - Standard Specification for Ductile Iron Castings.

P. ASTM A582/A582M - Standard Specification for Free-Machining Stainless Steel Bars;.

Q. ASTM B61 - Standard Specification for Steam or Valve Bronze Castings.

R. ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings.

S. AWWA C606 - Grooved and Shouldered Joints.

T. MSS SP-45 - Bypass and Drain Connections.

U. MSS SP-67 - Butterfly Valves.

V. MSS SP-68 - High Pressure Butterfly Valves with Offset Design.

W. MSS SP-70 - Cast Iron Gate Valves, Flanged and Threaded Ends.

X. MSS SP-71 - Cast Iron Swing Check Valves, Flanged and Threaded Ends.

Y. MSS SP-72 - Ball Valves with Flanged or Butt-Welding Ends for General Service.

Z. MSS SP-78 - Cast Iron Plug Valves, Flanged and Threaded Ends.

AA. MSS SP-80 - Bronze Gate, Globe, Angle and Check Valves.

BB. MSS SP-85 - Cast Iron Globe & Angle Valves, Flanged and Threaded Ends.

CC. MSS SP-108 - Resilient-Seated Cast Iron Eccentric Plug Valves.

DD. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.

EE. MSS SP-125 - Gray Iron and Ductile Iron In-Line, Spring-Loaded, Center-Guided Check Valves.

1.4 SUBMITTALS

A. Product Data: Provide data on valves including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.

B. Warranty: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

C. Maintenance Materials: Furnish Owner with one wrench for every five plug valves, in each size of square plug valve head.

1.5 QUALITY ASSURANCE

A. Manufacturer:
   1. Obtain valves for each valve type from single manufacturer.
   2. Company must specialize in manufacturing products specified in this section, with not less than three years of documented experience.

B. Welding Materials and Procedures: Conform to ASME BPVC-IX.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
   1. Minimize exposure of operable surfaces by setting plug and ball valves to open position.
   2. Protect valve parts exposed to piped medium against rust and corrosion.
   3. Protect valve piping connections such as grooves, weld ends, threads, and flange faces.
   4. Adjust globe, gate, and angle valves to the closed position to avoid clattering.

5. Secure check valves in either the closed position or open position.
6. Adjust butterfly valves to closed or partially closed position.

B. Use the following precautions during storage:
1. Maintain valve end protection and protect flanges and specialties from dirt.
a. Provide temporary inlet and outlet caps.
b. Maintain caps in place until installation.
2. Store valves in shipping containers and maintain in place until installation.
a. Store valves indoors in dry environment.
b. Store valves off the ground in watertight enclosures when indoor storage is not an option.

C. Exercise the following precautions for handling:
1. Handle large valves with sling, modified to avoid damage to exposed parts.
2. Avoid the use of operating handles or stems as rigging or lifting points.

PART 2 PRODUCTS

2.1 GENERAL

A. See Drawings for specific valve locations.

B. Refer to Part 3 for applications.

C. Substitutions of valves with higher CWP classes or SWP ratings for same valve types are permitted when specified CWP ratings or SWP classes are not available.

2.2 GENERAL REQUIREMENTS

A. Valve Pressure and Temperature Ratings: No less than rating indicated; as required for system pressures and temperatures.

B. Valve Sizes: Match upstream piping unless otherwise indicated.

C. Valve Actuator Types:
1. Gear Actuator: Quarter-turn valves 8 NPS and larger.
2. Handwheel: Valves other than quarter-turn types.
3. Hand Lever: Quarter-turn valves 6 NPS and smaller except plug valves.
4. Wrench: Plug valves with square heads.
5. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator, of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

D. Valves in Insulated Piping: Provide 2 inch stem extensions and the following features:
1. Gate Valves: Rising stem.
2. Ball Valves: Extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
3. Butterfly Valves: Extended neck.

4. Memory Stops: Fully adjustable after insulation is installed.

E. Memory Stops: Fully adjustable after insulation is installed.

F. Valve-End Connections:
1. Threaded End Valves: ASME B1.20.1.
2. Flanges on Iron Valves: ASME B16.1 for flanges on iron valves.
3. Pipe Flanges and Flanged Fittings 1/2 NPS through 24 NPS: ASME B16.5.
4. Solder Joint Connections: ASME B16.18.
5. Grooved End Connections: AWWA C606.

G. General ASME Compliance:
1. Ferrous Valve Dimensions and Design Criteria: ASME B16.10 and ASME B16.34.
2. Power Piping Valves: ASME B31.1.
3. Building Services Piping Valves: ASME B31.9.

H. Bronze Valves:
1. Fabricate from dezincification resistant material.
2. Copper alloys containing more than 15 percent zinc are not permitted.

I. Valve Bypass and Drain Connections: MSS SP-45.

J. Source Limitations: Obtain each valve type from a single manufacturer.

2.3 BRONZE GLOBE VALVES

A. Class 125: CWP Rating: 200 psig:.
1. Comply with MSS SP-80, Type 1.
2. Body: Bronze; ASTM B62, with integral seat and screw in bonnet.
3. Ends: Threaded or solder joint.
4. Stem and Disc: Bronze or PTFE
5. Packing: Asbestos free.
6. Handwheel: Malleable iron or bronze.
7. Manufacturers:
a. Nibco Inc.
b. Grinnell
c. Crane Co.
d. Milwaukee Valve Co.

2.4 IRON GLOBE VALVES

A. Class 125: CWP Rating: 200 psig:, and Class 250: CWP Rating: 500 psig:.
1. Comply with MSS SP-85, Type I.
2. Body: Gray iron; ASTM A126, with bolted bonnet.
3. Ends: Flanged.
4. Trim: Bronze.
5. Packing and Gasket: Asbestos free.
6. Operator: Handwheel or chainwheel.
7. Manufacturers:

a. Nibco Inc.
b. Grinnell
c. Crane Co.
d. Milwaukee Valve Co.

2.5 BRASS BALL VALVES

A. Two Piece, Full Port, Ball Valves with Stainless Steel Trim:
1. Comply with MSS SP-110.
2. SWP Rating: 150 psig.
3. CWP Rating: 600 psig.
4. Body: Forged brass.
5. Ends: Threaded.
6. Seats: PTFE
7. Stem: Stainless Steel.
8. Ball: Chrome-plated brass or Stainless steel, vented
9. Manufacturers:
a. Apollo
b. Nibco
c. Watts

B. Three Piece, Full Port with Stainless Steel Trim:
1. Comply with MSS SP-110.
2. SWP Rating: 150 psig.
3. CWP Rating: 600 psig.
4. Body: Forged brass.
5. Ends: Threaded.
6. Seats: PTFE
7. Stem: Stainless steel.
8. Ball: Stainless steel, vented.
9. Manufacturers:
a. Apollo
b. Nibco
c. Watts

2.6 BRONZE BALL VALVES

A. Two Piece, Full Port, Bronze Ball Valves with Stainless-Steel Trim:
1. Comply with MSS SP-110.
2. SWP Rating: 150 psig.
3. CWP Rating: 600 psig.
4. Body: Bronze.
5. Ends: Threaded.
6. Seats: PTFE.
7. Stem: Bronze, brass or stainless steel
8. Ball: Chrome plated brass or stainless steel, vented
9. Manufacturers:
a. Apollo
b. Nibco

c. Watts
d. Bray International

B. Three Piece, Full Port with Stainless Steel Trim:
1. Comply with MSS SP-110.
2. SWP Rating: 150 psig.
3. CWP Rating: 600 psig.
4. Body: Bronze.
5. Ends: Threaded.
6. Seats: PTFE.
7. Stem: Stainless steel.
8. Ball: Stainless steel, vented.
9. Manufacturers:
a. Apollo
b. Nibco
c. Watts
d. Bray International

2.7 CARBON STEEL BALL VALVES

A. Class 300, Full Port, Stainless Steel Trim:
1. Comply with MSS SP-72.
2. CWP Rating: 720 psig.
3. Body: Carbon steel, ASTM A216/A216M, Type WCB.
4. Ends: Flanged.
5. Seats: PTFE.
6. Stem: Stainless steel.
7. Ball: Stainless steel, vented.
8. Manufacturers:
a. Apollo
b. Nibco
c. Watts
d. Bray International
e. Substitutions: See Division 01 - General Requirements.

2.8 IRON BALL VALVES

A. Split Body, Full Port:
1. Comply with MSS SP-72.
2. CWP Rating: 200 psig.
3. Body: ASTM A126, gray iron.
4. Ends: Flanged.
5. Seats: PTFE.
6. Stem: Stainless steel.
7. Ball: Stainless steel.
8. Manufacturers:
a. Apollo
b. Nibco
c. Watts

d. Bray International
e. Substitutions: See Division 01 - General Requirements.

2.9 IRON, GROOVED-END BALL VALVES

A. Class 200:
1. CWP Rating: 600 psig.
2. Body: Ductile iron; ASTM A536, Grade 65-45-12.
3. Ends: Grooved.
4. Seats: Teflon.
5. Stem: Nickel plated carbon steel.
6. Ball: Nickel plated carbon steel, Type 304 stainless steel.
7. Manufacturers:
a. Apollo
b. Nibco
c. Watts
d. Substitutions: See Division 01 - General Requirements.

2.10 IRON, SINGLE FLANGE BUTTERFLY VALVES

A. Lug type: Bi-directional dead end service without downstream flange.
1. Comply with MSS SP-67, Type I.
2. CWP Rating: 150 psig or 200 psig.
3. Body Material: ASTM A126 cast iron, ASTM A536 ductile iron.
4. Stem: One or two-piece stainless steel.
5. Seat: NBR.
6. Disc: Coated ductile iron.
7. Manufacturers:
a. Nibco, Inc.
b. Crane Co.
c. Grinnell
d. Hammond Valve
e. Milwaukee Valve Co.
f. Bray International

2.11 IRON, GROOVED-END BUTTERFLY VALVES

A. CWP Rating: 175 psig, 300 psig: 8 NPS or smaller, 200 psig: 10 NPS or larger.
1. Comply with MSS SP-67, Type I.
2. Body: Coated ductile iron.
3. Stem: Stainless steel.
4. Disc: Coated ductile iron.
5. Disc Seal: EPDM.
6. Manufacturers:
a. Nibco, Inc.
b. Crane Co.
c. Grinnell
d. Hammond Valve
e. Milwaukee Valve Co.

f. Bray International

2.12 HIGH-PERFORMANCE SINGLE FLANGE BUTTERFLY VALVES

A. Lug type: Bi-directional dead end service without downstream flange.
1. Comply with MSS SP-68.
2. Class 150: CWP Rating: 285 psig, Class 300: CWP Rating: 720 psig.
3. Body: Provide carbon steel, cast iron, ductile Iron, stainless steel.
4. Seat: Metal or reinforced PTFE.
5. Offset stem: Stainless steel.
6. Disc: 316 Stainless Steel
7. Manufacturers:
a. Nibco, Inc.
b. Crane Co.
c. Grinnell
d. Hammond Valve
e. Milwaukee Valve Co.
f. Bray International

2.13 BRONZE LIFT CHECK VALVES

A. Class 125:
1. Comply with MSS SP-80, Type 1, Metal Disc to Metal Seat, Type 2, Nonmetallic Disc to Metal Seat.
2. CWP Rating: 200 psig.
3. Design: Vertical flow.
4. Body: Bronze.
5. Ends: Threaded.
6. Disc (Type 1): Bronze.
7. Disc (Type 2): NBR or PTFE.
8. Manufacturers:
a. Crane Co.
b. Nibco, Inc.
c. Milwaukee Valve Co.
d. Mueller Steam Specialty

2.14 BRONZE SWING CHECK VALVES

A. Class 125: CWP Rating: 200 psig, Class 150: CWP Rating: 300 psig.
1. Comply with MSS SP-80, Type 3.
2. Body Design: Horizontal flow.
3. Body Material: Bronze, ASTM B62.
4. Ends: Threaded.
5. Disc: Bronze.
6. Manufacturers:
a. Crane Co.
b. Nibco, Inc.
c. Milwaukee Valve Co.

2.15 IRON SWING CHECK VALVES

A. Class 125: CWP Rating: 200 psig with Metal Seats, Class 125: CWP Rating: 150 psig with Metal Seats, Class 250: CWP Rating: 500 psig with Metal Seats, Class 250: CWP Rating: 300 psig with Metal Seats, Class 125: CWP Rating: 200 psig with Nonmetallic-to-Metal Seats.
   1. Comply with MSS SP-71, Type I.
   2. Design: Clear or full waterway with flanged ends.
   3. Body: Gray iron with bolted bonnet in accordance with ASTM A126.
   4. Trim: Bronze.
   5. Disc Holder: Bronze.
   6. Disc: PTFE or TFE.
   7. Gasket: Asbestos free.

B. Manufacturers:
   a. Crane Co.
   b. Nibco, Inc.
   c. Milwaukee Valve Co.

2.16 IRON, CENTER-GUIDED SILENT CHECK VALVES

A. Class 125, Globe:
   1. Comply with MSS SP-125.
   2. 2-1/2 NPS to 12 NPS, CWP Rating: 200 psig.
   3. 14 NPS to 24 NPS, CWP Rating: 150 psig.
   4. Body Material: ASTM A126, gray iron.
   5. Style: Spring loaded.
   6. Ends: Flanged.
   7. Metal Seat: Bronze.
   8. Resilient Seat: EPDM, NBR
   9. Manufacturers:
      a. Nibco, Inc
      b. Mueller Steam Specialty
      c. Watts

B. Class 150, Globe:
   1. Comply with MSS SP-125.
   2. 2-1/2 NPS to 12 NPS, CWP Rating: 300 psig.
   3. 14 NPS to 24 NPS, CWP Rating: 250 psig.
   4. Body Material: ASTM A395/A395M or ASTM A536, ductile iron.
   5. Style: Spring loaded.
   6. Ends: Flanged.
   7. Metal Seat: Bronze.
   8. Resilient Seat: EPDM, NBR
   9. Manufacturers:
      a. Nibco, Inc.
      b. Mueller Steam Specialty
      c. Watts

2.17 BRONZE GATE VALVES

A. Non-Rising Stem (NRS), Rising Stem (RS):
1. Comply with MSS SP-80, Type I.
2. Class125: CWP Rating: 200 psig.
3. Class 150: CWP Rating: 300 psig.
4. Body Material: Bronze with integral seat and union-ring bonnet.
5. Ends: Threaded.
6. Stem: Bronze.
7. Disc: Solid wedge; bronze.
8. Packing: Asbestos free.
9. Handwheel: Malleable iron, bronze, or aluminum.
10. Manufacturers:
    a. Crane Co.
    b. Milwaukee Valve Co.
    c. Watts
    d. Nibco, Inc.

2.18 IRON GATE VALVES

A. NRS, OS & Y
1. Comply with MSS SP-70, Type I.
2. Class 125: 2-1/2 NPS to 12 NPS, CWP Rating: 200 psig.
3. Class 125: 14 NPS to 24 NPS, CWP Rating: 150 psig.
4. Class 250: 2-1/2 NPS to 12 NPS, CWP Rating: 500 psig.
5. Class 250: 14 NPS to 24 NPS, CWP Rating: 300 psig.
6. Body Material: Gray iron with bolted bonnet.
7. Ends: Flanged.
8. Trim: Bronze.
9. Disc: Solid wedge.
10. Packing and Gasket: Asbestos free.
11. Manufacturers:
    a. Crane Co.
    b. Milwaukee Valve Co.
    c. Watts
    d. Nibco, Inc.

2.19 ECCENTRIC PLUG VALVES

A. Resilient Seating with Flanged Ends.
1. Comply with MSS SP-108.
2. CWP Rating: 175 psig minimum.
3. Body and Plug: Gray or ductile iron.
4. Bearings: Oil-impregnated bronze or Stainless Steel.
5. Stem-Seal Packing: Asbestos free.
6. Plug, Resilient-Seating Material: Approved for potable water service.
7. Manufacturers:
    a. Mueller
    b. Stockham

c. DeZurik

2.20 CHAINWHEELS

A. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
2. Attachment: For connection to ball, butterfly, plug valve stems.
3. Sprocket Rim with Chain Guides: Ductile iron include zinc coating.
4. Chain: Hot-dip galvanized steel. Sized to fit sprocket rim.
5. Manufacturers:
a. Babbitt Steam Specialty Co.
b. Roto Hammer Industries
c. Trumbull Industries

PART 3 EXECUTION

3.1 EXAMINATION

A. Discard all packing materials and verify that valve interior, including threads and flanges are completely clean without signs of damage or degradation that could result in leakage.

B. Verify valve parts to be fully operational in all positions from closed to fully open.

C. Confirm gasket material to be suitable for the service, to be of correct size, and without defects that could compromise effectiveness.

D. Should valve is determined to be defective, replace with new valve.

3.2 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.3 VALVE APPLICATION

A. Valves on condenser water, chilled water, hot water and glycol services shall be as shown in the following tables. If valve applications are not indicated, use the following:
1. Shutoff Service: Ball, butterfly, or gate valves.
2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
3. Throttling Service except Steam: Globe or butterfly valves.
4. Pump-Discharge Check Valves:
a. NPS 2 and Smaller: Spring wafer check valve with bronze disc.
b. NPS 2-1/2 and Larger: Iron, center-guided, metal -seat check valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves with end connections as indicated in the tables. For applications not listed in the tables select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends.
2. For Steel Piping, NPS 2 and Smaller: Threaded ends.
3. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends.
4. For Steel Piping, NPS 5 and Larger: Flanged ends.

GLYCOL, CHILLED AND CONDENSER WATER SERVICE Maximum 150°F and 150 psig (1/2 inch - 12 inches), 125 psig (14 inches - 24 inches)					
Specialty	Application	Type	Size (inches)	Body/Seat Body/Trim	Minimum Rating[1,2]
Ball Valve	Isolation (with locking handle) and Modulation	Full Port 3-pc.	1/2 - 2	Bronze/Teflon	400 psig WOG
		Full Port 2 pc.	1/2 - 2	Bronze/Teflon	400 psig WOG
Gate Valve	Not Used				
Globe Valve	ATC Modulation	Control Valve	1/2 - 2	Bronze/Metal	400 psig WOG
			2-1/2 - 6	Bronze/Metal	400 psig WOG
Butterfly Valve	Isolation and Modulation	General Service	2-1/2 - 12	Ductile Iron/EPDM	175 psig CWP 150 psig bi-directional shutoff 150 psig dead end service
		General Service	14 - 24	Ductile Iron/EPDM	150 psig CWP 150 psig bi-directional shutoff 150 psig dead end service
Plug Valve	Manual Balancing	Non-lubricated	3 - 12	Steel/Iron	Class 125
Check Valve	Pumps	Silent	1/2 - 2	Bronze/Bronze	200 psig WOG
		Silent Globe	2-1/2 - 24	Iron/Bronze	Class 125
	Piping	Y-Pattern Swing	1/2 - 2	Bronze/Bronze	200 psig WOG
			2-1/2 - 24	Iron/Bronze	Class 125
Strainer	Control Valves and Flow Meters	Y-Type	1/2 -2	Bronze/Stainless (1/16 inch dia.)	200 psig WOG
			2-1/2 - 4	Iron/Stainless (1/16 inch dia.)	Class 125
			5 - 24	Iron/Stainless (1/8 inch dia.)	Class 125
	Pump Suction	In-Line Y-Type	1/2 - 2	Bronze/Stainless (1/16 inch dia.)	200 psig WOG
			2-1/2 - 4	Iron/Stainless (3/16 inch dia.)[3]	Class 125
			5 - 24	Iron/Stainless (1/4 inch dia.)[3]	Class 125
		Angle Suction Diffuser End Suction Pumps	2 - 12	Iron/Stainless (3/16 inch dia.)[3] Start Up Strainer = 16 Mesh Bronze	Class 125

1. These are minimum ratings for ASTM A126, Class B and ASTM B-61 and 62. For higher pressures and temperatures, adjust these values to include static head plus 1.1 times pressure relief valve setting plus pump shutoff head pressure. For actual maximum allowable valve and strainer ratings, refer to "Pressure-Temperature Ratings - Non Shock" tables and "Adjusted Pressure Ratings" for copper tube, soldered end valves [and strainers].
2. SWP=Steam Working Pressure CWP=Cold Water Working Pressure
   WSP=Working Steam Pressure WOG=Water, Oil or Gas
   Class=ANSI Standard
3. Use 1/8 inch dia for plate heat exchanger application.
4. Coordinate connection type with piping system.

GLYCOL, CHILLED AND CONDENSER WATER SERVICE Maximum 150°F and 275 psig (1/2 inch - 24 inches)					
Specialty	Application	Type	Size (inches)	Body/Seat Body/Trim	Minimum Rating[1,2]
Ball Valve	Isolation (with locking handle) and Modulation	Full Port 2 pc.	1/2 - 2	Bronze/Teflon	600 psig WOG
Gate Valve	Not Used				
Globe Valve	ATC Modulation	Control Valve	1/2 - 2	Bronze/Metal	600 psig WOG
			2-1/2 - 6	Bronze/Metal	600 psig WOG
Butterfly Valve	Isolation and Modulation	High Performance	2-1/2 - 24	Carbon Steel/PTFE	285 psig CWP
Plug Valve	Manual Balancing	Non-lubricated	3 - 12	Steel/Iron	Class 300
Check Valve	Pumps	Silent	1 - 2	Bronze/Bronze	Class 300
		Silent Globe	2-1/2 - 24	Iron/Bronze	Class 250
	Piping	Y-Pattern Swing	1/2 - 2	Bronze/Bronze	Class 300
			2-1/2 - 24	Iron/Bronze	Class 250
Strainer	Control Valves and Flow Meters	Y-Type	1/2 - 2	Bronze/Stainless (1/16 inch dia.)	Class 250
			2-1/2 - 4	Iron/Stainless (1/16 inch dia.)	Class 250
			5 - 24	Iron/Stainless (1/8 inch dia.)	Class 250
	Pump Suction	In-Line Y-Type	1/2 - 2	Iron/Stainless (1/16 inch dia.)	Class 250
			2-1/2 - 4	Iron/Stainless (3/16 inch dia.)[3]	Class 250
			5 - 24	Iron/Stainless (1/4 inch dia.)[3]	Class 250
		Angle Suction Diffuser End Suction Pumps	2 - 12	Iron/Stainless (3/16 inch dia.)[3] Start Up Strainer = 16 Mesh Bronze	Class 250

1. These are minimum ratings. For higher pressures and temperatures, adjust these values to include static head plus 1.1 times pressure relief valve setting plus pump shutoff head pressure. For actual maximum allowable valve and strainer ratings, refer to "Pressure-Temperature Ratings - Non Shock" tables.
2. SWP=Steam Working Pressure CWP=Cold Water Working Pressure
   WSP=Working Steam Pressure WOG=Water, Oil or Gas
   Class=ANSI Standard
3. Use 1/8 inch dia for plate heat exchanger application.
4. Coordinate connection type with piping system.

GLYCOL, CHILLED AND CONDENSER WATER SERVICE Maximum 150°F and 500 psig (½" - 24")/300 psig (14"-24")					
Specialty	Application	Type	Size (inches)	Body/Seat Body/Trim	Minimum Rating[1,2]
Ball Valve	Isolation (with locking handle) and Modulation	Full Port 2 pc.	1/2 - 2	Bronze/Teflon	600 psig WOG
Gate Valve	Not Used				
Globe Valve	ATC Modulation	Control Valve	1/2 - 2	Bronze/Metal	600 psig WOG
			2-1/2 - 6	Bronze/Metal	600 psig WOG
Butterfly Valve	Isolation and Modulation	High Performance	2-1/2 - 24	Carbon Steel/PTFE	740 psig CWP
Plug Valve	Manual Balancing	Non-lubricated	3 -12	Steel/Iron	Class 300
Check Valve	Pumps	Silent	1 - 2	Bronze/Bronze	Class 300
		Silent Globe	2-1/2 - 24	Iron/Bronze	Class 250
	Piping	Y-Pattern Swing	1/2 - 2	Bronze/Bronze	Class 300
			2-1/2 - 24	Iron/Bronze	Class 250
Strainer	Control Valves and Flow Meters	Y-Type	1/2 - 2	Bronze/Stainless (1/16" dia.)	Class 250
			2-1/2 - 4	Iron/Stainless (1/16" dia.)	Class 250
			5 - 24	Iron/Stainless (1/8" dia.)	Class 250
	Pump Suction	In-Line Y-Type	1/2 - 2	Iron/Stainless (1/16" dia.)	Class 250
			2-1/2 - 4	Iron/Stainless (3/16" dia.)[3]	Class 250
			5 - 24	Iron/Stainless (¼" dia.)[3]	Class 250
		Angle Suction Diffuser End Suction Pumps	2 - 12	Iron/Stainless (3/16" dia.)[3] Start Up Strainer = 16 Mesh Bronze	Class 250

1. These are minimum ratings. For higher pressures and temperatures, adjust these values to include static head plus 1.1 times pressure relief valve setting plus pump shutoff head pressure. For actual maximum allowable valve and strainer ratings, refer to "Pressure-Temperature Ratings - Non Shock" tables.
2. SWP=Steam Working Pressure CWP=Cold Water Working Pressure
   WSP=Working Steam Pressure WOG=Water, Oil or Gas
   Class=ANSI Standard
3. Use 1/8 inch dia for plate heat exchanger application.
4. Coordinate connection type with piping system.

GLYCOL AND HOT WATER SERVICE Maximum 250°F and 175 psig (½"-12")/125 psig (14"-24")					
Specialty	Application	Type	Size (inches)	Body/Seat, Body/Trim	Minimum Rating1,2
Ball Valve	Isolation (with locking handle) and Modulation	Full Port 3-pc.	1/2 - 2	Bronze/Teflon	400 psig WOG
		Full Port 2 pc.	1/2 - 2	Bronze/Teflon	400 psig WOG
Gate Valve	Not Used				
Globe Valve	ATC Modulation	Control Valve	1/2 - 2	Bronze/Metal	400 psig WOG
			2-1/2 - 6	Bronze/Metal	400 psig WOG
Butterfly Valve	Isolation and Modulation	General Service	2-1/2 - 12	Ductile Iron/EPDM	200 psig CWP 200 psig bi-directional shutoff 200 psig dead end service
			14 - 24	Ductile Iron/EPDM	150 psig CWP 150 psig bi-directional shutoff 150 psig dead end service
Plug Valve	Manual Balancing	Non-lubricated	3 -12	Steel/Iron	Class 125
Check Valve	Pumps	Silent	1/2 - 2	Bronze/Bronze	200 psig WOG
		Silent Globe	2-1/2 - 24	Iron/Bronze	Class 125
	Piping	Y-Pattern Swing	1/2 - 2	Bronze/Bronze	200 psig WOG
			2-1/2 - 24	Iron/Bronze	Class 125
Strainer	Control Valves and Flow Meters	Y-Type	1/2 - 2	Bronze/Stainless (1/16" dia.)	200 psig WOG
			2-1/2 - 4	Iron/Stainless (1/16" dia.)	Class 125
			5 - 24	Iron/Stainless (1/8" dia.)	Class 125
	Pump Suction	In-Line Y-Type	1/2 - 2	Bronze/Stainless (1/16" dia.)	200 psig WOG
			2-1/2 - 4	Iron/Stainless (3/16" dia.)[3]	Class 125
			5 -24	Iron/Stainless (¼" dia.)[3]	Class 125
		Angle Suction Diffuser End Suction Pumps	2 - 12	Iron/Stainless (3/16" dia.)[3] Start Up Strainer = 16 Mesh Bronze	Class 125

1. These are minimum ratings for ASTM A126, Class B and ASTM B-61 and 62. For higher pressures and temperatures, adjust these values to include static head plus 1.1 times pressure relief valve setting plus pump shutoff head pressure. For actual maximum allowable valve and strainer ratings, refer to "Pressure-Temperature Ratings - Non Shock" tables and "Adjusted Pressure Ratings" for copper tube, soldered end valves [and strainers].
2. SWP=Steam Working Pressure CWP=Cold Water Working Pressure
   WSP=Working Steam Pressure WOG=Water, Oil or Gas
   Class=ANSI Standard
3. Use 1/8 inch dia for plate heat exchanger application.
4. Coordinate connection type with piping system.

GLYCOL AND HOT WATER SERVICE Maximum 225°F and 250 psig (½"-24")					
Specialty	Application	Type	Size (inches)	Body/Seat, Body/Trim	Minimum Rating1,2
Ball Valve	Isolation (with locking handle) and Modulation	Full Port 3-pc.	1/2 - 2	Bronze/Teflon	400 psig WOG
		Full Port 2 pc.	1/2 - 2	Bronze/Teflon	400 psig WOG
Gate Valve	Not Used				
Globe Valve	ATC Modulation	Control Valve	1/2 - 2	Bronze/Metal	400 psig WOG
			2-1/2 - 6	Bronze/Metal	600 psig WOG
Butterfly Valve	Isolation and Modulation	High Performance	2-1/2 - 24	Carbon Steel/PTFE	285 psig CWP
Plug Valve	Manual Balancing	Non-lubricated	3 - 12	Steel/Iron	Class 250
Check Valve	Pumps	Silent	1 - 2	Bronze/Bronze	Class 250
		Silent Globe	2-1/2 - 24	Iron/Bronze	Class 250
	Piping	Y-Pattern Swing	1 -2	Bronze/Bronze	Class 250
			2-1/2 - 24	Iron/Bronze	Class 250
Strainer	Control Valves and Flow Meters	Y-Type	1/2 - 2	Bronze/Stainless (20 mesh)	400 psi WOG
			2-1/2 - 4	Iron/Stainless (1/16" dia.)	Class 250
			5 - 24	Iron/Stainless (1/8" dia.)	Class 250
	Pump Suction	In-Line Y-Type	1/2 - 2	Bronze/Stainless (1/16" dia.)	400 psig WOG
			2-1/2 - 4	Iron/Stainless (3/16" dia.)[3]	Class 250
			5 - 24	Iron/Stainless (¼" dia.)[3]	Class 250
		Angle Suction Diffuser End Suction Pumps	2 - 12	Iron/Stainless (3/16" dia.)[3] Start Up Strainer = 16 Mesh Bronze	Class 250

1. These are minimum ratings for ASTM A126, Class B and ASTM B-61 and 62. For higher pressures and temperatures, adjust these values to include static head plus 1.1 times pressure relief valve setting plus pump shutoff head pressure. For actual maximum allowable valve and strainer ratings, refer to "Pressure-Temperature Ratings - Non Shock" tables and "Adjusted Pressure Ratings" for copper tube, soldered end valves [and strainers].
2. SWP=Steam Working Pressure CWP=Cold Water Working Pressure
   WSP=Working Steam Pressure WOG=Water, Oil or Gas
   Class=ANSI Standard
3. Use 1/8 inch dia for plate heat exchanger application.
4. Coordinate connection type with piping system.

HOT WATER SERVICE Maximum 250°F and 400 psig (½"-12")/250 psig (14"-24")					
Specialty	Application	Type	Size (inches)	Body/Seat, Body/Trim	Minimum Rating1,2
Ball Valve	Isolation (with locking handle) and Modulation	Full Port 3-pc.	1/2 - 2	Bronze/Teflon	Do not use
		Full Port 2 pc.	1/2 - 2	Bronze/Teflon	600 psig WOG
Gate Valve	Not Used				
Globe Valve	ATC Modulation	Control Valve	1/2 = 2	Bronze/Metal	600 psig WOG
			2-1/2 - 6	Bronze/Metal	600 psig WOG
Butterfly Valve	Isolation and Modulation	High Performance	2-1/2 - 24	Carbon Steel/PTFE	740 psig CWP
Plug Valve	Manual Balancing	Non-lubricated	3 - 12	Steel/Iron	Class 250
Check Valve	Pumps	Silent	1 - 2	Bronze/Bronze	Class 250
		Silent Globe	2-1/2 - 24	Iron/Bronze	Class 250
	Piping	Y-Pattern Swing	1 - 2	Bronze/Bronze	Class 250
			2-1/2 - 24	Iron/Bronze	Class 250
Strainer	Control Valves and Flow Meters	Y-Type	1/2 - 2	Bronze/Stainless (20 mesh)	600 psig WOG
			2-1/2 - 4	Iron/Stainless (1/16" dia.)	Class 250
			5 - 24	Iron/Stainless (1/8" dia.)	Class 250
	Pump Suction	In-Line Y-Type	1/2 - 2	Bronze/Stainless (1/16" dia.)	600 psig WOG
			2-1/2 - 4	Iron/Stainless (3/16" dia.)[3]	Class 250
			5 - 24	Iron/Stainless (¼" dia.)[3]	Class 250
		Angle Suction Diffuser End Suction Pumps	2 -12	Iron/Stainless (3/16" dia.)[3] Start Up Strainer = 16 Mesh Bronze	Class 250

1. These are minimum ratings for ASTM A126, Class B and ASTM B-61 and 62. For higher pressures and temperatures, adjust these values to include static head plus 1.1 times pressure relief valve setting plus pump shutoff head pressure. For actual maximum allowable valve and strainer ratings, refer to "Pressure-Temperature Ratings - Non Shock" tables and "Adjusted Pressure Ratings" for copper tube, soldered end valves [and strainers].
2. SWP=Steam Working Pressure CWP=Cold Water Working Pressure
   WSP=Working Steam Pressure WOG=Water, Oil or Gas
   Class=ANSI Standard
3. Use 1/8 inch dia for plate heat exchanger application.
4. Coordinate connection type with piping system.

3.4 INSTALLATION

A. Provide unions or flanges with valves to facilitate equipment removal and maintenance while maintaining system operation and full accessibility for servicing.

B. Provide separate valve support as required and locate valve with stem at or above center of piping, maintaining unimpeded stem movement.

C. Where valve support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.

D. Install check valves where necessary to maintain direction of flow as follows:
   1. Lift Check: Install with stem plumb and vertical.
   2. Swing Check: Install horizontal maintaining hinge pin level.
   3. Orient plate-type, center-guided into horizontal or vertical position, between flanges.

E. Provide chainwheels on operators for valves 4 NPS and larger where located 96 NPS or more above finished floor, terminating 60 NPS above finished floor.

END OF SECTION 23 0523

SECTION 23 0529 - HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Pipe hangers and supports.

B. Duct hangers and supports

C. Hanger rods.

D. Inserts.

E. Flashing.

F. Formed steel channel.

G. Equipment bases and supports.

1.2 RELATED REQUIREMENTS

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

1.3 REFERENCES

A. American Society of Mechanical Engineers:
   1. ASME B31.1 - Power Piping.
   2. ASME B31.5 - Refrigeration Piping.
   3. ASME B31.9 - Building Services Piping.

B. ASTM International:
   1. ASTM E119 - Standard Test Methods for Fire Tests of Building Construction and Materials.
   2. ASTM E814 - Standard Test Method for Fire Tests of Through Penetration Fire Stops.
   3. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers.
   4. ASTM E1966 - Standard Test Method for Fire-Resistive Joint Systems.

C. American Welding Society:
   1. AWS D1.1 - Structural Welding Code - Steel.

D. FM Global:

1. FM - Approval Guide, A Guide to Equipment, Materials & Services Approved By Factory Mutual Research For Property Conservation.

E. Manufacturers Standardization Society of the Valve and Fittings Industry:
1. MSS SP 58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.
2. MSS SP 69 - Pipe Hangers and Supports - Selection and Application.
3. MSS SP 89 - Pipe Hangers and Supports - Fabrication and Installation Practices.

F. Intertek Testing Services (Warnock Hersey Listed):
1. WH - Certification Listings.

1.4 PERFORMANCE REQUIREMENTS

A. Contractor shall design supports for multiple pipes and/or ducts, including pipe and duct stands, capable of supporting combined weight of supported systems, system contents, and fluid.

B. Contractor shall design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.5 SUBMITTALS

A. Shop Drawings: Indicate system layout with location including critical dimensions, sizes, and pipe hanger and support locations and detail of trapeze hangers.

B. Product Data:
1. Hangers and Supports: Submit manufacturers catalog data including load capacity.

C. Design Data: Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers. Indicate calculations used to determine load carrying capacity of trapeze, multiple pipe, and riser support hangers.

D. Welding certificates.

E. Manufacturer's Installation Instructions:
1. Hangers and Supports: Submit special procedures and assembly of components.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel." and AWS D1.3, "Structural Welding Code--Sheet Steel."

B. Welding: Qualify procedures and personnel according to the following:
1. AWS D1.1, "Structural Welding Code--Steel."
2. AWS D1.2, "Structural Welding Code--Aluminum."
3. AWS D1.3, "Structural Welding Code--Sheet Steel."

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum three years documented experience.

B. Installer: Company specializing in performing Work of this section with minimum 3 years documented experience.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Accept materials on site in original factory packaging, labeled with manufacturer's identification.

B. Protect from weather and construction traffic, dirt, water, chemical, and damage, by storing in original packaging.

1.9 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.10 WARRANTY

A. Furnish five year manufacturer warranty for pipe hangers and supports.

PART 2 PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to the following::
1. B-Line Systems, Inc.
2. National Pipe Hanger Corporation
3. Empire Industries, Inc.
4. Globe Pipe Hanger Products Inc.
5. Michigan Hanger Co.
6. PHD Manufacturing, Inc.
7.

C. Galvanized, Metallic Coatings: Pre-galvanized or hot dipped.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.2 DUCT HANGERS AND SUPPORTS

A. Shall be in accordance with SMACNA's 2005 "HVAC Duct Construction Standards - Metal and Flexible" except non-engineered wire hangers are not permitted. Engineered cable support systems may be used if they meet SMACNA, Ductmate or approved equal.

B. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

C. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

D. Strap and Rod Sizes: Comply with SMACNA's 2005 "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct.

E. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

F. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

G. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

H. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

I. Trapeze and Riser Supports:
   1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
   2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
   3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate

2.3 ACCESSORIES

A. Hanger Rods: Mild steel threaded both ends, threaded on one end, or continuous threaded.

2.4 THERMAL SHIELD INSERTS

A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield. Insert shall be capable of supporting weight of pipe, insulations and fluid without crushing.

B. Manufacturers:
   1. Carpenter & Paterson, Inc.
   2. ERICO/Michigan Hanger Co.

3. PHS Industries, Inc.
4. Pipe Shields, Inc.
5. Rilco Manufacturing Company, Inc.
6. Value Engineered Products, Inc.

C. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.

D. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass.

E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated or stainless steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Manufacturers:
1. B-Line Systems, Inc.; a division of Cooper Industries.
2. Empire Industries, Inc.
3. Hilti, Inc.
4. ITW Ramset/Red Head.
5. MKT Fastening, LLC.
6. Powers Fasteners.

2.6 MISCELLANEOUS MATERIALS

A. Hanger Rods: Mild steel threaded both ends, threaded on one end, or continuous threaded.

B. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

C. Equipment Supports: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

D. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

E. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

2.7 FORMED STEEL CHANNEL

A. Manufacturers:
1. Allied Tube & Conduit Corp.
2. B-Line Systems
3. Midland Ross Corporation, Electrical Products Division
4. Unistrut Corp.

B. Product Description: Galvanized 12 gage thick steel. With holes 1-1/2 inches on center.

PART 3 EXECUTION

3.1 PIPE HANGER AND SUPPORT APPLICATIONS

A. Specific hanger and support requirements are specified in other Division 23 Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use padded hangers for piping that is subject to scratching.

F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system specific sections, install the following types:
1. MSS Type 1 - Adjustable, Steel Clevis Hangers: For suspension of non-insulated or insulated stationary pipes, 2 inch to 30 inch size.
2. MSS Type 2 - Yoke-Type Pipe Clamps: For suspension of 120 to 450 deg F pipes, 4 inch to 16 inch size, requiring up to 4 inches of insulation.
3. MSS Type 3 - Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps: For suspension of pipes, 3/4 inch to 24 inch size, requiring clamp flexibility and up to 4 inches of insulation.
4. MSS Type 4 - Steel Pipe Clamps: For suspension of cold and hot pipes, 1/2 inch to 24 inch size, if little or no insulation is required.
5. MSS Type 5 - Pipe Hangers: For suspension of pipes, 1/2 inch to 4 inch size, to allow off-center closure for hanger installation before pipe erection.
6. MSS Type 12 - Extension Hinged or 2-Bolt Split Pipe Clamps: For suspension of non-insulated stationary pipes, 3/8 inch to 3 inch size.
7. MSS Type 24 - U-Bolts: For support of heavy pipes, 1/2 inch to 30 inch.

8. MSS Type 26 - Clips: For support of insulated pipes not subject to expansion or contraction.
9. MSS Type 36 - Pipe Saddle Supports: For support of pipes, 4 inch to 36 inch size, with steel pipe base stanchion support and cast-iron floor flange.
10. MSS Type 37 - Pipe Stanchion Saddles: For support of pipes, 4 inch to 36 inch size, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
11. MSS Type 38 - Adjustable, Pipe Saddle Supports: For stanchion-type support for pipes, 2-1/2 inch to 36 inch size, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
12. MSS Type 41 - Single Pipe Rolls: For suspension of pipes, 1 inch to 30 inch size, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
13. MSS Type 43 - Adjustable Roller Hangers: For suspension of pipes, 2-1/2 inch to 20 inch size, from single rod if horizontal movement caused by expansion and contraction might occur.
14. MSS Type 44 - Complete Pipe Rolls: For support of pipes, 2 inch to 42 inch size, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
15. MSS Type 45 - Pipe Roll and Plate Units: For support of pipes, 2 inch to 24 inch, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
16. MSS Type 46 - Adjustable Pipe Roll and Base Units: For support of pipes, 2 inch to 30 inch size, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. MSS Type 8 - Extension Pipe or Riser Clamps: For support of pipe risers, ¾ inch to 20 inch size.
2. MSS Type 42 - Carbon- or Alloy-Steel Riser Clamps: For support of pipe risers, 3/4 inch to 20 inch size, if longer ends are required for riser clamps.

H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. MSS Type 13 - Steel Turnbuckles: For adjustment up to 6 inches for heavy loads.
2. MSS Type 14 - Steel Clevises: For 120 to 450 deg F piping installations.
3. MSS Type 15 - Swivel Turnbuckles: For use with MSS Type 11, split pipe rings.
4. MSS Type 16 - Malleable-Iron Sockets: For attaching hanger rods to various types of building attachments.
5. MSS Type 17 - Steel Weldless Eye Nuts: For 120 to 450 deg F piping installations.

I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. MSS Type 18 - Steel or Malleable Concrete Inserts: For upper attachment to suspend pipe hangers from concrete ceiling.

2. MSS Type 19 - Top-Beam C-Clamps: For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. MSS Type 20 - Side-Beam or Channel Clamps: For attaching to bottom flange of beams, channels, or angles.
4. MSS Type 21 - Center-Beam Clamps: For attaching to center of bottom flange of beams.
5. MSS Type 22 - Welded Beam Attachments: For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. MSS Type 23 - C-Clamps: For structural shapes.
7. MSS Type 25 - Top-Beam Clamps: For top of beams if hanger rod is required tangent to flange edge.
8. MSS Type 27 - Side-Beam Clamps: For bottom of steel I-beams.
9. MSS Type 28 - Steel-Beam Clamps with Eye Nuts: For attaching to bottom of steel I-beams for heavy loads.
10. MSS Type 29 - Linked-Steel Clamps with Eye Nuts: For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. MSS Type 30 - Malleable Beam Clamps with Extension Pieces: For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.
13. MSS Type 34 - Side-Beam Brackets: For sides of steel or wooden beams.
14. MSS Type 57 - Plate Lugs: For attaching to steel beams if flexibility at beam is required.
15. MSS Type 58 - Horizontal Travelers: For supporting piping systems subject to linear horizontal movement where headroom is limited.

J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. MSS Type 39 - Steel Pipe-Covering Protection Saddles: To fill interior voids with insulation that matches adjoining insulation.
2. MSS Type 40 - Protection Shields: Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

K. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. MSS Type 47 - Restraint-Control Devices: Where indicated to control piping movement.
2. MSS Type 48 - Spring Cushions: For light loads if vertical movement does not exceed 1-1/4 inches.
3. MSS Type 49 - Spring-Cushion Roll Hangers: For equipping Type 41 roll hanger with springs.
4. MSS Type 50 - Spring Sway Braces: To retard sway, shock, vibration, or thermal expansion in piping systems.

5. MSS Type 51 - Variable-Spring Hangers: Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.
6. MSS Type 52 - Variable-Spring Base Supports: Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
7. MSS Type 53 - Variable-Spring Trapeze Hangers: Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
   a. Horizontal (MSS Type 54): Mounted horizontally.
   b. Vertical (MSS Type 55): Mounted vertically.
   c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

L. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.

M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

3.2 PIPE HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Metal Framing System for Multiple Hangers: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:
1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Stand Installation:
   1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
   2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Division 07 Section "Roof Accessories" for curbs.
   3. Floor Support: concrete pier or steel support.

G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Install lateral bracing with pipe hangers and supports to prevent swaying.

J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

K. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

M. Insulated Piping: Comply with the following:
   1. Attach clamps and spacers to piping.
      a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
      b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
      c. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.
   2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
5. Pipes NPS 8 and Larger: Include wood inserts.
6. Insert Material: Length at least as long as protective shield.
7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

N. Design hangers for pipe movement without disengagement of supported pipe.

O. Provide clearance in hangers and from structure and other equipment for installation of insulation. Refer to Section 23 07 00 Provide supplemental angles, channels and formed steel supports to support piping, ductwork, equipment, etc. from building's structure. Piping, ductwork, equipment, etc. shall not be supported from the roof deck.

3.3 DUCT HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's 2005 "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's 2005 "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5- 2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

3.4 EQUIPMENT BASES AND SUPPORTS

A. Provide housekeeping pads of concrete, minimum 3-1/2 inches thick and extending 6 inches beyond supported equipment. Refer to Section 03 30 00.

B. Using templates furnished with equipment, install anchor bolts, and accessories for mounting and anchoring equipment.

C. Construct supports to suspend equipment from structure overhead or to support equipment above floor. Fabricate supports from welded-structural steel shapes. Brace and fasten with flanges bolted to structure.

D. Provide rigid anchors for pipes after vibration isolation components are installed. Refer to Section 23 05 48.

3.5 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.6 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.7 SCHEDULES

A. Copper and Steel Pipe Hanger Spacing:

PIPE SIZE Inches	COPPER TUBING MAXIMUM HANGER SPACING Feet	STEEL PIPE MAXIMUM HANGER SPACING Feet	COPPER TUBING HANGER ROD DIAMETER Inches	STEEL PIPE HANGER ROD DIAMETER Inches
1/2	5	7	3/8	3/8
3/4	5	7	3/8	3/8
1	6	7	3/8	3/8
1-1/4	7	7	3/8	3/8
1-1/2	8	9	3/8	3/8
2	8	10	3/8	3/8
2-1/2 (Note 2)	9	11	1/2	1/2
3	10	12	1/2	1/2
4	12	14	1/2	5/8
5	13	16	1/2	5/8
6	14	17	5/8	3/4
8	16	19	3/4	3/4

B. Plastic and Ductile Iron Pipe Hanger Spacing:

PIPE MATERIAL	MAXIMUM HANGER SPACING Feet	HANGER ROD DIAMETER Inches
ABS (All sizes)	4	3/8
FRP (All Sizes)	4	3/8
Ductile Iron (Note 2)		
PVC (All Sizes)	4	3/8

C. Note 1: Refer to manufacturer's recommendations for grooved end piping systems.

D. Note 2: 20 feet maximum spacing, minimum of one hanger for each pipe section close to joint behind bell. Provide hanger at each change of direction and each branch connection. For pipe sizes 6 inches and smaller, subjected to loadings other than weight of pipe and contents, limit span to maximum spacing for water service steel pipe.

END OF SECTION 23 0529

SECTION 23 0548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Equipment support bases.

B. Vibration isolators.

C. Seismic snubber assemblies.

D. Seismic restraints for suspended components and equipment.

E. Roof curbs.

1.2 RELATED REQUIREMENTS

A. Division 01 - General Requirements.

B. Division 03 - Concrete.

C. Section 23 04 00 – General Conditions for Mechanical Trades.

1.3 REFERENCE STANDARDS (follow the most currently adopted amended version)

A. ASCE 7 - Minimum Design Loads for Buildings and Other Structures.

B. ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications.

C. FEMA 412 - Installing Seismic Restraints for Mechanical Equipment.

D. FEMA 413 - Installing Seismic Restraints for Electrical Equipment.

E. FEMA 414 - Installing Seismic Restraints for Duct and Pipe.

F. FEMA E-74 - Reducing the Risks of Nonstructural Earthquake Damage.

G. IAS AC172 - Accreditation Criteria for Fabricator Inspection Programs for Structural Steel; International Accreditation Service, Inc.

H. SMACNA (SRM) - Seismic Restraint Manual Guidelines for Mechanical Systems; Sheet Metal and Air Conditioning Contractors' National Association.

1.4 SUBMITTALS

A. Product Data: Submit schedule of vibration isolator type with location and load on each. Submit catalog information indicating, materials, dimensional data, pressure losses, and acoustical performance for standard sound attenuation products.Shop Drawings:
   1. Provide schedule of vibration isolator type with location and load on each.
   2. Fully dimensioned fabrication drawings and installation details for vibration isolation bases, member sizes, attachments to isolators, and supported equipment.
   3. Include auxiliary motor slide bases and rails, base weights, inertia bases, concrete weights, equipment static loads, support points, vibration isolators, and detailed layout of isolator location and orientation with static and dynamic load on each isolator.
   4. Include selections from prescriptive design tables that indicate compliance with the applicable building code and the vibration isolator manufacturer's requirements.
      Clearly indicate the load and capacity assumptions selected. Include copies of any calculations.

B. Seismic Certification and Analysis:
   1. Include the calculations that indicate compliance with the applicable building code for seismic controls and the vibration isolator manufacturer's requirements.
   2. Include the seal of the Professional Structural Engineer registered where the Project is located, on the drawings and calculations which at a minimum include the following:
      a. Seismic Restraint Details: Detailed drawings of seismic restraints and snubbers including anchorage details that indicate quantity, diameter, and depth of penetration, edge distance, and spacing of anchors.
      b. Equipment Seismic Qualification Certification: Certification by the manufacturer or responsible party that each piece of equipment provided will withstand seismic force levels as specified in the applicable building code for seismic controls.
         1) Basis for Certification: Indicate whether the withstand certification is based on actual testing of assembled components, on calculations, or on historic data.
         2) Indicate equipment to be sufficiently durable to resist design forces and or remain functional after the seismic event.
      c. Dimensioned outline drawings of equipment identifying center of gravity, locations, and provisions for mounting and anchorage.
      d. Detailed description of the equipment anchorage devices on which the certifications are based.
      e. Statement of Special Inspections: Prepared by the registered design professional in responsible charge.

C. Delegated-Design Submittal:
   1. For each vibration isolation device.
      a. Include design calculations and details for selecting vibration isolators, vibration isolation bases, and appropriate attachment methods for all equipment.

b. Design Calculations: Calculate static and dynamic loading due to equipment weight and required to select vibration isolators and for designing vibration isolation bases.
   1) Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

c. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure and spring deflection changes. Include certification that riser system was examined for excessive stress and that none exists.

2. Mechanical equipment, appliances, ductwork, and supports that are exposed to wind shall be designed to resist the wind pressures determined in accordance with the International Building Code.
   a. Design Calculations: Calculate loading due to wind pressure and required to select vibration isolators and for designing vibration isolation bases.
   b. Include the seal of the Professional Structural Engineer registered where the Project is located, on the drawings and calculations.

D. Manufacturer's Instructions: Indicate installation instructions with special procedures and setting dimensions.

1.5 QUALITY ASSURANCE

A. Perform design and installation in accordance with applicable codes.

B. Designer Qualifications: Perform design under direct supervision of a Professional Engineer experienced in design of this type of work and registered and licensed in the State in which the Project is located.

C. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than three years of documented experience.
   1. Member of Vibration Isolation and Seismic Control Manufacturers Association (VISCMA).

D. Installer Qualifications: Company specializing in performing the work of this section with minimum 3 years of experience.

E. Testing Agency Qualifications: Independent firm specializing in performing testing and inspections of the type specified in this section.
   1. See Division 01 – General Requirements.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Mason Industries.

B. Novia Associates (Seismic Control Products)

C. Vibration Eliminator Company, Inc.

D. Vibro-Accoustics Ltd

E. Pate

F. Substitutions: See Division 01 - General Requirements.

2.2 PERFORMANCE REQUIREMENTS

A. General:
1. All vibration isolators, base frames and inertia bases to conform to all uniform deflection and stability requirements under all operating loads.
2. Steel springs to function without undue stress or overloading.
3. Steel springs to operate in the linear portion of the load versus deflection curve over deflection range of not less than 50 percent above specified deflection.
4. Lateral to vertical stiffness ratio to not exceed 0.08 with spring deflection at minimum 75 percent of specified deflection.
5. All equipment mounted on vibration isolated bases to have minimum operating clearance of 2 inches between the base and floor or support beneath unless noted otherwise.

2.3 EQUIPMENT SUPPORT BASES

A. Structural Bases:
1. Construction: Engineered, structural steel frames with welded brackets for side mounting of the isolators.
2. Frames: Square, rectangular or T-shaped.
3. Design: Sufficiently rigid to prevent misalignment or undue stress on machine, and to transmit design loads to isolators and snubbers.
4. Applications: Adjustable motor slide rails for centrifugal fans.

B. Concrete Inertia Bases:
1. Construction: Engineered, steel forms, with integrated isolator brackets and anchor bolts, welded or tied reinforcing bars running both ways in a single layer.
2. Size: 6 inches minimum depth and sized to accommodate elbow supports.
3. Mass: Minimum of 1.5 times weight of isolated equipment.
4. Connecting Point: Reinforced to connect isolators and snubbers to base including template and fastening devices for equipment.
5. Concrete: Filled on site with minimum 3000 psi concrete. See Section 03 3000 for additional requirements.
6. Applications: Adjustable motor slide rails for centrifugal fans.

2.4 VIBRATION ISOLATORS

A. Non-Seismic Type:
1. All Elastomeric-Fiber Glass Pads:

a. Configuration: Flat or molded.
b. Thickness: 0.25 inch minimum.
c. Assembly: Single or multiple layers using bonded, galvanized sheet metal separation plate between each layer with load plate providing evenly distributed load over pad surface.

2. Elastomeric Mounts:
a. Material: Oil, ozone, and oxidant resistant compounds.
b. Assembly: Encapsulated load transfer plate bolted to equipment and base plate with anchor hole bolted to supporting structure.

3. Steel Springs:
a. Assembly: Freestanding, laterally stable without housing.
b. Leveling Device: Rigidly connected to equipment or frame.

4. Restrained Steel Springs:
a. Housing: Rigid blocking during rigging prevents equipment installed and operating height from changing during temporary weight reduction.
b. Equipment Wind Loading: Adequate means for fastening isolator top to equipment and isolator base plate to supporting structure.

5. Elastomeric Hangers:
a. Housing: Steel construction containing elastomeric isolation element to prevent rod contact with housing and short-circuiting of isolating function.
b. Incorporate steel load distribution plate sandwiching elastomeric element to housing.

6. Spring Hanger:
a. Housing: Steel construction containing stable steel spring and integral elastomeric element preventing metal to metal contact.
b. Bottom Opening: Sized to allow plus/minus 15 degrees rod misalignment.

7. Combination Elastomeric-Spring Hanger:
a. Housing: Steel construction containing stable steel spring with elastomeric element in series isolating upper connection of hanger box to building structure.
b. Bottom Opening: Sized to allow plus/minus 15 degrees rod misalignment.

8. Thrust Restraints:
a. Housing: Steel construction containing stable steel spring and integral elastomeric element installed in pairs to resist air pressure thrusts.
b. Bottom Openings: Sized to allow plus/minus 15 degrees rod misalignment.

B. Seismic Type:
1. Coil Springs Consisting of Single Elements:
a. Housing Manufactured from cast iron material.
b. Ductile Material: Designed and rated for seismic applications.
c. Spring: Restrained by housing without significant degradation of vibration isolation capabilities during normal equipment operating conditions.

d. Resilient Snubbing Grommet System: Incorporated and designed with clearances of no more than 0.25 inch in any direction preventing direct metal-to-metal contact between supported member and fixed restraint housing.
e. Resilient Pad: Located in series with spring.
f. Coil Springs: Color coded elements to have a lateral stiffness greater than 0.8 times the rated vertical stiffness with 50 percent overload capacity.
g. Finish: Suitable for the application.

2. All Directional Elastomeric:
a. Material: Molded from oil, ozone, and oxidant resistant compounds.
b. Operating Parameters: Designed to operate within the isolator strain limits providing maximum performance and service life.
c. Attachment Method: Encapsulated load transfer plate bolted to equipment and base plate with anchor hole bolted to supporting structure.
d. Rating: Cast iron and aluminum housings rated for seismic restraint applications.
e. Minimum Operating Static Deflections: Deflections indicated in project documents are not to exceed published load capacities.

2.5 SEISMIC SNUBBER ASSEMBLIES

A. Comply with:
1. ASHRAE (HVACA) Handbook - HVAC Applications.
2. FEMA 412.
3. FEMA 413.
4. FEMA 414.
5. FEMA E-74.
6. SMACNA (SRM).

B. All Directional External:
1. Application: Minimum three (3) snubbers are required for each equipment installation, oriented properly to restrain isolated equipment in all directions.
2. Construction: Interlocking steel construction attached to the building structure and equipment in a manner consistent with anticipated design loads.
3. Performance: Equipment movement at each snubber location limited to a maximum of 0.25 inches in any direction without significantly degrading the vibration isolation capability of the isolator during normal operating conditions.
4. Resilient Pad: Minimum 0.25 inch thick cushions any impact and prevents metal-to-metal contact.

C. Lateral External:
1. Application: Minimum three (3) snubbers are required for each stable equipment installation, oriented properly to restrain isolated equipment in all lateral directions where uplift forces are zero or addressed by other restraints.
2. Construction: Steel construction attached to the building structure and equipment in a manner consistent with anticipated design loads.

3. Performance: Equipment movement at each snubber location limited to a maximum of 0.25 inches in any direction without significantly degrading the vibration isolation capability of the isolator during normal operating conditions.
4. Resilient Pad: Minimum 0.25 inch thick cushions any impact and prevents metal-to-metal contact.

D. Omni Directional External:
1. Application: Minimum four (4) snubbers are required for each stable equipment installation, oriented properly to restrain isolated equipment in all lateral directions.
2. Construction: Steel construction attached to the building structure and equipment in a manner consistent with anticipated design loads.
3. Performance: Equipment movement at each snubber location limited to a maximum of 0.25 inches in any direction without significantly degrading the vibration isolation capability of the isolator during normal operating conditions.
4. Resilient Pad: Minimum 0.25 inch thick cushions any impact and prevents metal-to-metal contact.

E. Horizontal Single Axis External:
1. Application: Minimum four (4) snubbers are required for each stable equipment installation, oriented properly to restrain isolated equipment in all lateral directions where uplift forces are zero or addressed by other restraints.
2. Construction: Steel construction attached to the building structure and equipment in a manner consistent with anticipated design loads.
3. Performance: Equipment movement at each snubber location limited to a maximum of 0.25 inches in any direction without significantly degrading the vibration isolation capability of the isolator during normal operating conditions.
4. Resilient Pad: Minimum 0.25 inch thick cushions any impact and prevents metal-to-metal contact.

2.6 SEISMIC RESTRAINTS FOR SUSPENDED COMPONENTS AND EQUIPMENT

A. Comply with:
1. ASHRAE (HVACA) Handbook - HVAC Applications.
2. FEMA 412.
3. FEMA 413.
4. FEMA 414.
5. FEMA E-74.
6. SMACNA (SRM).

B. Cable Restraints:
1. Wire Rope: Steel wire strand cables sized to resist seismic loads in all lateral directions.
2. Protective Thimbles: Eliminates potential for dynamic cable wear and strand breakage.
3. Size: Based on the lesser of cable capacity or anchor load taking into account bracket geometry.
4. Connections:

a. Use overlapping wire rope U clips, cable clamping bolts, swaged sleeves or seismically rated tool-less wedge insert lock connectors.
b. Internally brace clevis hanger bracket cross bolt to prevent deformation.

5. Vertical Suspension Rods: Attach required bracing of sufficient strength to prevent rod buckling from vertical compression forces utilizing series of attachment clips.

C. Rigid Restraints:
1. Structural Element: Sized to resist seismic loads in all lateral directions and carry both compressive and tensile loading.
2. Size: Based on the lesser of cable capacity or anchor load taking into account bracket geometry.
3. Connections: Internally brace clevis hanger bracket cross bolt to prevent deformation.
4. Static Support System: Anchorage capable of carrying additional tension loads generated by the vertical component of the rigid brace compression which is additive to any static load requirements on the system.
5. Vertical Suspension Rods: Attached required bracing of sufficient strength to prevent rod buckling from vertical compression forces utilizing series of attachment clips.

2.7 ROOF CURBS

A. Vibration Isolation Curbs:
1. Non-Seismic Curb Rail:
a. Location: Between existing roof curb and rooftop equipment.
b. Construction: Aluminum.
c. Integral vibration isolation to conform to requirements of this section.
d. Weather exposed components consist of corrosion resistant materials.
2. Non-Seismic Curb:
a. Location: Between structure and rooftop equipment.
b. Construction: Aluminum.
c. Integral vibration isolation to conform to requirements of this section.
d. Weather exposed components consist of corrosion resistant materials.
3. Seismic Curb:
a. Location: Between structure and rooftop equipment.
b. Construction: Steel.
c. Integral vibration isolation to conform to requirements of this section.
d. Snubbers consist of minimum 0.25 inch thick resilient pads to avoid metal-to-metal contact without compromising vibration isolating capabilities.
e. Weather exposed components consist of corrosion resistant materials.

B. Seismic Type Non-Isolated Curb and Fabricated Equipment Piers:
1. Location: Between structure and rooftop equipment.
2. Construction: Steel.
3. Weather exposed components consist of corrosion resistant materials.

PART 3 EXECUTION

3.1 INSTALLATION - GENERAL

A. Install in accordance with manufacturer's instructions.

B. Bases:
1. Set steel bases for one inch clearance between housekeeping pad and base.
2. Set concrete inertia bases for 2 inches clearance between housekeeping pad and base.
3. Adjust equipment level.

C. On closed spring isolators, adjust so side stabilizers are clear under normal operating conditions.

D. Prior to making piping connections to equipment with operating weights substantially different from installed weights, block up equipment with temporary shims to final height. When full load is applied, adjust isolators to load to allow shim removal.

E. Provide pairs of horizontal limit springs on fans with more than 6.0 inches WC static pressure, and on hanger supported, horizontally mounted axial fans.

F. Support piping connections to equipment mounted on isolators using isolators or resilient hangers for scheduled distance.
1. Up to 4 Inches Pipe Size: First three points of support.
2. 5 to 8 Inches Pipe Size: First four points of support.
3. 10 inches Pipe Size and Over: First six points of support.
4. Select three hangers closest to vibration source for minimum 1.0 inch static deflection or static deflection of isolated equipment. Select remaining isolators for minimum 1.0 inch static deflection or 1/2 static deflection of isolated equipment.

3.2 INSTALLATION - SEISMIC

A. Comply with:
1. ASHRAE (HVACA) Handbook - HVAC Applications.
2. FEMA 412.
3. FEMA 413.
4. FEMA 414.
5. FEMA E-74.
6. SMACNA (SRM).

B. Seismic Snubbers:
1. Provide on all isolated equipment, piping and ductwork.
2. Provide minimum of four seismic snubbers located close to isolators.
3. Snub equipment designated for post-disaster use to 0.05 inch maximum clearance.
4. Snub all other equipment between 0.15 inch and 0.25 inch clearance.

C. Floor and Base-Mounted Equipment, Vibration Isolated Equipment and associated Vibration and Seismic Controls for Connections:
   1. Install equipment anchorage items designed to resist seismic design force in any direction.
   2. Install vibration and seismic controls designed to include base and isolator requirements.
   3. Provide flexible connections between equipment and interconnected piping.
   4. Provide isolators and restraints designed for amplified code forces per ASCE 7 and with demonstrated ability to resist required forces including gravity, operational and seismic forces.
   5. Where equipment is not designed to be point loaded, provide base capable of transferring gravity and seismic demands from equipment to isolator base plate anchorage.
   6. Where concrete floor thickness is less than required for expansion anchor installation, install through bolt in lieu of expansion anchor.
   7. Where timber/wood floor or other substrate is inadequate for installation of lag bolts, screws or other mechanical fasteners, install supplemental framing or blocking to transfer loads to structural elements.

D. Suspended Mechanical Equipment:
   1. Provide supports and bracing to resist seismic design force in any direction.
   2. Provide flexible connections between equipment and interconnected piping.
   3. Brace equipment hung from spring mounts using cable or other bracing that will not transmit vibration to the structure.
   4. Use of proprietary restraint systems with a certificate of compliance, verified and listed by an accredited inspection body is acceptable (pending shop drawing approval), as an alternative to project specific seismic bracing design.

E. Wall mounted Mechanical Equipment:
   1. Provide support and bracing to resist seismic design force in any direction.
   2. Install backing plates or blocking as required to deliver load to primary wall framing members.
   3. Anchoring to gypsum wallboard, plaster or other wall finish that has not been engineered to resist imposed loads is not permitted.

F. Piping:
   1. Provide seismic bracing in accordance ASCE 7.
   2. Provide supports, braces, and anchors to resist gravity and seismic design forces.
   3. Provide flexible connections between floor mounted equipment and suspended piping; between unbraced piping and restrained suspended items; as required for thermal movement; at building separations and seismic joints; and wherever relative differential movements could damage pipe in an earthquake.
   4. Brace resiliently supported pipe with cable bracing or alternate means designed to prevent transmission of vibrations and noise to the structure.
   5. Brace every run 5.0 feet or more in length with two transverse and one longitudinal bracing locations.
   6. Pipes and Connections Constructed of Ductile Materials (copper, ductile iron, steel or aluminum and brazed, welded or screwed connections):

a. Provide transverse bracing at spacing not more than 40.0 feet on center.
b. Provide longitudinal bracing at spacing not more than 80.0 feet on center.

7. Pipes and Connections Constructed of Non Ductile Materials (cast iron, no-hub, plastic or non-UL listed grooved coupling pipe):
   a. Provide transverse bracing at spacing not more than 20.0 feet on center.
   b. Provide longitudinal bracing at spacing not more than 40.0 feet on center.
8. Provide lateral restraint for risers at not more than 30 feet on center or as required for horizontal runs, whichever is less.
9. Piping Explicitly Exempt from Seismic Bracing Requirements:
   a. Provide flexible connections between piping and connected equipment, including in-line devices such as VAV boxes and reheat coils.
   b. Install piping consistent with ASCE 7, such that swinging of the pipes will not cause damaging impact with adjacent components, finishes, or structural framing while maintaining clear horizontal distance of 67 percent of the hanger length between subject components.
   c. Provide swing restraints as required to control potential impact due to limited space between subject components.
10. Use of proprietary restraint systems with a certificate of compliance, verified and listed by an accredited inspection body is acceptable (pending shop drawing approval), as an alternative to project specific seismic bracing design.
11. Re-use of Existing Hangers:
    a. Re-using existing hangers at locations of seismic bracing are to be judged on a case-by-case basis by the registered project design professional.
    b. Unless otherwise shown on the drawings, it is assumed all hangers supporting new piping, located at a seismic brace, will be new.

G. Ductwork:
1. Provide seismic bracing for ducts with cross sectional area greater than 6 sq ft (independent of duct contents).
2. Provide seismic bracing for all ducts containing hazardous materials.
3. Provide supports, braces, and anchors to resist gravity and seismic design forces.
4. Install ducts and duct risers designed to accommodate interstory drift.
5. Independently support in-line devices weighing more than 20 pounds.
6. Independently support and brace all in-line devices weighing more than 75 pounds.
7. Provide unbraced piping attached to braced in-line equipment with adequate flexibility to accommodate differential displacements.
8. Positively attach dampers, louvers, diffusers and similar appurtenances to ductwork with mechanical fasteners.
9. Install duct supports designed to resist not less than 150 percent of the duct weight.
10. 1The use of power driven fasteners is prohibited in the hanging of ducts weighing over 10 pounds per lineal foot for seismic design categories D, E, and F.

11. 1Use of proprietary restraint systems with a certificate of compliance, verified and listed by an IAS AC172 accredited inspection body or otherwise accepted by applicable codes is acceptable (pending shop drawing approval), as an alternative to project specific seismic bracing design.

H. Tanks:
1. Install tank anchorage, tank legs and/or supporting structure designed to resist design force.
2. Provide flexible connections between tank and interconnected piping.

3.3 FIELD QUALITY CONTROL

A. See Division 01 - Quality Requirements, for additional requirements.

B. Inspect isolated equipment after installation and submit report. Include static deflections.

C. Perform testing and inspections of the installation in accordance with Division 01.

3.4 SCHEDULE

A. Pipe Isolation Schedule.
1. 1 Inch Pipe Size: Isolate 120 diameters from equipment.
2. 2 Inch Pipe Size: Isolate 90 diameters from equipment.
3. 3 Inch Pipe Size: Isolate 80 diameters from equipment.
4. 4 Inch Pipe Size: Isolate 75 diameters from equipment.
5. 6 Inch Pipe Size: Isolate 60 diameters from equipment.
6. 8 Inch Pipe Size: Isolate 60 diameters from equipment.
7. 10 Inch Pipe Size: Isolate 54 diameters from equipment.
8. 12 Inch Pipe Size: Isolate 50 diameters from equipment.
9. 16 Inch Pipe Size: Isolate 45 diameters from equipment.
10. 24 Inch Pipe Size: Isolate 38 diameters from equipment.
11. Over 24 Inch Pipe Size: As indicated.

B. Equipment Isolation Schedule.
1. Direct Fired Air Units.
   a. Base: Structural steel base.
   b. Base Thickness: _____ inches.
   c. Isolator Type: Open spring isolators.
   d. Isolator Deflection: _____ inches.
2. Fuel Fired Unit Heaters.
   a. Base: Structural steel base.
   b. Base Thickness: _____ inches.
   c. Isolator Type: Open spring isolators.
   d. Isolator Type: _____.
   e. Isolator Deflection: _____ inches.
3. Air Cooled Condensing Units.
   a. Base: Structural steel base.
   b. Base Thickness: _____ inches.
   c. Isolator Type: Open spring isolators.

d. Isolator Deflection: _____ inches.

4. Air Cooled Refrigerant Condensers.
   a. Base: Structural steel base.
   b. Base Thickness: _____ inches.
   c. Isolator Type: Open spring isolators.
   d. Isolator Deflection: _____ inches.
5. Packaged Roof Top Air Conditioning Units.
   a. Base: Structural steel base.
   b. Base Thickness: _____ inches.
   c. Isolator Type: Open spring isolators.
   d. Isolator Deflection: _____ inches.
6. Computer Room Air Conditioning Units.
   a. Base: Structural steel base.
   b. Base Thickness: _____ inches.
   c. Isolator Type: Open spring isolators.
   d. Isolator Deflection: _____ inches.

END OF SECTION 23 0548

SECTION 23 0553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Nameplates.

B. Tags.

C. Duct Markers.

D. Pipe markers.

E. Warning Signs and Labels

F. Warning Tags

G. Ceiling Tacks

1.2 RELATED REQUIREMENTS

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

B. Division 09- Finishes.

1.3 REFERENCE STANDARDS (follow the most currently adopted amended version)

A. ASME A13.1 - Scheme for the Identification of Piping Systems.

B. ASTM D709 - Standard Specification for Laminated Thermosetting Materials.

1.4 SUBMITTALS

A. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.

B. Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.

C. Product Data: Provide manufacturers catalog literature for each product required.

D. Manufacturer's Installation Instructions: Indicate special procedures, and installation.

E. Project Record Documents:

1. Valve Schedules: For each piping system. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or

space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

2. Equipment Schedules: For each item of equipment to be labeled. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

PART 2 PRODUCTS

2.1 EQUIPMENT NAMEPLATES

A. Manufacturers:
1. Advanced Graphic Engraving, LLC
2. Brimar Industries, Inc;
3. Kolbi Pipe Marker Co.
4. Seton Identification Products
5. Substitutions: See Division 01-General Requirements.

B. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-inch, Stainless steel, 0.025-inch, Aluminum, 0.032-inchor anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel rivets or self-tapping screws.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Plastic Labels for Equipment:

1. Material and Thickness: Conform to ASTM D709. Multilayer, multicolor, plastic labels for mechanical engraving, minimum 1/16 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: White.
3. Background Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch
6. Minimum Letter Size: 1/4 inchfor name of units if viewing distance is less than 24 inches, 1/2 inchfor viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

D. Label Content: Include equipment's Drawing designation or unique equipment number.

2.2 TAGS

A. Manufacturers:
1. Advanced Graphic Engraving
2. Brady Corporation
3. Brimar Industries, Inc
4. Kolbi Pipe Marker Co
5. Seton Identification Products, a Tricor Company
6. Substitutions: See Division 01-General Requirements.

B. Metal Tags: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware. Brass wire-link, beaded chain or S-hook fasteners. Minimum 1-1/2 inch diameter with smooth edges.

2.3 DUCT MARKERS

A. Manufacturers:
1. Brimar Industries, Inc
2. Kolbi Pipe Marker Co
3. Seton Identification Products

B. General Requirements for Manufactured Duct Labels: Preprinted self-adhesive, premium grade vinyl, color-coded, with lettering indicating service, and showing flow direction.

C. Material: High gloss acrylic adhesive-backed vinyl film 0.0032 inch printed with UV and chemical resistant inks.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

F. Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
2. Lettering Size: Prepared with letter sizes according to ASME A13.1, at least 1-1/2 incheshigh.

2.4 PIPE MARKERS

A. Manufacturers:

1. Brady Corporation
2. Brimar Industries, Inc
3. Kolbi Pipe Marker Co
4. MIFAB, Inc
5. Seton Identification Products
6. Substitutions: See Division 01-General Requirements.

B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

C. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.

D. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.

E. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.

F. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: Prepared with letter sizes according to ASME A13.1, at least 1-1/2 incheshigh.

2.5 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inchthick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Red.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inchfor name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.6 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: Approximately 4 by 7 inches.
2. Fasteners: Reinforced grommet and wire or string.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Red, white, black.

2.7 CEILING TACKS

A. Manufacturers:
1. Brimar
2. Craftmark
3. Seton Identification Products
4. Substitutions: See Division 01-General Requirements.

B. Description: Steel with 3/4 inch diameter color coded head.

C. Color code as follows:
1. HVAC Equipment: Yellow.
2. Fire Dampers and Smoke Dampers: Red.
3. Heating/Cooling Valves: Blue.

PART 3 EXECUTION

3.1 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment, including all scheduled equipment on the drawings, air terminal units, automatic control devices, control panels, instruments, relays and major control components.

B. Locate equipment labels where accessible and readable from the floor.

C. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

3.3 VALVE TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application:

1. Valve-Tag Size and Shape: 1-1/2 inches, round.

2. Valve-Tag Color: Natural

3. Letter Color: Black

3.4 PIPE LABEL INSTALLATION

A. Install plastic pipe markers in accordance with manufacturer's instructions.

B. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.

C. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

D. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.

E. Pipe Label Color Schedule:

1. Potable, Cooling, Heating and Other Water Piping:

a. Background Color: Green.
b. Letter Color: White.

2. Combustible Fluid Piping:

a. Background Color: Brown.
b. Letter Color: White.

3. Flammable & Oxidizing Fluid Piping:

a. Background Color: Yellow.
b. Letter Color: Black.

4. Toxic & Corrosive Piping:

a. Background Color: Orange.
b. Letter Color: Black.

F. Identify valves in main and branch piping with tags.

3.5 DUCT LABEL INSTALLATION

A. Install duct labels with permanent adhesive on air ducts in the following color codes:

1. Blue: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.
3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
4. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.6 CEILING TACK INSTALLATION

A. Locate ceiling tacks to locate valves or dampers above lay-in panel ceilings. Locate in corner of panel closest to equipment.

3.7 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 23 0553

SECTION 23 0593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Testing, adjustment, and balancing of air systems.

B. Testing, adjustment, and balancing of hydronic, steam, and refrigerating systems.

C. Measurement of final operating condition of HVAC systems.

D. Sound measurement of equipment operating conditions.

E. Vibration measurement of equipment operating conditions.

1.2 RELATED REQUIREMENTS

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

1.3 REFERENCE STANDARDS (follow the most currently adopted amended version)

A. AABC (NSTSB) - AABC National Standards for Total System Balance

B. ASHRAE Std 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems.

C. NEBB (TAB) - Procedural Standards for Testing Adjusting and Balancing of Environmental Systems;.

D. SMACNA (TAB) - HVAC Systems Testing, Adjusting and Balancing;.

1.4 SUBMITTALS

A. Installer Qualifications: Submit name of adjusting and balancing agency and TAB supervisor for approval within 30 days after award of Contract.

B. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
   1. Submit to Architect.
   2. Submit to the Commissioning Authority.
   3. Submit to Engineer of Record.
   4. Submit six weeks prior to starting the testing, adjusting, and balancing work.
   5. Include certification that the plan developer has reviewed the contract documents, the equipment and systems, and the control system with the Architect and other installers to sufficiently understand the design intent for each system.

6. Include at least the following in the plan:
   a. Preface: An explanation of the intended use of the control system.
   b. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
   c. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
   d. Identification and types of measurement instruments to be used and their most recent calibration date.
   e. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
   f. Final test report forms to be used.
   g. Detailed step-by-step procedures for TAB work for each system and issue, including:
      1) Terminal flow calibration (for each terminal type).
      2) Diffuser proportioning.
      3) Branch/submain proportioning.
      4) Total flow calculations.
      5) Rechecking.
      6) Diversity issues.
   h. Criteria for using air flow straighteners or relocating flow stations and sensors; analogous explanations for the water side.
   i. Details of how TOTAL flow will be determined; for example:
      1) Air: Sum of terminal flows via control system calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations.
      2) Water: Pump curves, circuit setter, flow station, ultrasonic, etc.
   j. Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and methods to verify this.
   k. Confirmation of understanding of the outside air ventilation criteria under all conditions.
   l. Method of verifying and setting minimum outside air flow rate will be verified and set and for what level (total building, zone, etc.).
   m. Method of checking building static and exhaust fan and/or relief damper capacity.
   n. Methods for making coil or other system plant capacity measurements, if specified.
   o. Time schedule for TAB work to be done in phases (by floor, etc.).
   p. Description of TAB work for areas to be built out later, if any.
   q. Time schedule for deferred or seasonal TAB work, if specified.
   r. False loading of systems to complete TAB work, if specified.
   s. Exhaust fan balancing and capacity verifications, including any required room pressure differentials.
   t. Interstitial cavity differential pressure measurements and calculations, if specified.
   u. differential pressure measurements and calculations between the building and its exterior.

v. Procedures for field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).
w. Procedures for formal progress reports, including scope and frequency.
x. Procedures for formal deficiency reports, including scope, frequency and distribution.

C. Control System Coordination Reports: Communicate in writing to the controls installer all setpoint and parameter changes made or problems and discrepancies identified during TAB that affect, or could affect, the control system setup and operation.

D. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
1. Submit under provisions of Division 01 – General Conditions.
2. Submit to the Commissioning Authority within two weeks after completion of testing, adjusting, and balancing.
3. Revise TAB plan to reflect actual procedures and submit as part of final report.
4. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Architect and Engineer of Record and for inclusion in operating and maintenance manuals.
5. Provide reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.
6. Include actual instrument list, with manufacturer name, serial number, and date of calibration.
7. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.
8. Units of Measure: Report data in both I-P (inch-pound) units.
9. Include the following on the title page of each report:
   a. Name of Testing, Adjusting, and Balancing Agency.
   b. Address of Testing, Adjusting, and Balancing Agency.
   c. Telephone number of Testing, Adjusting, and Balancing Agency.
   d. Project name.
   e. Project location.
   f. Project Architect.
   g. Project Engineer.
   h. Project Contractor.
   i. Project altitude.
   j. Report date.

E. Project Record Documents: Record actual locations of flow measuring stations and balancing valves and rough setting.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.1 GENERAL REQUIREMENTS

A. Perform total system balance in accordance with one of the following:
   1. AABC (NSTSB), AABC National Standards for Total System Balance.
   2. ASHRAE Std 111, Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems.
   3. NEBB Procedural Standards for Testing Adjusting Balancing of Environmental Systems.
   4. SMACNA (TAB)Maintain at least one copy of the standard to be used at project site at all times.

B. Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of the project.

C. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with the authorities having jurisdiction.

D. TAB Agency Qualifications:
   1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
   2. Having minimum of three years documented experience.
   3. Certified by one of the following:
      a. AABC, Associated Air Balance Council completion submit AABC National Performance Guaranty.
      b. NEBB, National Environmental Balancing Bureau
      c. TABB, The Testing, Adjusting, and Balancing Bureau of National Energy Management Institute

E. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.

3.2 EXAMINATION

A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
   1. Systems are started and operating in a safe and normal condition.
   2. Temperature control systems are installed complete and operable.
   3. Proper thermal overload protection is in place for electrical equipment.
   4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
   5. Duct systems are clean of debris.
   6. Fans are rotating correctly.
   7. Fire and volume dampers are in place and open.

8. Air coil fins are cleaned and combed.
9. Access doors are closed and duct end caps are in place.
10. Air outlets are installed and connected.
11. Duct system leakage is minimized.
12. Hydronic systems are flushed, filled, and vented.
13. Pumps and fans are rotating correctly.
14. Proper strainer baskets are clean and in place.
15. Service and balance valves are open.

3.3 PREPARATION

A. Hold a pre-balancing meeting at least one week prior to starting TAB work.
   1. Require attendance by all installers and control providers whose work will be tested, adjusted, or balanced.

3.4 ADJUSTMENT TOLERANCES

A. Air Handling Systems: Adjust to within plus or minus 10 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.

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

C. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

3.5 RECORDING AND ADJUSTING

A. Field Logs: Maintain written logs including:
   1. Running log of events and issues.
   2. Discrepancies, deficient or uncompleted work by others.
   3. Contract interpretation requests.
   4. Lists of completed tests.

B. Ensure recorded data represents actual measured or observed conditions.

C. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.

D. Mark on the drawings the locations where traverse and other critical measurements were taken and cross reference the location in the final report.

E. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

F. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

G. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

H. Check and adjust systems approximately two seasons after final acceptance and submit report.

3.6 AIR SYSTEM PROCEDURE

A. Work with Control vendor to establish minimum setpoints necessary to satisfy contract documents. Iterative testing to determine these minimum setpoints will be expected to be in the submittals.

B. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.

C. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.

D. Measure air quantities at air inlets and outlets.

E. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.

F. Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.

G. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.

H. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.

I. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

J. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.

K. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.

L. For variable air volume system powered units set volume controller to air flow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable air volume temperature control.

3.7 WATER SYSTEM PROCEDURE

A. Work with Control vendor to establish minimum setpoints necessary to satisfy contract documents. Iterative testing to determine these minimum setpoints will be expected in the submittals.

B. Adjust water systems to provide required or design quantities.

C. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gages to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.

D. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.

E. Effect system balance with automatic control valves fully open to heat transfer elements.

F. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.

G. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

3.8 COMMISSIONING

A. See Division 01- General Requirements for additional requirements.

3.9 SCOPE

A. Test, adjust, and balance the following:
1. Plumbing Pumps.
2. Boiler Feedwater Pumps.
3. HVAC Pumps.
4. Boilers
5. Air Cooled Refrigerant Condensers.
6. Packaged Roof Top Heating/Cooling Units.
7. Packaged Terminal Air Conditioning Units.
8. Variable Refrigerant Volume/Flow Systems (VRF or VRV)
9. Computer Room Air Conditioning Units.
10. Air Coils.
11. Terminal Heat Transfer Units.
12. Air Handling Units.
13. Dedicated Outdoor Air Units.
14. Fans.
15. Air Filters.

16. Air Terminal Units.
17. Air Inlets and Outlets.

3.10 MINIMUM DATA TO BE REPORTED

A. Electric Motors:
1. Manufacturer.
2. Model/Frame.
3. HP/BHP.
4. Phase, voltage, amperage; nameplate, actual, no load.
5. RPM.
6. Service factor.
7. Starter size, rating, heater elements.
8. Sheave Make/Size/Bore.
9. VFD Setpoints.
10. ECM Setpomts.

B. V-Belt Drives:
1. Identification/location.
2. Required driven RPM.
3. Driven sheave, diameter and RPM.
4. Belt, size and quantity.
5. Motor sheave diameter and RPM.
6. Center to center distance, maximum, minimum, and actual.

C. Pumps:
1. Identification/number.
2. Manufacturer.
3. Size/model.
4. Impeller.
5. Service.
6. Design flow rate, pressure drop, BHP.
7. Actual flow rate, pressure drop, BHP.
8. Discharge pressure.
9. Suction pressure.
10. Total operating head pressure.
11. Shut off, discharge and suction pressures.
12. Shut off, total head pressure.

D. Combustion Equipment:
1. Boiler manufacturer.
2. Model number.
3. Serial number.
4. Firing rate.
5. Overfire draft.
6. Gas meter timing dial size.
7. Gas meter time per revolution.
8. Gas pressure at meter outlet.

9. Gas flow rate.
10. Heat input.
11. Burner manifold gas pressure.
12. Percent carbon monoxide (CO).
13. Percent carbon dioxide (CO2).
14. Percent oxygen (O2).
15. Percent excess air.
16. Flue gas temperature at outlet.
17. Ambient temperature.
18. Net stack temperature.
19. Percent stack loss.
20. Percent combustion efficiency.
21. Heat output.

E. Air Cooled Condensers:
1. Identification/number.
2. Location.
3. Manufacturer.
4. Model number.
5. Serial number.
6. Entering DB air temperature, design and actual.
7. Leaving DB air temperature, design and actual.
8. Number of compressors.

F. Cooling Coils:
1. Identification/number.
2. Location.
3. Service.
4. Manufacturer.
5. Air flow, design and actual.
6. Entering air DB temperature, design and actual.
7. Entering air WB temperature, design and actual.
8. Leaving air DB temperature, design and actual.
9. Leaving air WB temperature, design and actual.
10. Water flow, design and actual.
11. Water pressure drop, design and actual.
12. Entering water temperature, design and actual.
13. Leaving water temperature, design and actual.
14. Saturated suction temperature, design and actual.
15. Air pressure drop, design and actual.

G. Heating Coils:
1. Identification/number.
2. Location.
3. Service.
4. Manufacturer.
5. Air flow, design and actual.
6. Water flow, design and actual.

7. Water pressure drop, design and actual.
8. Entering water temperature, design and actual.
9. Leaving water temperature, design and actual.
10. Entering air temperature, design and actual.
11. Leaving air temperature, design and actual.
12. Air pressure drop, design and actual.

H. Air Moving Equipment:
1. Location.
2. Manufacturer.
3. Model number.
4. Serial number.
5. Arrangement/Class/Discharge.
6. Air flow, specified and actual.
7. Return air flow, specified and actual.
8. Outside air flow, specified and actual.
9. Total static pressure (total external), specified and actual.
10. Inlet pressure.
11. Discharge pressure.
12. Sheave Make/Size/Bore.
13. Number of Belts/Make/Size.
14. Fan RPM.

I. Return Air/Outside Air:
1. Identification/location.
2. Design air flow.
3. Actual air flow.
4. Design return air flow.
5. Actual return air flow.
6. Design outside air flow.
7. Actual outside air flow.
8. Return air temperature.
9. Outside air temperature.
10. Required mixed air temperature.
11. Actual mixed air temperature.
12. Design outside/return air ratio.
13. Actual outside/return air ratio.

J. Exhaust Fans:
1. Location.
2. Manufacturer.
3. Model number.
4. Serial number.
5. Air flow, specified and actual.
6. Total static pressure (total external), specified and actual.
7. Inlet pressure.
8. Discharge pressure.
9. Sheave Make/Size/Bore.

10. Number of Belts/Make/Size.
11. Fan RPM.

K. Duct Traverses:
1. System zone/branch.
2. Duct size.
3. Area.
4. Design velocity.
5. Design air flow.
6. Test velocity.
7. Test air flow.
8. Duct static pressure.
9. Air temperature.
10. Air correction factor.

L. Duct Leak Tests:
1. Description of ductwork under test.
2. Duct design operating pressure.
3. Duct design test static pressure.
4. Duct capacity, air flow.
5. Maximum allowable leakage duct capacity times leak factor.
6. Test apparatus:
   a. Blower.
   b. Orifice, tube size.
   c. Orifice size.
   d. Calibrated.
7. Test static pressure.
8. Test orifice differential pressure.
9. Leakage.

M. Air Monitoring Stations:
1. Identification/location.
2. System.
3. Size.
4. Area.
5. Design velocity.
6. Design air flow.
7. Test velocity.
8. Test air flow.

N. Flow Measuring Stations:
1. Identification/number.
2. Location.
3. Size.
4. Manufacturer.
5. Model number.
6. Serial number.
7. Design Flow rate.

8. Design pressure drop.
9. Actual/final pressure drop.
10. Actual/final flow rate.
11. Station calibrated setting.

O. Terminal Unit Data:
1. Manufacturer.
2. Type, constant, variable, single, dual duct.
3. Identification/number.
4. Location.
5. Model number.
6. Size.
7. Minimum static pressure.
8. Minimum design air flow.
9. Maximum design air flow.
10. Maximum actual air flow.
11. Inlet static pressure.

P. Air Distribution Tests:
1. Air terminal number.
2. Room number/location.
3. Terminal type.
4. Terminal size.
5. Area factor.
6. Design velocity.
7. Design air flow.
8. Test (final) velocity.
9. Test (final) air flow.
10. Percent of design air flow.

END OF SECTION 23 0593

SECTION 23 0700 - HVAC INSULATION

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. HVAC piping insulation, jackets and accessories.
2. HVAC equipment insulation, jackets and accessories.
3. HVAC ductwork insulation, jackets, and accessories.

B. Related Sections:
1. Division 01- General Requirements
2. Division 07 – Firestopping
3. Division 09- Finishes
4. Section 23 0553- Identification of HVAC Piping and Equipment
5. Section 23 3100- HVAC ducts and casings
6. Section 23 2113 – Hydronic Piping

1.2 REFERENCES

A. ASTM International:
1. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
2. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement.
3. ASTM C449/C449M - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
4. ASTM C450 - Standard Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging.
5. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
6. ASTM C534 - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
7. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation.
8. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
9. ASTM C578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.
10. ASTM C585 - Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).
11. ASTM C591 - Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation.
12. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
13. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.

14. ASTM C921 - Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
15. ASTM C1071 - Standard Specification for Thermal and Acoustical Insulation (Glass Fiber, Duct Lining Material).
16. ASTM C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
17. ASTM C1290 - Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts.
18. ASTM D1785 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
19. ASTM D4637 - Standard Specification for EPDM Sheet Used in Single-Ply Roof Membrane.
20. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials.
21. ASTM E162 - Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source.

B. Sheet Metal and Air Conditioning Contractors':
   1. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.

C. Underwriters Laboratories Inc.:
   1. UL 1978 - Standard for Safety for Grease Ducts.

1.3 SUBMITTALS

A. See Division 01- General Requirements

B. Product Data: Submit product description, thermal characteristics and list of materials and thickness for each service, and location.

C. Manufacturer's Instructions: Indicate installation procedures necessary to ensure acceptable workmanship and that installation standards will be achieved.

D. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.4 QUALITY ASSURANCE

A. Test pipe insulation for maximum flame spread index of 25 and maximum smoke developed index of not exceeding 50 in accordance with ASTM E84.

B. Pipe insulation manufactured in accordance with ASTM C585 for inner and outer diameters.

C. Factory fabricated fitting covers manufactured in accordance with ASTM C450.

D. Duct insulation, Coverings, and Linings: Maximum 25/50 flame spread/smoke developed index, when tested in accordance with ASTM E84, using specimen procedures and mounting procedures of ASTM E 2231.

E. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section with not less than three years of documented experience.

F. Applicator Qualifications: Company specializing in performing the type of work specified in this section, with minimum three years of experience and approved by manufacturer.

1.5 PRE-INSTALLATION MEETINGS

A. Division 01 - Administrative Requirements:

B. Convene minimum one week prior to commencing work of this section.

1.6 DELIVERY, STORAGE, AND HANDLING

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

B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping. Store all insulation materials in a clean, dry environment.

1.7 FIELD CONDITIONS

A. Maintain ambient conditions required by manufacturers of each product.

B. Maintain temperature before, during, and after installation for minimum of 24 hours.

1.8 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.9 WARRANTY

A. Division 01 - Execution and Closeout Requirements.

1.10 SCHEDULING

A. Schedule insulation application after pressure and leak testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

PART 2 PRODUCTS

2.1 REGULATORY REQUIREMENTS

A. Surface Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive,

mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

2.2 MANUFACTURER

A. Manufacturers for Flexible Glass Fiber (FGF), Pre-Molded Glass Fiber (PGF) and Rigid Glass Fiber (RGF) Insulation Products:
   1. Knauf Insulation
   2. Johns Manville Corporation
   3. Owens-Corning.
   4. Substitutions: Division 01.

B. Manufacturers for Closed Cell Elastomeric (CCE) Insulation Products:
   1. Aeroflex. USA, Inc.
   2. Armacell, LLC (Interior- ArmaFlex, Exterior- ArmaTuff)
   3. K-Flex USA LLC
   4. Substitutions: Division 01.

C. Manufacturers for Polyisocyanurate Foam Insulation Products: (steam only)
   1. Dow Chemical Company.
   2. Owens-Corning
   3. Johns Manville Corporation
   4. Substitutions: Division 01.

D. Manufacturers for Fire Rated (FR) Insulation Products:
   1. 3M Fire Barrier Duct Wrap 615+.
   2. Morgan Theramal Ceramics Pyroscat DuctWrap XL.
   3. Unifrax FyreWrap Elite 1.5.
   4. Substitutions: Division 01.

E. Manufacturers for Jacketing (PVC):
   1. Johns Manville
   2. P.I.C. Plastics Inc.
   3. Proto Corporation
   4. Substitutions: Division 01.

F. Manufacturers for Jacketing (ALM):
   1. Childers Brand
   2. ITW Insulation Systems
   3. RPR Products
   4. Substitutions: Division 01.

G. Manufacturers for exterior pipe/ duct waterproof jacketing (WJ):
   1. Polyguard Products, Inc.; Alumaguard 60.
   2. Venture Tape Corporation; VentureClad Plus.

3. MFM Building Products Corp: Flex Clad 400
4. Substitutions: Division 01.

2.3 PIPE INSULATION

A. Pre-Molded Glass Fiber (PGF) Insulation:
1. ASTM C547 and ASTM C795, rigid molded, noncombustible.
2. 'K' ('Ksi') Value: ASTM C177, 0.24 at 75°F.
3. Maximum Service Temperature: 850°F.
4. Maximum Moisture Absorption: 0.2 percent by volume.
5. Vapor Barrier Jacket: White kraft paper with glass fiber yarn, bonded to aluminized film; self-sealing lap, moisture vapor transmission when tested in accordance with ASTM E96/E96M of 0.02 perm-inches (ASJ-SSL).

B. Closed Cell Elastomeric (CCE) Insulation:
1. Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 3; use molded tubular material wherever possible.
2. Minimum Service Temperature: Minus 40°F.
3. Maximum Service Temperature: 220°F.
4. Connection: Waterproof vapor barrier adhesive.

2.4 PIPE INSULATION JACKETS

A. Polyvinyl-chloride (PVC): Plastic Pipe Jacket.
1. Product Description: ASTM D1785, One piece molded type fitting covers and sheet material, off-white color.
2. Thickness: 10 mil.
3. Connections: Brush on welding adhesive.

B. Aluminum (ALM): Self-Adhesive Waterproofing Jacket. Minimum 12 mil thick, vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; UV resistant, zero permeability with textured aluminum-foil facing, impact and tear resistant.

2.5 PIPE INSULATION ACCESSORIES

A. Vapor Retarder Lap Adhesive: Compatible with insulation.

B. Covering Adhesive Mastic: Compatible with insulation.

C. Piping 1-1/2 inches diameter and smaller: Galvanized steel insulation protection shield. MSS SP-69, Type 40. Length: Based on pipe size and insulation thickness.

D. Piping 2 inches diameter and larger: hydrous calcium silicate. Inserts length: not less than 6 inches long, matching thickness and contour of adjoining insulation.

E. Closed Cell Elastomeric Insulation Pipe Hanger: Polyurethane insert with aluminum single piece construction with self-adhesive closure. Thickness to match pipe insulation.

F. Valve insulation Wraps: White, noncombustible, conforming to ASTM E 84. Match insulation thickness to pipe size. Valve covers shall be easily removable.

2.6 EQUIPMENT INSULATION

A. Closed Cell Elastomeric (CCE) Insulation:
1. Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 3, in sheet form.
2. Minimum Service Temperature: -40°F.
3. Maximum Service Temperature: 220°F.
4. Connection: Waterproof vapor barrier adhesive.

B. PVC Plastic Equipment Jacket:
1. Product Description: ASTM D1785, sheet material, off-white color.
2. Minimum Service Temperature: -40°F.
3. Maximum Service Temperature: 150°F.
4. Water Vapor Permeance: ASTM E96/E96M; 0.02 perms.
5. Thickness: 10 mil.
6. Connections: Pressure sensitive color matching vinyl tape.

C. Aluminum Equipment Jacket:
1. ASTM B209
2. Thickness: 0.020 inch thick sheet.
3. Finish: Smooth.
4. Joining: Longitudinal slip joints and 2 inch laps.
5. Fittings: 0.02 inch thick die shaped fitting covers with factory attached protective liner.
6. Metal Jacket Bands: 3/8 inch wide; 0.02 inch thick aluminum.

2.7 EQUIPMENT INSULATION ACCESSORIES

A. Vapor Retarder Lap Adhesive: Compatible with insulation.

B. Covering Adhesive Mastic: Compatible with insulation.

C. Tie Wire: 0.048 inch stainless steel with twisted ends on maximum 12 inch centers.

D. Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement: ASTM C449/C449M.

E. Adhesives: Compatible with insulation. Refer to manufacturers' installation manual.

2.8 DUCTWORK INSULATION

A. Flexible Glass Fiber (FGF) Insulation: ASTM C553 Type I, II, or III, ASTM C1290 Type III, in accordance to NFPA 90A and NFPA 90B for duct coverings, with ASTM C1136 foil scrim kraft (FSK).
1. Thermal performance: 1.0 lb/ft^3, 7.4 ft^2 hr °F/btu minimum R-value for 2" thick at 75°F mean temperature per ASTM C177 and ASTM C518.
2. Operating temperature range: 40°F to 250°F.

3. Water vapor permeance: 0.02 perms maximum per ASTM E96.
4. Water vapor sorption: 5% by weight maximum per ASTM C1104.
5. Corrosiveness: Does not accelerate per ASTM C665.
6. Fungi growth: No fungi growth per ASTM C1338.

B. Rigid Glass Fiber (RGF) Insulation: Glass fiber board, ASTM C 612 Type 1A or 1B, in accordance to NFPA 90A and NFPA 90B for duct coverings, with ASTM C 1136 foil scrim kraft (FSK).
1. Thermal performance: 8.7 ft^2 hr °F/btu minimum R-value for 2" thick at 75°F mean temperature per ASTM C177 and ASTM C518.
2. Operating temperature range: 0°F to 450°F.
3. Water vapor permeance: 0.02 perms maximum per ASTM E96.
4. Water vapor sorption: 5% by weight maximum per ASTM C1104.
5. Corrosiveness: Does not accelerate per ASTM C665.
6. Fungi growth: No fungi growth per ASTM C1338.

C. Closed Cell Elastomertic (CCE) Insulation:
1. Thermal performance: 8.0 ft^2 hr °F/btu minimum R-value for 2" thick at 75°F mean temperature per ASTM C177 and ASTM C518.
2. Operating temperature range: -40°F to 220°F.
3. Water absorption: 0.2% by volume per ASTM C 209 or ASTM C1763.
4. Water vapor permeability: 0.08 perm-in per ASTM E 96.
5. Ultraviolet (UV) resistance: Excellent per ASTM G 53 or ASTM G 90.
6. Weatherability: Excellent per ASTM D 471.

D. Fire Rated (FR) Insulation:
1. Inorganic blanket encapsulated with scrim reinforced foil meeting UL 1978
2. Thermal Conductivity: 0.42 at 500°F.
3. Weight: 1.4 pound per square foot.
4. Surface Burning Characteristics: Maximum 0/0 flame spread/smoke developed index when tested in accordance with ASTM E84.

E. Technical Data:
1. Insulation shall pass when tested in accordance with the following:
   a. Non-combustibility per ASTM E136.
   b. Fire resistance (wall) per ASTM E119.
   c. Durability test per ASTM C518.
   d. Internal fire test per ASTM E2336.
   e. Fire engulfment (duct) per ASTM E814.
   f. ULC grease duct test protocol.
   g. Grease duct clearances per UL1978.
   h. Air duct ventilation enclosure per ISO6944.
2. Thermal performance: 6.3 ft^2 hr °F/btu minimum R-value for 1-1/2" thick at 75°F mean temperature per ASTM C177 and ASTM C518.

2.9 DUCTWORK JACKETS

A. Aluminum (ALM): Self-Adhesive Waterproofing Jacket: Minimum 12 mil thick, vapor barrier and waterproofing membrane for installation over insulation located aboveground

outdoors; UV resistant, zero permeability with textured aluminum-foil facing, impact and tear resistant.

2.10 DUCTWORK INSULATION ACCESSORIES

A. Vapor Retarder Tape:
1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

B. Vapor Retarder Lap Adhesive: Compatible with insulation.

C. Adhesive: Waterproof, ASTM E162 fire-retardant type.

D. Liner Fasteners: Galvanized steel, self-adhesive pad with head.

E. Tie Wire: 0.048 inch stainless steel with twisted ends on maximum 12 inch centers.

F. Lagging Adhesive: Fire retardant type with maximum 25/450 flame spread/smoke developed index when tested in accordance with ASTM E84.

G. Impale Anchors: Galvanized steel, 12 gage self-adhesive pad.

H. Adhesives: Compatible with insulation.

I. Membrane Adhesives: As recommended by membrane manufacturer.

PART 3 EXECUTION

3.1 EXAMINATION

A. Protect insulation from exposure to moisture prior to and after installation. All insulation other than flexible elastomeric that becomes wet shall be replaced at no cost to the project.

B. Verify piping, equipment and ductwork has been tested before applying insulation materials.

C. Verify piping, equipment and ductwork surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION - PIPING SYSTEMS

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with NAIMA National Insulation Standards.

C. Piping Exposed to View in Finished Spaces Provide with PVC Plastic pipe jacketing for additional protection. Locate insulation and cover seams in least visible locations.

D. Piping Exposed to view in mechanical spaces. Provide with PVC Plastic pipe jacketing for additional protection. Locate insulation and cover seams in least visible locations.

E. Continue insulation through penetrations of building assemblies or portions of assemblies having fire resistance rating of one hour or less. Provide intumescent firestopping when continuing insulation through assembly. Finish at supports, protrusions, and interruptions. Refer to Section 07 for penetrations of assemblies with fire resistance rating greater than one hour.

F. Piping Systems Conveying Fluids Below Ambient Temperature:
1. Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.
2. Furnish factory-applied or field-applied vapor retarder jackets. Secure factory-applied jackets with pressure sensitive adhesive self-sealing longitudinal laps and butt strips. Secure field-applied jackets with outward clinch expanding staples and seal staple penetrations with vapor retarder mastic.
3. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with glass cloth and vapor retarder adhesive or PVC fitting covers.

G. For all hot piping conveying fluids, insulate flanges and unions at equipment.

H. Glass fiber insulated pipes conveying fluids above ambient temperature.
1. Provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples.
2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.

I. Inserts and Shields:
1. Application: Piping 1-1/2 inches diameter or larger.
2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
3. Insert location: Between support shield and piping and under the finish jacket.
4. Insert Configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
5. Insert Material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.

J. Insulation Terminating Points:
1. Coil Branch Piping 1 inch and Smaller: Terminate hot water piping at union upstream of the coil control valve.
2. Chilled Water Coil Branch Piping: Insulate chilled water piping and associated components up to coil connection.
3. Condensate Piping: Insulate entire piping system and components to prevent condensation.

K. Closed Cell Elastomeric Insulation:
1. Push insulation on to piping.
2. Miter joints at elbows.

3. Seal seams and butt joints with manufacturer's recommended adhesive.
4. When application requires multiple layers, apply with joints staggered.
5. Insulate fittings and valves with insulation of like material and thickness as adjacent pipe.

L. Exterior Applications: Provide vapor barrier jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

M. 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.

N. Install valve bags on all chilled water valves unless otherwise indicated. Valve bags shall be easily removable for servicing of valves.

O. Prepare pipe insulation for finish painting. Refer to Division 09.

3.3 INSTALLATION - EQUIPMENT

A. Factory Insulated Equipment: Do not insulate.

B. Exposed Equipment: Locate insulation and cover seams in least visible locations.

C. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor retarder cement.

D. Equipment Containing Fluids Below Ambient Temperature:
1. Insulate entire equipment surfaces.
2. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
3. Furnish factory-applied or field-applied vapor retarder jackets. Secure factory-applied jackets with pressure sensitive adhesive self-sealing longitudinal laps and butt strips. Secure field-applied jackets with outward clinch expanding staples and seal staple penetrations with vapor retarder mastic.
4. Finish insulation at supports, protrusions, and interruptions.

E. Equipment Containing all Fluids Above Ambient Temperature:
1. Insulate flanges and unions with removable sections and jackets.
2. Install insulation with factory-applied or field applied jackets, with or without vapor barrier. Finish with glass cloth and adhesive.
3. Finish insulation at supports, protrusions, and interruptions.

F. Nameplates and ASME Stamps: Bevel and seal insulation around; do not cover with insulation.

G. Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation for easy removal and replacement without damage.

3.4 INSTALLATION - DUCTWORK SYSTEMS

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with NAIMA National Insulation Standards.

C. Protect insulation from exposure to moisture prior to and after installation. All insulation other than flexible elastomeric that becomes wet shall be replaced at no cost to the project.

D. Duct dimensions indicated on Drawings are finished inside dimensions.

E. Insulated ductwork conveying air below ambient temperature:
1. Provide insulation with vapor retarder jackets.
2. Finish with tape and vapor retarder jacket.
3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.

F. Insulated ductwork conveying air above ambient temperature:
1. Provide with or without standard vapor retarder jacket.
2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.

G. External Elastomeric Duct Insulation:
1. Adhere to clean oil-free surfaces with full coverage of adhesive.
2. Seal seams and butt joints with manufacturer’s recommended adhesive.
3. When application requires multiple layers, apply with joints staggered.
4. Insulate standing metal duct seams with insulation of like material and thickness as adjacent duct surface. Apply adhesive at joints with flat duct surfaces.
5. Lift ductwork off trapeze hangers and insert spacers.

H. Ducts Exterior to Building:
1. Install insulation according to external duct insulation paragraph above.
2. Provide external insulation with vapor retarder jacket. Cover with outdoor jacket finished with caulked aluminum jacket with seams located on bottom side of horizontal duct section.
3. Finish with aluminum duct jacket.
4. Calk seams at flanges and joints. Located major longitudinal seams on bottom side of horizontal duct sections.

I. Duct Acoustical Liner
1. Ductwork shall still be insulated per this specification even if the ductwork is acoustically lined. Acoustically lined ductwork does not negate the use of wrap as insulation.

J. Prepare duct insulation for finish painting. Refer to Division 09.

3.5 SCHEDULES

3.6 DUCTWORK SCHEDULES

A. Items Not Insulated:
1. Fibrous-glass ducts.
2. Factory-insulated flexible ducts.
3. Factory-insulated plenums and casings.
4. Vibration-control devices.
5. Factory-insulated access panels and doors.
6. Stair pressurization supply ductwork.

B. Provide insulation materials and thicknesses identified below. If more than one material is listed for a duct location, selection from materials listed is Division 23 option.

Heating and Cooling Supply and Heat/Energy Recovery System Exhaust Ducts Climate Zone 4A				
Description	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Jacketing
Exterior to building envelope	R-8.0	Closed Cell Elastomeric (CCE)	2.0	ALM
Concealed within thermal envelope of building	R-6.0	Flexible Glass Fiber (FGF)	2.0	FSK
Exposed in mechanical rooms	R-6.0	Rigid Glass Fiber (RGF)	2.0	FSK

Unconditioned Outside Air Intake Ducts and Exhaust/Relief Duct Inside Building Envelope Climate Zones 4A				
Description	Minimum As-Installed R-Value	Insulation Type	Minimum Thickness (inches)	Jacketing
For outside air intakes, all ductwork between the building envelope and the first system heating coil, cooling coil or air handling unit connection.	R-12.0	Flexible Glass Fiber (FGF)	3.0	FSK
		Rigid Glass Fiber (RGF)	3.0	FSK
For exhaust/relief ducts, all ductwork between the building envelope and first system isolation damper.	R-12.0	Flexible Glass Fiber (FGF)	3.0	FSK
		Rigid Glass Fiber (RGF)	3.0	FSK

3.7 DUCT LINER

A. See Section 23 3100 - HVAC Ducts and Casings, for duct liner specifications

3.8 PIPE INSULATION SCHEDULE

A. Provide insulation materials and thicknesses scheduled for each system type and pressure/temperature range. If more than one material is listed for a system, selection from materials listed is Division 23 option.

B. For dual temperature systems (heating and cooling), provide thickness equal to greater of heating or cooling scheduled value. Dual temperature piping shall also meet all vapor barrier requirements for cooling insulation (perm rating).

C. Insulation for pre-insulated piping shall meet all specified requirements.

D. Insulate piping operating at temperatures below 40°F and systems operating between 40°F to 65°F in accordance with NAIMA Guide to Insulating Chilled Water Piping Systems with Mineral Fiber Pipe Insulation. Comply with all recommendations including but not limited to the requirement for vapor dams every fourth section of insulation.

Heating Hot Water Systems						
Insulation Type		Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor - Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
E. F.	Pre-Molded Glass Fiber (PGF)	Less than 1 to 1.5	1.5	3.0	ASJ-SSL	Indoor: PVC for exposed piping finished space and mechanical rooms. Outdoor: ALM
		1.5 and Larger	2.0	4.0		

All Outdoor Heat Traced Piping					
Insulation Type		Pipe Size (inch)	Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
G.	Pre-Molded Glass Fiber (PGF)	Less than 1	1.25*	ASJ-SSL	Outdoor: ALM
		1 to Less than 1.5	1.5*		
		1.5 to 2	2.0*		
		2.5 to 3	3.0*		
		4	4.0*		

1. *Insulation thickness to be determined by heat trace manufacturer installation instructions

Cooling Coil Condensate Piping, Outdoor Cooling Tower Makeup Water Piping and Equipment Drain Piping: All					
Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor - Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
H. Closed Cell Elastomeric (CCE)	All Sizes	0.75	2.0	N/A	Indoor (CCE): N/A Outdoor (CCE): ALM

Refrigerant Piping					
Insulation Type	Pipe Size (inch)	Indoor - Minimum Thickness (inch)	Outdoor - Minimum Thickness (inch)	Factory Applied Jacket	Field Applied Jacket
Closed Cell Elastomeric (CCE)	Less than 3	1.0	1.0	N/A	Indoor: N/A Outdoor: ALM

3.9 EQUIPMENT INSULATION SCHEDULE

A. Provide insulation materials and thicknesses scheduled for each system type and pressure/temperature range. If more than one material is listed for a system, selection from materials listed is Division 23 option.

END OF SECTION 23 0700

SECTION 23 0923 - DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 GENERAL

1.1 SUMMARY

A. Section includes control equipment and software.

B. Related Sections:
1. Section 23 04 00 – General Conditions for Mechanical Trades
2. Section 23 09 00 - Instrumentation and Control for HVAC: Control system components.
3. Section 23 09 93 - Sequence of Operations for HVAC Controls: Sequences of operation implemented using products specified in this section.
4. Division 26 - Equipment Wiring Connections: Execution requirements for electric connections specified by this section.

1.2 REFERENCES

A. American National Standards Institute:
1. ANSI MC85.1 - Terminology for Automatic Control.

1.3 SYSTEM DESCRIPTION

A. Automatic temperature controls field monitoring and control system using field programmable microprocessor based units.

B. Base system on distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment on token passing network, with central and remote hardware, software, and interconnecting wire and conduit.

C. Provide computer software and hardware, operator input/output devices, control units, local area networks (LAN), sensors, control devices, actuators.

D. Provide controls for variable refrigerant volume terminals, radiation, unit heaters, split system air conditioning units, and Dedicated Outdoor Air Systems when directly connected to control units.

E. Provide control systems consisting of thermostats, control valves, dampers and operators, indicating devices, interface equipment and other apparatus and accessories to operate mechanical systems, and to perform functions specified.

F. Provide installation and calibration, supervision, adjustments, and fine tuning necessary for complete and fully operational system.

1.4 SUBMITTALS

A. Division 01 - Submittal Procedures: Submittal procedures.

B. Shop Drawings: Indicate the following:
   1. Trunk cable schematic showing programmable control-unit locations and trunk data conductors.
   2. Connected data points, including connected control unit and input device.
   3. System graphics showing monitored systems, data (connected and calculated) point addresses, and operator notations.
   4. System configuration with peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
   5. Description and sequence of operation for operating, user, and application software.
   6. Use terminology in submittals conforming to ASME MC85.1.
   7. Coordinate submittals with information requested in Section 23 09 93.

C. Product Data: Submit data for each system component and software module.

D. Manufacturer's Installation Instructions: Submit installation instruction for each control system component.

E. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.5 CLOSEOUT SUBMITTALS

A. Division 01 - Execution and Closeout Requirements: Requirements for submittals.

B. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors.
   1. Revise shop drawings to reflect actual installation and operating sequences.
   2. Submit data specified in "Submittals" in final "Record Documents" form.

C. Operation and Maintenance Data:
   1. Submit interconnection wiring diagrams complete field installed systems with identified and numbered, system components and devices.
   2. Submit keyboard illustrations and step-by-step procedures indexed for each operator function.
   3. Submit inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years experience, and with service facilities within 100 miles of Project.

B. Installer: Company specializing in performing Work of this section with minimum three years experience approved by manufacturer.

1.7 PRE-INSTALLATION MEETINGS

A. Division 01 - Administrative Requirements: Pre-installation meeting.

B. Convene minimum one week prior to commencing work of this section.

1.8 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.9 WARRANTY

A. Division 01 - Execution and Closeout Requirements: Product warranties and product bonds.

B. Furnish five year manufacturer warranty for direct digital controls.

1.10 MAINTENANCE SERVICE

A. Division 01 - Execution and Closeout Requirements: Requirements for maintenance service.

B. Furnish service and maintenance of control systems for one years from Date of Substantial Completion.

C. Furnish complete service of controls systems, including callbacks. Make minimum of 2 complete normal inspections of approximately 4 hours duration in addition to normal service calls to inspect, calibrate, and adjust controls. Submit written report after each inspection.

D. Furnish two complete inspections per year, one in each season, to inspect, calibrate, and adjust controls. Submit written report after each inspection.

E. Examine unit components monthly. Clean, adjust, and lubricate equipment.

F. Include systematic examination, adjustment, and lubrication of unit, and controls checkout and adjustments. Repair or replace parts in accordance with manufacturer's operating and maintenance data. Use parts produced by manufacturer of original equipment.

G. Perform work without removing units from service during building normal occupied hours.

H. Provide emergency call back service at all hours for this maintenance period.

I. Maintain locally, near Place of the Work, adequate stock of parts for replacement or emergency purposes. Have personnel available to ensure fulfillment of this maintenance service, without unreasonable loss of time.

J. Perform maintenance work using competent and qualified personnel under supervision and in direct employ of manufacturer or original installer.

K. Do not assign or transfer maintenance service to agent or subcontractor without prior written consent of Owner.

PART 2 PRODUCTS

2.1 DIRECT DIGITAL CONTROLS

A. Manufacturers:
1. Alerton
2. Schneider Electric as provided by SNE
3. Siemens Apogee
4. Automated Logic
5. Substitutions: Division 01 - Product Requirements.

2.2 OPERATOR WORKSTATION

A. Manufacturers:
1. Dell Corporation
2. Acer
3. HP
4. Substitutions: Division 01 - Product Requirements.

B. Furnish each operator workstation consisting of the following:

C. Personal Computer: PC compatible with sufficient memory and hard drive storage to support graphics, reports, and communication requirements. Furnish with the following minimum configuration requirements:
1. Processor: Intel i5 4.0 GHz.
2. Hard Drive: 1 TB
3. Memory: 8 Gigabyte DDR4 SDRAM.
4. Drive 1: DVD-RW
5. Wireless: 802.11 bgn + Blueooth 4.0
6. Ports: Required serial, parallel, network communications, USB, and cables for proper system operation.
7. Expansion Slots: 1 used for LAN card, 1 available.
8. LAN Card: EtherNet - RJ45 (100 base-T minimum).
9. Mouse: two-button optical type wireless.
10. Keyboard: 104 key.

D. Monitor: Minimum of 24 inch color, flat panel display.

E. Operating System: Minimum Windows 10

F. Printer: Furnish each operator workstation with color ink jet printer and associated cables. Printer capable of minimum of 14 pages per minute (PPM) operation and compatible with standard parallel or USB communications or network capable.

2.3 PORTABLE OPERATOR'S TERMINAL

A. Manufacturers:
   1. Dell Corporation
   2. Acer
   3. HP
   4. Substitutions: Division 01 - Product Requirements.

B. Furnish device capable of accessing system data and capable of being connected to any point on system network or connected directly to any controller for programming, set-up, and troubleshooting. Portable Operators Terminal uses Read (Initiate) and Write (Execute) Services as defined in Clauses 15.5 and 15.8, respectively, of ASHRAE Standard 135, to communicate with BACnet objects in internetwork. Objects supported include: Analog input, analog output, analog value, binary input, binary output, binary value, device.

C. Furnish notebook-style PC including software and hardware required with:

   1. Processor: Intel i5 4.0 GHz.
   2. Hard Drive: 1 TB
   3. Memory: 8 Gigabyte DDR4 SDRAM.
   4. Drive 1: DVD-RW
   5. Wireless: 802.11 bgn + Blueooth 4.0
   6. Ports: Required serial, parallel, network communications, USB, and cables for proper system operation.
   7. Expansion Slots: 1 used for LAN card, 1 available.
   8. LAN Card: EtherNet - RJ45 (100 base-T minimum).
   9. Mouse: two-button optical type wireless.
   10. Keyboard: 104 key.

2.4 CONTROL UNITS

A. Units: Modular in design and consisting of processor board with programmable RAM memory, local operator access and display panel, and integral interface equipment.

B. Provide controllers required to operate perimeter heating at first stage and/or second stage heating.

C. Battery Backup: For minimum of 48hours for complete system including RAM without interruption, with automatic battery charger.

D. Control Units Functions:
   1. Monitor or control each input/output point.
   2. Completely independent with hardware clock/calendar and software to maintain control independently.
   3. Acquire, process, and transfer information to operator station or other control units on network.

4. Accept, process, and execute commands from other control unit's or devices or operator stations.
5. Access both data base and control functions simultaneously.
6. Record, evaluate, and report changes of state or value occurring among associated points. Continue to perform associated control functions regardless of status of network.
7. Perform in stand-alone mode:
    a. Start/stop.
    b. Duty cycling.
    c. Automatic Temperature Control.
    d. Demand control via a sliding window, predictive algorithm.
    e. Event initiated control.
    f. Calculated point.
    g. Scanning and alarm processing.
    h. Full direct digital control.
    i. Trend logging.
    j. Global communications.
    k. Maintenance scheduling.

E. Global Communications:
1. Broadcast point data onto network, making information available to other system controls units.
2. Transmit input/output points onto network for use by other control units and use data from other control units.

F. Input/output Capability:
1. Discrete/digital input (contact status).
2. Discrete/digital output.
3. Analog input.
4. Analog output.
5. Pulse input (5 pulses/second).
6. Pulse output (0-655 seconds in duration with 0.01-second resolution).

G. Monitor, control, or address data points. Include analog inputs, analog outputs, pulse inputs, pulse outputs and discrete inputs/outputs. Furnish control units with minimum 30percent spare capacity.

H. Point Scanning: Set scan or execution speed of each point to operator selected time from 1 to 250 seconds.

I. Upload/Download Capability: Download from or upload to operator station. Upload/Download time for entire control unit database maximum 10 seconds on hard-wired LAN

J. Test Mode Operation: Place input/output points in test mode to allow testing and developing of control algorithms on line without disrupting field hardware and controlled environment. In test mode:

1. Inhibit scanning and calculation of input points. Issue manual control to input points (set analog or digital input point to operator determined test value) from workstation.
2. Control output points but change only database state or value; leave external field hardware unchanged.
3. Enable control-actions on output points but change only data base state or value.

K. Local display and adjustment panel: Integral to control-unit containing digital display, and numerical keyboard. Display and adjust:
1. Input/output point information and status.
2. Controller set points.
3. Controller tuning constants.
4. Program execution times.
5. High and low limit values.
6. Limit differential.
7. Set/display date and time.
8. Control outputs connected to the network.
9. Automatic control outputs.
10. Perform control unit diagnostic testing.

L. Points in "Test" mode.

2.5 LOCAL AREA NETWORKS (LAN):

A. Furnish communication between control units over local area network (LAN).

B. LAN Capacity: Not less than 60stations or nodes.

C. Break in Communication Path: Alarm and automatically initiate LAN reconfiguration.

D. LAN Data Speed: Minimum 25Mbps.

E. Communication Techniques: Allow interface into network by multiple operation stations and by auto-answer/auto-dial modems. Support communication over telephone lines utilizing modems.

F. Transmission Median: Fiber optic or single pair of solid 24 gauge twisted, shielded copper cable.

G. Network Support: Time for global point to be received by any station, less than 3 seconds. Furnish automatic reconfiguration when station is added or lost. In event transmission cable is cut, reconfigure two sections with no disruption to system's operation, without operator intervention.

2.6 OPERATING SYSTEM SOFTWARE

A. Input/output Capability From Operator Station:
1. Request display of current values or status in tabular or graphic format.
2. Command selected equipment to specified state.

3. Initiate logs and reports.
4. Change analog limits.
5. Add, delete, or change points within each control unit or application routine.
6. Change point input/output descriptors, status, alarm descriptors, and unit descriptors.
7. Add new control units to system.
8. Modify and set up maintenance scheduling parameters.
9. Develop, modify, delete or display full range of color graphic displays.
10. Automatically archive select data even when running third party software.
11. Capability to sort and extract data from archived files and to generate custom reports.
12. Support two printer operations.
13. Alarm printer: Print alarms, operator acknowledgments, action messages, system alarms, operator sign-on and sign-off.
14. Data printer: Print reports, page prints, and data base prints.
15. Select daily, weekly or monthly as scheduled frequency to synchronize time and date in digital control units. Accommodate daylight savings time adjustments.
16. Print selected control unit database.

B. Operator System Access: Via software password with minimum 30access levels at work station and minimum 3access levels at each control unit.

C. Data Base Creation and Support: Use standard procedures for changes. Control unit automatically checks workstation data base files upon connection and verify data base match. Include the following minimum capabilities:
1. Add and delete points.
2. Modify point parameters.
3. Change, add, or delete English language descriptors.
4. Add, modify, or delete alarm limits.
5. Add, modify, or delete points in start/stop programs, trend logs, and other items.
6. Create custom relationship between points.
7. Create or modify DDC loops and parameters.
8. Create or modify override parameters.
9. Add, modify, and delete applications programs.
10. Add, delete, develop, or modify dynamic color graphic displays.

D. Dynamic Color Graphic Displays:
1. Utilizes custom symbols or system supported library of symbols.
2. Sixteen (16) colors.
3. Sixty (60) outputs of real-time live dynamic data for each graphic.
4. Dynamic graphic data.
5. 1,000 separate graphic pages.
6. Modify graphic screen refresh rate between 1 and 60 seconds.

E. Operator Station:
1. Accept data from LAN as needed without scanning entire network for updated point data.
2. Interrogate LAN for updated point data when requested.

3. Allow operator command of devices.
4. Allow operator to place specific control units in or out of service.
5. Allow parameter editing of control units.
6. Store duplicate data base for every control unit and allow down loading while system is on line.
7. Control or modify specific programs.
8. Develop, store and modify dynamic color graphics.
9. Data archiving of assigned points and support overlay graphing of this data using up to four (4) variables.

F. Alarm Processing:
1. Off normal condition: Cause alarm and appropriate message, including time, system, point descriptor, and alarm condition. Select alarm state or value and alarms causing automatic dial-out.
2. Critical alarm or change-of-state: Display message, stored on disk for review and sort, or print.
3. Print on line changeable message, up to 60characters in length, for each alarm point specified.
4. Display alarm reports on video. Display multiple alarms in order of occurrence.
5. Define time delay for equipment start-up or shutdown.
6. Allow unique routing of specific alarms.
7. Operator specifies when alarm requires acknowledgment.
8. Continue to indicate unacknowledged alarms after return to normal.
9. Alarm notification:
10. Print automatically.
11. Display indicating alarm condition.
12. Selectable audible alarm indication.

G. Event Processing: Automatically initiate commands, user defined messages, take specific control actions or change control strategy and application programs resulting from event condition. Event condition may be value crossing operator defined limit, change of state, specified state, or alarm occurrence or return to normal.

H. Automatic Restart: Automatically start field equipment on restoration of power. Furnish time delay between individual equipment restart and time of day start/stop.

I. Messages:
1. Automatically display or print user-defined message subsequent to occurrence of selected events.
2. Compose, change, or delete message.
3. Display or log message at any time.
4. Assign any message to event.

J. Reports:
1. Manually requested with time and date.
2. Long term data archiving to hard disk.
3. Automatic directives to download to transportable media including floppy diskettes for storage.

4. Data selection methods to include data base search and manipulation.
5. Data extraction with mathematical manipulation.
6. Data reports to allow development of XY curve plotting, tabular reports (both statistical and summary), and multi-point timed based plots with not less than four (4) variables displayed.
7. Generating reports either normally at operator direction, or automatically under workstation direction.
8. Either manually display or print reports. Automatically print reports on daily, weekly, monthly, yearly or scheduled basis.
9. Include capability for statistical data manipulation and extraction.
10. Capability to generate four types of reports: Statistical detail reports, summary reports, trend graphic plots, x-y graphic plots.

K. Parameter Save/Restore: Store most current operating system, parameter changes, and modifications on disk or diskette.

L. Data Collection:
1. Automatically collect and store in hard drive.
2. Daily electrical energy consumption, peak demand, and time of peak demand for up to electrical meters over 2-year period.
3. Daily consumption for up to 30 meters over a 2 year period.
4. Daily billable electrical energy consumption and time for up to 1024 zones over a 10 year period.
5. Archiving of stored data for use with system supplied custom reports.

M. Graphic Display: Support graphic development on work station with software features:
1. Page linking.
2. Generate, store, and retrieve library symbols.
3. Single or double height characters.
4. Sixty (60) dynamic points of data for each graphic page.
5. Pixel level resolution.
6. Animated graphics for discrete points.
7. Analog bar graphs.
8. Display real time value of each input or output line diagram fashion.

N. Maintenance Management:
1. Run time monitoring, for each point.
2. Maintenance scheduling targets with automatic annunciation, scheduling and shutdown.
3. Equipment safety targets.
4. Display of maintenance material and estimated labor.
5. Target point reset, for each point.

O. Advisories:
1. Summary containing status of points in locked out condition.
2. Continuous operational or not operational report of interrogation of system hardware and programmable control units for failure.
3. Report of power failure detection, time and date.

4. Report of communication failure with operator device, field interface unit, point and programmable control unit.

2.7 LOAD CONTROL PROGRAMS

A. General: Support inch-pounds and S.I. metric units of measurement.

B. Demand Limiting:
1. Monitor total power consumption for each power meter and shed associated loads automatically to reduce power consumption to an operator set maximum demand level.
2. Input: Pulse count from incoming power meter connected to pulse accumulator in control unit.
3. Forecast demand (kW): Predicted by sliding window method.
4. Automatically shed loads throughout the demand interval selecting loads with independently adjustable on and off time of between one and 255 minutes.
5. Demand Target: Minimum of 3 for each demand meter; change targets based upon (1) time, (2) status of pre-selected points, or (3) temperature.
6. Load: Assign load shed priority, minimum "ON" time and maximum "OFF" time.
7. Limits: Include control band (upper and lower limits).
8. Output advisory when loads are not available to satisfy required shed quantity, advise shed requirements [and requiring operator acknowledgment].

C. Duty Cycling:
1. Periodically stop and start loads, based on space temperature, and according to various On/Off patterns.
2. Modify off portion of cycle based on operator specified comfort parameters. Maintain total cycle time by increasing on portion of cycle by equal quantity off portion is reduced.
3. Set and modify following parameters for each individual load.
   a. Minimum and maximum off time.
   b. On/Off time in one-minute increments.
   c. Time period from beginning of interval until cycling of load.
   d. Manually override the DDC program and place a load in an On or Off state.
   e. Cooling Target Temperature and Differential.
   f. Heating Target Temperature and Differential.
   g. Cycle off adjustment.

D. Automatic Time Scheduling:
1. Self-contained programs for automatic start/stop/scheduling of building loads.
2. Support up to seven (7) normal day schedules, seven (7) "special day" schedules and two (2) temporary day schedules.
3. Special day’s schedule supporting up to 30 unique date/duration combinations.
4. Number of loads assigned to time program; with each load having individual time program.

5. Each load assigned at least 16 control actions for each day with 1 minute resolution.
6. Furnish the following time schedule operations:
   a. Start.
   b. Optimized Start.
   c. Stop.
   d. Optimized Stop.
   e. Cycle.
   f. Optimized Cycle.
7. Capable of specifying minimum of 30 holiday periods up to 100 days in length for the year.
8. Create temporary schedules.
9. Broadcast temporary "special day" date and duration.

E. Start/Stop Time Optimization:
1. Perform optimized start/stop as function of outside conditions, inside conditions, or both.
2. Adaptive and self-tuning, adjusting to changing conditions unattended.
3. For each point under control, establish and modify:
   a. Occupancy period.
   b. Desired temperature at beginning of occupancy period.
   c. Desired temperature at end of occupancy period.

F. Night Setback/Setup Program: Reduce heating space temperature set point or raise cooling space temperature set-point during unoccupied hours; in conjunction with scheduled start/stop and optimum start/stop programs.

G. Calculated Points: Define calculations and totals computed from monitored points (analog/digital points), constants, or other calculated points.
1. Employ arithmetic, algebraic, Boolean, and special function operations.
2. Treat calculated values like any other analog value; use for any function where a "hard wired point" might be used.

H. Event Initiated Programming: Any data point capable of initiating event, causing series of controls in a sequence.
1. Define time interval between each control action between 0 to 3600 seconds.
2. Output may be analog value.
3. Provide for "skip" logic.
4. Verify completion of one action before proceeding to next action. When not verified, program capable of skipping to next action.

I. Direct Digital Control: Furnish with each control unit Direct Digital Control software so operator is capable of customizing control strategies and sequences of operation by defining appropriate control loop algorithms and choosing optimum loop parameters.
1. Control loops: Defined using "modules" are analogous to standard control devices.
2. Output: Paired or individual digital outputs for pulse width modulation, and analog outputs.

3. Firmware:
   a. PID with analog or pulse-width modulation output.
   b. Floating control with pulse-width modulated outputs.
   c. Two-position control.
   d. Primary and secondary reset schedule selector.
   e. Hi/Low signal selector.
   f. Single pole double-throw relay.
   g. Single pole double throw time delay relay with delay before break, delay before make and interval time capabilities.
4. Direct Digital Control loop: Downloaded upon creation or on operator request. On sensor failure, program executes user defined failsafe output.
5. Display: Value or state of each of lines interconnecting DDC modules.

J. Fine Tuning Direct Digital Control PID or floating loops:
1. Display information:
   a. Control loop being tuned.
   b. Input (process) variable.
   c. Output (control) variable.
   d. Set-point of loop.
   e. Proportional band.
   f. Integral (reset) Interval.
   g. Derivative (rate) Interval.
2. Display format: Graphic, with automatic scaling; with input and output variable superimposed on graph of "time" versus "variable".

K. Trend logging:
1. Each control unit capable of storing samples of control unit's data points.
2. Update file continuously at operator assigned intervals.
3. Automatically initiate upload requests and then stores data on hard disk.
4. Time synchronize sampling at operator specified times and intervals with sample resolution of one minute.
5. Co-ordinate sampling with specified on/off point- state.
6. Display trend samples on workstation in graphic format. Automatically scale trend graph with minimum 60 samples of data in plot of time versus data.

2.8 HVAC CONTROL PROGRAMS

A. General:
1. Support Inch-pounds and S.I. metric units of measurement.
2. Identify each HVAC Control system.

B. Optimal Run Time:
1. Control start-up and shutdown times of HVAC equipment for both heating and cooling.
2. Base on occupancy schedules, outside air temperature, seasonal requirements, and interior room mass temperature.

3. Start-up systems by using outside air temperature, room mass temperatures, and adaptive model prediction for how long building takes to warm up or cool down under different conditions.
4. Use outside air temperature to determine early shut down with ventilation override.
5. Analyze multiple building mass sensors to determine seasonal mode and worse case condition for each day.
6. Operator commands:
    a. Define term schedule.
    b. Add/delete fan status point.
    c. Add/delete outside air temperature point.
    d. Add/delete mass temperature point.
    e. Define heating/cooling parameters.
    f. Define mass sensor heating/cooling parameters.
    g. Lock/unlock program.
    h. Request optimal run-time control summary.
    i. Request optimal run-time mass temperature summary.
    j. Request HVAC point summary.
    k. Request HVAC saving profile summary.
7. Control Summary:
    a. HVAC Control system begin/end status.
    b. Optimal run time lock/unlock control status.
    c. Heating/cooling mode status.
    d. Optimal run time schedule.
    e. Start/Stop times.
    f. Selected mass temperature point ID.
    g. Optimal run-time system normal start-times.
    h. Occupancy and vacancy times.
    i. Optimal run time system heating/cooling mode parameters.
8. Mass temperature summary:
    a. Mass temperature point type and ID.
    b. Desired and current mass temperature values.
    c. Calculated warm-up/cool-down time for each mass temperature.
    d. Heating/cooling season limits.
    e. Break point temperature for cooling mode analysis.
9. HVAC point summary:
    a. Control system identifier and status.
    b. Point ID and status.
    c. Outside air temperature point ID and status.
    d. Mass temperature point ID and status.
    e. Calculated optimal start and stop times.
    f. Period start.

C. Supply Air Reset:
    1. Monitor heating and cooling loads in building spaces, terminal reheat systems, both hot deck and cold deck temperatures on dual duct and multizone systems, single zone unit discharge temperatures.

2. Adjust discharge temperatures to most energy efficient levels satisfying measured load by:
   a. Raising cooling temperatures to highest possible value.
   b. Reducing heating temperatures to lowest possible level.
3. Operator commands:
   a. Add/delete fan status point.
   b. Lock/unlock program.
   c. Request HVAC point summary.
   d. Add/Delete discharge controller point.
   e. Define discharge controller parameters.
   f. Add/delete air flow rate.
   g. Define space load and load parameters.
   h. Request space load summary.
4. Control summary:
   a. HVAC control system status (begin/end).
   b. Supply air reset system status.
   c. Optimal run time system status.
   d. Heating and cooling loop.
   e. High/low limits.
   f. Deadband.
   g. Response timer.
   h. Reset times.
5. Space load summary:
   a. HVAC system status.
   b. Optimal run time status.
   c. Heating/cooling loop status.
   d. Space load point ID.
   e. Current space load point value.
   f. Control heat/cool limited.
   g. Gain factor.
   h. Calculated reset values.
   i. Fan status point ID and status.
   j. Control discharge temperature point ID and status.
   k. Space load point ID and status.
   l. Airflow rate point ID and status.

D. Enthalpy Switchover:
1. Calculate outside and return air enthalpy using measured temperature and relative humidity; determine energy expended and control outside and return air dampers.
2. Operator commands:
   a. Add/delete fan status point.
   b. Add/delete outside air temperature point.
   c. Add/delete discharge controller point.
   d. Define discharge controller parameters.
   e. Add/delete return air temperature point.
   f. Add/delete outside air dewpoint/humidity point.
   g. Add/delete return air dewpoint/humidity point.
   h. Add/delete damper switch.

i. Add/delete minimum outside air.
j. Add/delete atmospheric pressure.
k. Add/delete heating override switch.
l. Add/delete evaporative cooling switch.
m. Add/delete air flow rate.
n. Define enthalpy deadband.
o. Lock/unlock program.
p. Request control summary.
q. Request HVAC point summary.

3. Control summary:
   a. HVAC control system begin/end status.
   b. Enthalpy switchover optimal system status.
   c. Optimal return time system status.
   d. Current outside air enthalpy.
   e. Calculated mixed air enthalpy.
   f. Calculated cooling cool enthalpy using outside air.
   g. Calculated cooling cool enthalpy using mixed air.
   h. Calculated enthalpy difference.
   i. Enthalpy switchover deadband.
   j. Status of damper mode switch.

2.9 PROGRAMMING APPLICATION FEATURES

A. Trend Point:
   1. Sample up to 100 points, real or computed, with each point capable of collecting 100 samples at intervals specified in minutes, hours, days, or month.
   2. Output trend logs as line-graphs or bar graphs. Output graphic on terminal, with each point for line and bar graphs designated with a unique pattern and color, vertical scale either actual values or percent of range, and horizontal scale time base. Print trend logs up to 12 columns of one point/column.

B. Alarm Messages:
   1. Allow definition of minimum of 100 messages, each having minimum length of 50 characters for each individual message.
   2. Assign alarm messages to system messages including point's alarm condition, point's off-normal condition, totaled point's warning limit, hardware elements advisories.
   3. Output assigned alarm with "message requiring acknowledgment".
   4. Operator commands include define, modify, or delete; output summary listing current alarms and assignments; output summary defining assigned points.

C. Weekly Scheduling:
   1. Automatically initiate equipment or system commands, based on selected time schedule for points specified.
   2. Program times for each day of week, for each point, with one minute resolution.
   3. Automatically generate alarm output for points not responding to command.
   4. Allow for holidays, minimum of 366 consecutive holidays.
   5. Operator commands:

a. System logs and summaries.
b. Start of stop point.
c. Lock or unlock control or alarm input.
d. Add, delete, or modify analog limits and differentials.
e. Adjust point operation position.
f. Change point operational mode.
g. Open or close point.
h. Enable/disable, lock/unlock, or execute interlock sequence or computation profile.
i. Begin or end point totals.
j. Modify total values and limits.
k. Access or secure point.
l. Begin or end HVAC or load control system.
m. Modify load parameter.
n. Modify demand limiting and duty cycle targets.

6. Output summary: Listing of programmed function points, associated program times, and respective day of week programmed points by software groups or time of day.

D. Interlocking:
1. Permit events to occur, based on changing condition of one or more associated master points.
2. Binary contact, high/low limit of analog point or computed point capable of being used as master. Master capable of monitoring or commanding multiple slaves.
3. Operator commands:
a. Define single master/multiple master interlock process.
b. Define logic interlock process.
c. Lock/unlock program.
d. Enable/disable interlock process.
e. Execute terminate interlock process.
f. Request interlock type summary.

PART 3 EXECUTION

3.1 EXAMINATION

A. Divsion 01 - Administrative Requirements: Coordination and project conditions.

B. Verify conditioned power supply is available to control units and to operator workstation.

C. Verify field end devices, wiring, and pneumatic tubing is installed prior to installation proceeding.

3.2 INSTALLATION

A. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.

B. Install software in control units and in operator workstation. Implement features of programs to specified requirements and appropriate to sequence of operation. Refer to Section 23 09 93.

C. Install with 120 volts alternating current, 15 amp dedicated emergency power circuit to each programmable control unit.

D. Install conduit and electrical wiring in accordance with Section 26 05 03.

E. Install electrical material and installation in accordance with appropriate requirements of Division 26.

3.3 MANUFACTURER'S FIELD SERVICES

A. Division 01 - Quality Requirements: Manufacturers' field services.

B. Start and commission systems. Allow adequate time for start-up and commissioning prior to placing control systems in permanent operation.

C. Furnish service technician employed by system installer to instruct Owner's representative in operation of systems plant and equipment for 3day period.

3.4 DEMONSTRATION AND TRAINING

A. Division 01 - Execution and Closeout Requirements: Requirements for demonstration and training.

B. Furnish basic operator training for up to 12 persons on data display, alarm and status descriptors, requesting data, execution commands and log requests. Include a minimum of 40 hours instructor time. Furnish training on site.

C. Demonstrate complete and operating system to Owner.

END OF SECTION 23 0923

SECTION 23 0993 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes sequence of operation for:
   1. Cabinet Heaters.
   2. Unit heaters.
   3. Radiant ceiling panels.
   4. Radiation.
   5. Variable Refrigerant Flow Units.
   6. Dedicated Outdoor Air Units.
   7. Split System Air Conditioning Units.

B. Related Sections:
   1. Section 23 04 00 – General Conditions for Mechanical Trades
   2. Section 23 09 00 - Instrumentation and Control for HVAC: For equipment, devices, and system components to implement sequences of operation.
   3. Section 23 09 23 - Direct-Digital Control System for HVAC: For equipment, devices, system components, and software to implement sequences of operation.
   4. Section 23 09 53 - Pneumatic and Electric Control System for HVAC: For equipment, devices, and system components to implement sequences of operation.
   5. Section 25 50 00 - Integrated Automation Facility Controls: For equipment, devices, system components, and software to implement sequences of operation.

1.2 SUBMITTALS

A. Division 01 - Submittal Procedures: Submittal procedures.

B. Shop Drawings: Indicate mechanical system controlled and control system components.
   1. Label with settings, adjustable range of control and limits. Submit written description of control sequence.
   2. Submit flow diagrams for each control system, graphically depicting control logic.
   3. Submit draft copies of graphic displays indicating mechanical system components, control system components, and controlled function status and value.
   4. Coordinate submittals with information requested in Section 23 09 23.

1.3 CLOSEOUT SUBMITTALS

A. Division 01 - Execution and Closeout Requirements: Closeout procedures.

B. Project Record Documents: Record actual locations of components and set points of controls, including changes to sequences made after submission of shop drawings.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.1 CABINET UNIT HEATERS

A. General: Each CUH shall have fan status provided at the DDC display. Each CUH shall have stainless steel sheath thermistor double tie wrapped to return piping adjacent to CUH control valve, temperature reading from thermistor shall be displayed at the central personal computer (PC) for monitoring/troubleshooting purposes, thermistor reading shall not be used for control.

B. Warm-up (morning): On call for heating, the control valves shall be open and the fan shall be on.

C. Occupied: On call for heating, the control valves shall be open and the fan shall be on.

D. Cool-down (evening): The control valve shall be closed and the fan shall be off.

E. Unoccupied: On call for heating, the control valves shall be open and the fan shall be on.

3.2 UNIT HEATERS

A. General: Each UH shall have fan status provided at the DDC display. Each UH shall have stainless steel sheath thermistor double tie wrapped to return piping adjacent to UH control valve, temperature reading from thermistor shall be displayed at the central personal computer (PC) for monitoring/troubleshooting purposes, thermistor reading shall not be used for control.

B. Warm-up (morning): On call for heating, the control valve shall be open and the fan shall be on.

C. Occupied: On call for heating, the control valve shall be open and the fan shall be on.

D. Cool-down (evening): The control valve shall be closed and the fan shall be off.

3.3 Unoccupied: On call for heating, the control valve shall be open and the fan shall be on

3.4 DOA SEQUENCE OF OPERATIONS (DOA-1 & DOA-2)

A. Enabling: DOA will be controlled by the building automation system (BAS) unless otherwise noted. DOA factory furnished controller will control compressor and condenser functions for cooling mode and dehumidification mode. BAS unit controller to operate in occupied mode or unoccupied mode if any of the following devises are not activated.

1. Internal safety devices.
2. Smoke Detector.
3. Low temperature limit.
4. High static pressure.

B. Unoccupied and Occupied Mode:
   1. Based on a timed schedule, BAS shall index unit to either unoccupied or occupied mode.

C. Unoccupied Mode
   1. Unoccupied damper actuator control. BAS controller shall command the following control sequence:
      a. Outside air damper shall be fully closed.
      b. Exhaust air damper shall be fully closed.
      c. Return air damper fully opened.
      d. Exhaust air ERV wheel damper shall be fully closed.
      e. Outside air ERV wheel damper shall be fully closed.

D. Unoccupied Fan Control. BAS controller shall command the following control sequence:
      a. Supply fan VFD shall be off.
      b. Exhaust fan VFD shall be off.

E. Morning Warm-Up Control
   1. Morning warm-up damper actuator control. BAS controller shall command the following control sequence:
      a. Outside air damper shall be fully closed.
      b. Exhaust air damper shall be fully closed.
      c. Mixed air damper fully opened.
      d. Exhaust air ERV wheel damper shall be fully closed.
      e. Outside air ERV wheel damper shall be fully closed.
   2. Morning Warm-Up Fan Control. BAS controller shall command the following control sequence:
      a. Supply fan VFD shall modulate the supply fan as required to maintain ductwork static pressure only after all supply and exhaust dampers are 50% open.
      b. Exhaust fan VFD shall be off.
   3. Morning Warm-Up Heating Mode Control. BAS shall modulate hot water control valve as required to maintain discharge air temperature set point.

F. Occupied Mode:
   1. Occupied Damper Actuator Control. BAS controller shall command the following control sequence:
      a. Outside air damper shall be fully open.
      b. Exhaust air damper shall be fully open.
      c. Outside air ERV wheel bypass damper shall be fully closed unless economizer cooling is enabled.
      d. Exhaust air ERV wheel bypass damper shall be fully closed unless economizer cooling is enabled.

2. Air Flow measuring station (AFMS) serving OA intake and EA discharge. BAS controller shall monitor OA and EA airflow. OA and EA airflow shall be displayed on the operator work station.
3. Energy Wheel Control. BAS controller shall command the following control sequence:
   a. Energy wheel shall be enabled to start unless economizer cooling is enabled.
4. DOA Fan Control. BAS controller shall command the following control sequence:
   a. Supply fan VFD shall modulate the supply fan as required to maintain ductwork static pressure.
   b. Exhaust fan VFD shall modulate as required to maintain EA AFMS airflow. EA AFMS airflow shall track OA AFMS airflow.
5. Discharge air temperature control: BAS controller shall command the following control sequence:
   a. When discharge air temperature set point decreases below setpoint, BAS controller shall modulate hot water control valve as required to maintain discharge air temperature setpoint.
   b. When discharge air temperature increases above setpoint, and OA temperature and enthalpy is less than return air temperature and enthalpy, BAS controller shall enable economizer mode. BAS controller shall command the following economizer control sequence:
      1) Mechanical cooling and dehumidification mode locked-out
      2) Exhaust air ERV wheel damper shall be fully opened.
      3) Outside air ERV wheel damper shall be fully opened.
   c. BAS controller shall index RTU factory controller to mechanical cooling mode when space temperature increases above setpoint and economizer cooling is not enabled. Mechanical cooling control sequence listed below.
      1) BAS controller shall operate as required to maintain temperature after the DX coil.
6. Occupied Dehumidification Mode Control. BAS shall be index to dehumidification mode when the mixed air dewpoint temperature increases above setpoint and cooling or heating mode is not activated. Dehumidification control sequence listed below:
   a. DOA factory controller shall modulate DX coil as required to maintain DX coil discharge air temperature.
   b. DOA factory controller shall modulate hot gas coil as required to maintain hot gas coil discharge air temperature.

3.5 VRF AND HOT WATER HEAT SEQUENCE OF OPERATIONS

A. The BAS shall enable, disable, set operating modes and send setpoints to the VRF Controls System via BACnet Communication interface. For the VRF system, enable indicates the unit is on and disable indicates the unit is off. Setpoint temperature will define the occupied and unoccupied condition.

B. The Automatic Temperature Controls (ATC) contractor shall also be responsible for installation and communication wiring of all VRF control components to provide a complete and operational system including but not limited to return air thermistor, indoor units (air handlers and heat recovery boxes), and outdoor units. The VRF manufacturer will furnish (1) wall controller per indoor unit and associated cabling.

C. BAS shall index the VRF zone into off mode (unoccupied), fan mode, heat mode and cool mode. For heating or cooling mode, BAS shall send setpoint temperature to VRF control system

D. Morning Warm-up Control for VRF and perimeter heating control:
   1. BAS shall enable morning warm-up during optimal time scheduling when OA temperature is below 64 °F. BAS shall index the following heating stages:
      a. When space temperature decreases below 1st stage heating setpoint, BAS shall command the following control sequence.
         1) BAS shall command VRF to heating mode with morning space temperature setpoint.
         2) BAS shall command perimeter two-position hot water control valve to be fully closed.
      b. When space temperature decreases below 2nd stage heating setpoint, BAS shall command the following control sequence.
         1) VRF to remain in heating mode.
         2) BAS shall command perimeter two-position hot water control valve to be fully open.

E. Unoccupied heating control for VRF and perimeter heating control:
   1. BAS shall enable unoccupied heating mode when OA temperature is below 64 °F during unoccupied time schedule. BAS shall index the following heating stages:
      a. When space temperature decreases below 1st stage heating setpoint, BAS shall command the following control sequence.
         1) BAS shall command perimeter two-position hot water control valve to be fully open.
         2) BAS shall command VRF to off command.
      b. When space temperature decreases below 2nd stage heating setpoint, BAS shall command the following control sequence.
         1) Perimeter two-position hot water control valve shall remain fully open.
         2) BAS shall command VRF to heating mode with morning space temperature setpoint.

F. Occupied heating control for VRF and perimeter heating control:
   1. BAS shall enable occupied heating mode when OA temperature is below 64 °F during occupied time schedule. BAS shall index the following heating stages:
      a. When space temperature decreases below 1st stage heating setpoint, BAS shall command the following control sequence.
         1) BAS shall command VRF to heating mode with occupied heating space temperature setpoint.

2) BAS shall command perimeter two-position hot water control valve to be fully closed.

b. When space temperature decreases below 2nd stage heating setpoint, BAS shall command the following control sequence.
1) VRF to remain in heating mode.
2) BAS shall command perimeter two-position hot water control valve to be fully open.

G. Occupied / Unoccupied Cooling Mode Control:
1. When space temperature increases above cooling setpoint, BAS shall command VRF to cooling mode with either an occupied or unoccupied space temperature setpoint.

3.6 SPLIT SYSTEM AIR CONDITIONING UNITS

A. The Split System Air Conditioning units will be provided with integral controllers and wireless zone sensors by the unit manufacturer.

B. The Automatic Temperature Controls (ATC) contractor shall also be responsible for installation and communication wiring of all split system components to provide a complete and operational system including but not limited to communication wiring between the indoor and outdoor unit.

C. BAS shall monitor space temperature. If space temperature does not match setpoint for a predetermined time period, an alarm shall be generated at the Operator Workstation.

3.7 RADIANT CEILING PANEL HEAT (RCP) SEQUENCE OF OPERATIONS

A. BAS shall command the RCP into unoccupied heating mode or morning warm-up mode or heating mode.

B. Unoccupied Heating Mode Control:
1. BAS shall enable unoccupied heating mode when outside air temperature is less than or equal to 64°F and command the control sequence.
2. When space temperature decreases below unoccupied setpoint, the following sequence shall be performed:
a. Two-position hot water control valve shall fully open

C. Morning Warm-up Heating Mode Control:
1. BAS shall enable morning warm-up heating mode when outside air temperature is less than or equal to 64°F and command the control sequence.
2. Based on time schedule, the following sequence shall be performed when space temperature decreases below morning warm-up setpoint.
a. Two-position hot water control valve shall fully open

D. Occupied Heating Mode Control:

1. BAS shall enable occupied heating mode when outside air temperature is less than or equal to 64°F and command the control sequence.
2. When space temperature decreases below occupied setpoint, the following sequence shall be performed:
   a. Two-position hot water control valve shall fully open

3.8 ALARMS:

A. DOA Alarm.
1. BAS controller shall monitor DOA factory furnished internal safety alarms. Alarm shall be issued to BAS Operator Work Station if any internal safety alarms are activated.
2. BAS controller shall monitor high static pressure switch status. ATC to provide supply and exhaust fan hard-wired shut down. BAS shall command the following on a high static pressure alarm:
   a. Alarm shall be issued to BAS Operator Work Station
3. BAS controller shall monitor freeze stat status. ATC to provide supply and exhaust fan hard-wired shut down. BAS shall command the following on a freeze stat alarm:
   a. Alarm shall be issued to BAS Operator Work Station
   b. Fully open return air damper
   c. Fully close OA damper and EA damper
   d. Fully close bypass dampers
   e. Fully close HW control valve
4. BAS controller shall monitor Smoke detector alarm status. Alarm shall be issued to the BAS Operator Work Station if duct mounted smoke detector is activated. Associated unit and fans shall not operate.
5. BAS controller shall monitor fan status. If fan status does not match the command, DX compressors shall not operate and alarm shall be generated at the Operator Workstation.
6. DOA Factory furnished controller shall monitor (3) filter status per DOA. If filter status does not match setpoint, an alarm shall be generated at the Operator Workstation.
7. During unoccupied mode, BAS controller shall monitor case temperature status via the mixed air temperature sensor. When case temperature decreases below setpoint, BAS shall command the following:
   a. Fully open hot water
   b. An alarm shall be generated at the Operator Workstation.
8. BAS controller shall monitor duct exhaust air discharge temperature status after the plate heat exchanger. If duct discharge temperature does not match setpoint for a predetermined time period, BAS shall enable dehumidification mode and command the following:
   a. Fully open exhaust air plate heat exchanger bypass dampers such that 100% of the airflow is diverted to the plate heat exchanger.

b. Fully close OA plate heat exchanger bypass dampers such that 100% of the airflow is diverted to the bypass.
c. An alarm shall be generated at the Operator Workstation.

9. BAS controller shall monitor duct supply air discharge temperature status after the DX coil. If duct discharge temperature does not match setpoint for a predetermined time period, an alarm shall be generated at the Operator Workstation.
10. BAS controller shall monitor duct supply air discharge dewpoint status after the DX coil. If duct discharge dewpoint does not match setpoint for a predetermined time period, an alarm shall be generated at the Operator Workstation.
11. BAS controller shall monitor duct supply air discharge temperature status hot gas reheat coil. If duct discharge temperature does not match setpoint for a predetermined time period, an alarm shall be generated at the Operator Workstation.
12. DOA Factory furnished controller shall monitor filter status. If filter status does not match setpoint, an alarm shall be generated at the Operator Workstation.

B. Fan Alarm.
1. BAS controller shall monitor damper position. If damper position does not match the command, an alarm shall be generated at the BAS Operator Workstation and the associated fan shall be commanded to stop.
2. BAS controller shall monitor fan status. If fan status does not match the command, alarm shall be generated at the Operator Workstation.

C. VRF Alarm.
1. BAS shall monitor VRF control system internal safety alarms via BACnet interface. Alarm shall be issued to BAS Operator Work Station if any internal safety alarms are activated.
2. VRF control system shall monitor space temperature. Alarm shall be issued to BAS Operator Work Station if any space temperature does not match setpoint.
3. BAS shall monitor condensate auxiliary drain pan water detection. If sensor is activated, alarm shall be generated at the BAS Operator work station
4. BAS shall monitor space temperature status. If space temperature does not match setpoint for a predetermined time period, an alarm shall be generated at the Operator Workstation.
5. BAS shall monitor space dewpoint status where temperature and humidity sensor are noted on plan. If space dewpoint does not match setpoint for a predetermined time period, an alarm shall be generated at the Operator Workstation.

D. CUH/UH Alarm.
1. BAS controller shall monitor fan status. If fan status does not match the command, alarm shall be generated at the Operator Workstation.
2. BAS shall monitor space temperature status. If space temperature does not match setpoint for a predetermined time period, an alarm shall be generated at the Operator Workstation.

3. BAS shall monitor HWR pipe temperature via thermistor. If temperature does not match setpoint for a predetermined time period, an alarm shall be generated at the Operator Workstation.

E. RCP Alarm.
   1. BAS shall monitor space temperature status. If space temperature does not match setpoint for a predetermined time period, an alarm shall be generated at the Operator Workstation.
   2. BAS shall monitor HWR pipe temperature via thermistor. If temperature does not match setpoint for a predetermined time period, an alarm shall be generated at the Operator Workstation.

END OF SECTION 23 0993

SECTION 23 2113 - HYDRONIC PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Heating water piping, above ground.

B. Glycol piping, above ground.

C. Coil condensate drain piping

D. Radiant heating piping.

E. Equipment drains and over flows.

F. Unions and flanges.

1.2 RELATED SECTIONS

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

1.3 REFERENCES

A. American Society of Mechanical Engineers:
1. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
2. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
3. ASME B31.9 - Building Services Piping.
4. ASME Section IX - Boiler and Pressure Vessel Code - Welding and Brazing Qualifications.

B. ASTM International:
1. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
2. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
3. ASTM B32 - Standard Specification for Solder Metal.
4. ASTM B75 – Standard Specification for Seamless Copper Tube.
5. ASTM B88 - Standard Specification for Seamless Copper Water Tube.
6. ASTM B584 - Standard Specification for Copper Alloy Sand Castings for General Applications.
7. ASTM D1785 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
8. ASTM D2235 - Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings.
9. ASTM D2241 - Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.

10. ASTM D2464 - Standard Specification for Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
11. ASTM D2466 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
12. ASTM D2467 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
13. ASTM D2564 - Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.
14. ASTM D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings.
15. ASTM F437 - Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
16. ASTM F438 - Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.
17. ASTM F439 - Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
18. ASTM F441/F441M - Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
19. ASTM F493 - Standard Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
20. ASTM F876 - Standard Specification for Crosslinked Polyethylene (PEX) Tubing.
21. ASTM F877 - Standard Specification for Crosslinked Polyethylene (PEX) Plastic Hot-and Cold-Water Distribution Systems.
22. ASTM F1476 - Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications.

C. American Welding Society:
   1. AWS A5.8 - Specification for Filler Metals for Brazing and Braze Welding.
   2. AWS D1.1 - Structural Welding Code - Steel.

1.4 SYSTEM DESCRIPTION

A. Where more than one piping system material is specified, provide compatible system components and joints. Use non-conducting dielectric connections whenever jointing dissimilar metals in open systems.

B. Provide flanges, union, and couplings at locations requiring servicing. Use unions, flanges, and Grooved coupling couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.

1.5 SUBMITTALS

A. Shop Drawings: Indicate layout of piping system, including equipment, critical dimensions, and sizes.
   1. Grooved joint couplings and fittings shall be shown on drawings and product submittals, and be specifically identified with the applicable Grooved coupling style or series number.

B. Product Data:
   1. Piping: Submit data on pipe materials, fittings, and accessories. Submit manufacturers catalog information.

C. Test Reports: Indicate results of piping system pressure test.

D. Welders' Certificates.

1.6 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of valves equipment and accessories.

1.7 QUALITY ASSURANCE

A. Perform Work in accordance with ASME B31.9 code for installation of piping systems and ASME Section IX for welding materials and procedures.

B. Perform Work in accordance with applicable authority for welding hanger and support attachments to building structure.

C. To assure uniformity and compatibility of piping components in grooved piping systems, all grooved products utilized shall be supplied by a single manufacturer. Grooving tools shall be supplied by the same manufacturer as the grooved components.

1.8 QUALIFICATIONS

A. Fabricator or Installer: Company specializing in performing Work of this section with minimum three years documented experience.

B. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

B. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the Work, and isolating parts of completed system.

PART 2 PRODUCTS

2.1 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A53/A53M., black steel with plain ends; welded and seamless, Grade B.
   1. Fittings: ASME B16.3, malleable iron or ASTM A234/A234M, forged steel welding type.

2. Joints: Threaded for pipe 2 inch and smaller; welded for pipe 2-1/2 inches and larger.
3. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

B. Steel Pipe, grooved joints: ASTM A53/A53M, black steel with grooved ends.
1. Fittings: ASTM A536 ductile iron, or ASTM A53 forged steel or fabricated from carbon steel pipe, grooved ends designed to accept Grooved coupling standard or AGS "W" series couplings.
2. Joints: Grooved mechanical couplings meeting ASTM F1476.
a. Housing Clamps: STM A536 ductile iron, enamel coated, compatible with steel piping sizes, rigid or flexible type.
1) Rigid Type: 2 inch through 12 inch: "Installation ready" rigid coupling with offsetting, angle pattern bolt pads designed for direct 'stab' installation onto grooved end pipe without prior disassembly of the coupling, no torque requirement and Grade "EHP" EPDM gasket.
2) Rigid Type: 14 inch through 24 inch: AGS grooves, wide housing key with flat bolt pads. Grade "E" EPDM FlushSeal® gasket.
3) Flexible Type: 2 inch through 24" inch: Use in locations where vibration attenuation and stress relief are required. Flexible couplings may be used in lieu of flexible connectors for vibration isolation at equipment connections. Three (3) couplings, for each connector, shall be placed in close proximity to the source of vibration.
b. Grade "E" EPDM Gasket: Elastomer composition for operating temperature range from -30 degrees F to 230 degrees F.
c. Grade "EHP" EPDM Gasket: Elastomer composition for operating temperature range from -30 degrees F to 250 degrees F
d. Accessories: Steel bolts, nuts, and washers.

C. Stainless Steel Pipe: ASTM A312, Schedule 10S for 2 inch and smaller, Type 304/304L, full finish annealed pipe.
1. Fittings: Precision cold drawn austenitic stainless steel, Type 304/304L, complete with synthetic rubber O-rings.
2. Joints: Press-seal
a. O-rings: EPDM Elastomer composition for operating temperature range from -30 degrees F to 250degrees F.
b. 500 PSI rated

2.2 PRE-INSULATED PIPING SYSTEM

A. Pre-Insulated Steel Piping System:
1. Carrier Pipe: Steel Pipe: ASTM A53/A53M., Schedule 40, black steel with plain ends; welded and seamless, Grade B
2. Insulation: Closed Cellular Foam
3. Outer Jacket: PVC.

4. Joints: Welded
5. Manufacturers:
   a. Rovanco
   b. Perm-a-Pipe

B. Pre-Insulated Polyethylene Piping System:
1. Carrier Pipe: PEX A crosslinked polyethylene pipe for hot service, HDPE suitable for temperatures 180 Deg. F to -20 Deg. F for cold service.
2. Insulation: Flexible urethane
3. Outer Jacket: Polyethylene, corrugated to be flexible.
4. Joints: Electrofusion
5. Manufacturers:
   a. Rovanco Rhinoflex
   b. Uponor Ecoflex

2.3 COPPER PIPE AND FITTINGS

A. Drawn-Temper Copper Tubing, solder joints: ASTM B88, Type K, L, or M as specified in part 3 for application.
1. Fittings:
   a. ASME B16.22, solder wrought copper.
2. Prohibited Tee Connections: Mechanically extracted collars with notched and dimpled branch tube (T-Drill) fittings are prohibited.
3. Joints: Solder, lead free, ASTM B32, 95-5 tin-antimony, or tin and silver, with melting range 430 to 535 degrees F.

B. Drawn-Temper Copper Tubing, press-seal joints: ASTM B88, Type L or M as specified in section 3 for application.
1. Press Fittings: IAPMO PS 117, ANSI LC1002, NSF61-G
2. Housing: Copper.
3. O-Rings and Pipe Stops: EPDM.
4. Tools: Manufacturer's special tools.
5. Minimum 200-psig working-pressure rating at 250 deg F.

2.4 POLYETHYLENE PIPE AND FITTINGS

A. Polyethylene Pipe: ASTM F876 and ASTM F877, cross-linked polyethylene, 100 psig operating pressure at 180 degrees F.
1. Fittings: Brass and copper.
2. Joints: Mechanical compression fittings.

B. Composite Polyethylene Pipe: Aluminum tube laminated between two layers of cross-linked polyethylene, 125 psig operating pressure at maximum 140degrees F.
1. Fittings: Brass flared compression.
2. Joints: Fittings adapt to copper tubing or copper tube fittings, threaded pipe and fittings, and copper compression fittings.

2.5 PLASTIC PIPE AND FITTINGS

A. PVC Pipe: ASTM D1785, Schedule 40, polyvinyl chloride (PVC) material.
   1. Fittings: ASTM D2466, Schedule 40, PVC.
   2. Joints: ASTM D2855, solvent weld with ASTM D2564 solvent cement. Prime joints with a contrasting color.
      a. PVC solvent cement shall have a VOC content of 510 g/L or less.
      b. Adhesive primer shall have a VOC content of 550 g/L or less.

B. CPVC Pipe: ASTM F441/F441M, Schedule 40, chlorinated polyvinyl chloride (CPVC) material.
   1. Fittings: ASTM F438, CPVC, Schedule 40, socket type.
   2. Joints: ASTM D2846/D2846M, solvent weld with ASTM F493 solvent cement. Prime joints with a contrasting color.
      a. CPVC solvent cement shall have a VOC content of 490 g/L or less.
      b. Adhesive primer shall have a VOC content of 550 g/L or less.

C. Plastic-to-metal transition fittings: One-piece fitting with one threaded brass or copper insert and one solvent-cement-joint end of material and wall thickness to match plastic pipe material.

2.6 UNIONS AND FLANGES

A. Unions for Pipe 2 inches and Smaller:
   1. Ferrous Piping: Class 150 malleable iron, threaded.
   2. Copper Piping: Class 150, bronze unions with soldered.
   3. Dielectric Connections:
      a. Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.
      b. Waterway fitting with zinc electroplated steel or ductile iron body, male thread, grooved, or plain end, water impervious isolation barrier.
   4. PVC Piping: PVC.
   5. Plastic-to-metal transition unions: Brass or copper end, solvent-cement-joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

B. Flanges for Pipe 2-1/2 inches and Larger:
   1. Ferrous Piping:
      a. Class 150 forged steel, slip-on flanges.
      b. Grooved joint flange adapter, flat face, for direct connection to ANSI Class 125 and 150 flanges. For direct connection to ANSI Class 300 flanges
      c. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
   2. Copper Piping:
      a. Class 150, slip-on bronze flanges.
      b. Grooved joint flange adapter, flat face, for direct connection to ANSI Class 125 and 150 flanges.
   3. PVC Piping: PVC flanges.

4. Gaskets: 1/16 inch thick preformed neoprene gaskets.

C. PVC Pipe Materials: For connections to equipment and valves with threaded connections, furnish solvent-weld socket to screwed joint adapters and unions, or ASTM D2464, Schedule 80, threaded, PVC pipe.

PART 3 EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, 2-inch and smaller, shall be the following:
1. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and press-seal joints where exposed and where installed above accessible ceilings only.

B. Hot-water heating piping aboveground, 2-1/2 inch and larger shall be any of the following:
1. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and press-seal joints where exposed and where installed above accessible ceilings only.
3. Schedule 40 steel pipe [0.375 inch wall for sizes 12 inch and larger,], wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
4. Schedule 40 steel pipe [0.375 inch wall for sizes 12 inch and larger,], grooved, mechanical joint coupling and fittings; and grooved, mechanical joints where exposed and where installed above accessible ceilings only.

C. Makeup-water piping installed aboveground shall be the following:
1. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

D. Condensate-Drain Piping: Type M (PVC for non-plenum applications), drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

E. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

F. Air-Vent Piping:
1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

G. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with

metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

3.2 EXAMINATION

A. Verify excavations are to required grade, dry, and not over-excavated.

3.3 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel or groove plain end ferrous pipe.

B. Remove scale and dirt on inside and outside before assembly.

C. Prepare piping connections to equipment with flanges or unions.

D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

E. After completion, fill, clean, and treat systems. Refer to Section 23 25 00.

3.4 INSTALLATION - PIPE HANGERS AND SUPPORTS

A. Install pipe hangers and supports in accordance with Section 23 05 29.

3.5 INSTALLATION - ABOVE GROUND PIPING SYSTEMS

A. Install Work in accordance with Owner’s guidelines.

B. Route piping parallel to building structure and maintain gradient.

C. Install piping to conserve building space, and not interfere with use of space.

D. Group piping whenever practical at common elevations.

E. Sleeve pipe passing through partitions, walls and floors. Refer to Section 23 05 29.

F. Install firestopping at fire rated construction perimeters and openings containing penetrating sleeves and piping.

G. Install pipe identification in accordance with Section 23 05 53.

H. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

I. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors.

J. Slope hydronic piping and arrange systems to drain at low points.

K. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.

L. Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting. Refer to Division 09.

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

N. Insulate piping and equipment; refer to Section 23 07 00.

3.6 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

H. Grooved joint piping systems: Install in accordance with the manufacturer's guidelines and recommendations.
   1. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be supplied by the grooved coupling manufacturer. Grooved end shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove for proper gasket sealing.
   2. A factory trained field representative shall provide on-site training to contractor's field personnel in the installation of grooved piping products. Factory trained

representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.

3. Use roll sets or cut groovers compatible with the pipe material and wall thickness per manufacturer's installation instructions.

I. Press connections: Copper and copper alloy press connections shall be made in accordance with the manufacturer's installation instructions. The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. The joints shall be pressed using the tool(s) recommended by the manufacturer. Contractor shall be trained on the use and installation of the system by manufacturer's representative.

3.7 FIELD QUALITY CONTROL

A. Comply with Division 01.

B. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

C. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping." Pressure test for press-seal fittings shall not exceed 85 psi. If there is a significant drop in pressure, the system shall be walked to check for un-pressed fittings. Should an un-pressed fitting be located, the pressure should be released from the system and the un-pressed fitting shall be pressed.

5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

D. Perform the following before operating the system:
1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

E. Test hydronic piping systems in accordance with ASME B31.9.

F. Pressure test to identify un-pressed fittings: Utilizing air or water, the system shall be pressurized, not to exceed 85 psi. If there is a significant drop in pressure, the system shall be walked to check for un-pressed fittings. Should an un-pressed fitting be located, the pressure should be released from the system and the un-pressed fitting shall be pressed. If no un-pressed fitting is identified the system shall be pressurized to test pressures required by code, not to exceed 600 psi.

G. HANGERS AND SUPPORTS
1. Comply with requirements in Division 23 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

PIPE SIZE Inches	COPPER TUBING MAXIMUM HANGER SPACING Feet	STEEL PIPE MAXIMUM HANGER SPACING Feet	COPPER TUBING HANGER ROD DIAMETER Inches	STEEL PIPE HANGER ROD DIAMETER Inches
1/2	5	7	3/8	3/8
3/4	5	7	3/8	3/8
1	6	7	3/8	3/8
1-1/4	7	7	3/8	3/8

1-1/2	8	9	3/8	3/8
2	8	10	3/8	3/8
2-1/2 (Note 1)	9	11	1/2	1/2
3	10	12	1/2	1/2

H. Plastic and Ductile Iron Pipe Hanger Spacing:

PIPE HANGER SPACING		
PIPE MATERIAL	MAXIMUM HANGER SPACING Feet	HANGER ROD DIAMETER Inches
ABS (All sizes)	4	3/8
FRP (All Sizes)	4	3/8
Ductile Iron (Note 2)		
PVC (All Sizes)	4	3/8

I. Note 1: Refer to manufacturer's recommendations for grooved end piping systems.

J. Note 2: 20 feet maximum spacing, minimum of one hanger for each pipe section close to joint behind bell. Provide hanger at each change of direction and each branch connection. For pipe sizes 6 inches and smaller, subjected to loadings other than weight of pipe and contents, limit span to maximum spacing for water service steel pipe.

END OF SECTION 23 2113

SECTION 23 2114 - HYDRONIC SPECIALTIES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Air vents.

B. Pressure-temperature test plugs.

C. Balancing valves.

D. Combination flow controls.

E. Flow meters.

F. Radiator valves.

G. Relief valves.

H. Thermometers

I. Pressure Gauges

J. Glycol system.

1.2 RELATED REQUIREMENTS

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

B. Section 22 - Plumbing Piping Specialties: Backflow preventers.

C. Section 23 - Hydronic Piping.

D. Section 23 - HVAC Water Treatment: Pipe cleaning.

1.3 REFERENCE STANDARDS (follow the most currently adopted amended version)

A. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.

B. ASME B16.5 - Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard.

C. ASME B16.11 - Forged Fittings, Socket-welding and Threaded.

D. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1 - Rules for Construction of Pressure Vessels.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination: Coordinate the installation of work of this section with size, location and installation of service utilities.

B. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.

C. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.5 SUBMITTALS

A. Product Data: Provide product data for manufactured products and assemblies required for this project. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description and model.

B. Certificates: Inspection certificates for pressure vessels from authority having jurisdiction.

C. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.

D. Maintenance Contract.

E. Project Record Documents: Record actual locations of flow controls.

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

G. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. Extra Glycol Solution: One container, 1 gallon size.
   2. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flow meter, probes, hoses, flow charts, and carrying case.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.

B. Provide temporary protective coating on cast iron and steel valves.

C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

D. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 PRODUCTS

2.1 AIR VENTS

A. Manufacturers:
1. Armstrong International, Inc.
2. ITT Bell & Gossett
3. Taco, Inc.

B. Manual Type: Short vertical sections of 2 inch diameter pipe to form air chamber, with 1/8 inch brass needle valve at top of chamber.

C. Float Type:
1. Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.
2. Cast iron body and cover, float, bronze pilot valve mechanism suitable for system operating temperature and pressure; with isolating valve.

D. Washer Type:
1. Brass with hygroscopic fiber discs, vent ports, adjustable cap for manual shut-off, and integral spring loaded ball check valve.

2.2 STRAINERS

A. Manufacturers:
1. Armstrong International, Inc.
2. Watts
3. Grinnell Products

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

C. Size 2-1/2 inch to 4 inch:
1. Provide flanged iron body for 175 psi working pressure, Y pattern with 3/64 inch stainless steel perforated screen.

D. Size 5 inch and Larger:
1. Provide flanged iron body for 175 psi working pressure, basket pattern with 1/8 inch stainless steel perforated screen.

2.3 PRESSURE-TEMPERATURE TEST PLUGS

A. Manufacturers:
1. Ferguson Enterprises Inc

2. Peterson Equipment Company Inc
3. Sisco Manufacturing Company Inc
4. Substitutions: See Section 01 - Product Requirements.

B. Construction: Brass body designed to receive temperature or pressure probe with removable protective cap, and Neoprene rated for minimum 200 degrees F .

C. Application: Use extended length plugs to clear insulated piping.

2.4 BALANCING VALVES - MANUAL

A. Manufacturers:
1. Armstrong Fluid Technology
2. ITT Bell & Gossett
3. Taco, Inc
4. Nexus
5. Grisworld
6. Tour & Anderson

B. Brass or Bronze, Calibrated-Orifice, Balancing Valves:
1. Construction: Bronze or brass alloy housing, ball or plug type with calibrated orifice or venturi. The valve shall come fully assembled and be permanently marked to show direction of flow.
2. CWP rating: 400PSI/250°F.
3. Pressure gauge connections: dual pressure/temperature test valves for flow reading, and a union end which will accept various end pieces.
4. The body design shall allow inspection or repair of handle operated stem without disturbing piping connections. The repairable stem shall include two Teflon seals and one EPDM O-ring for protection against chemicals and modulating temperature.

C. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
1. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
2. Ball: Brass or stainless steel.
3. Stem Seals: EPDM O-rings.
4. Disc: Manufacturer standard construction.
5. Seat: PTFE.
6. End Connections: Flanged or grooved.
7. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig 860 kPa.
10. Maximum Operating Temperature: 250 deg F 121 deg C.

2.5 BALANCING VALVES AUTOMATIC

A. Manufacturers:

1. Nexus UltraMatic UM Series
2. Grisworld Isolator R Series
3. Flow Design AC Series
4. Victaulic 76B Series

B. Description:
1. Brass or bronze body with union on inlet and outlet, temperature and pressure test plug on inlet and outlet with combination blow-down and back-flush drain.
2. Calibration: Control within 10 percent of design flow over entire operating pressure with a maximum operating temperature of at least 232 deg F.
3. Control Mechanism: Either piston and spring or diaphragm and orifice plates are acceptable types. For piston and spring types: Stainless steel or nickel plated brass piston or regulator cup, operating against stainless steel helical or wave formed spring. For diaphragm and orifice plate types: elastomeric polymer diaphragm with polyphenylsulfone orifice seat.
4. Accessories: In-line strainer on inlet and ball valve on outlet.
5. Manufacturer shall be able to provide certified independent laboratory tests verifying accuracy of performance. (Consult the factory for details).
6. All flow control valve cartridges shall be warranted by the manufacturer for five years from date of sale.
7. The body design shall allow inspection or removal of 20 mesh stainless steel strainer without disturbing piping connections.
8. Ball Valve shall be made of brass. Maximum pressure rating of 400 PSI. Ball Valve shall include a union end which will accept various end pieces.
9. The body design shall allow inspection or repair of handle operated stem without disturbing piping connections. The repairable stem shall include two Teflon seals and one EPDM O-ring for protection against chemicals and modulating temperature.
10. A pressure/temperature test valve, manual air vent and drain valve shall be included.
11. Dual pressure or pressure/temperature test valves for verifying accuracy of flow performance shall be provided for all valve sizes.
12. Valve shall have a body tag to indicate model number and a hanging tag showing Cv and flow/delta P reading required for specific flow rate.

2.6 COMBINATION FLOW CONTROLS

A. Manufacturers:
1. Armstrong Fluid Technology
2. ITT Bell & Gossett
3. Taco, Inc
4. Nexus
5. Grisworld

B. Size 2 inch and Under:
1. 300 psi, threaded or soldered ends; non-ferrous Ametal® brass copper alloy body, EPDM o-ring seals. 4-turn digital readout handwheel for balancing, hidden memory feature with locking tamper-proof setting. Victaulic / TA Hydronics Series 787, 78K STAD or 786 STAS.

C. Size 2-1/2 inch and Larger:
   1. 250 psi Flanged or 350 psi Grooved ends, ASTM A536 ductile iron body, all other metal parts of Ametal® brass copper alloy, EPDM O-ring seals. 8, 12 or 16 turn digital readout handwheel for balancing, hidden memory feature with locking tamper-proof setting. Victaulic / TA Hydronics Series 789 STAG or 788 STAF
   2. Coil hook-up assemblies may be used to reduce installation time and space requirements. Victaulic TA Series 799 or 79V Koil Kit coil pack assembly. Coil pack can include; Victaulic Series 78U union port fitting, Series 78Y strainer/ball valve or Series 78T union/ball valve combination, and two flexible hoses

2.7 FLOW METERS (stand-alone type) Refer to 230900 for BAS flow meters

A. Manufacturers:
   1. Dwyer Instruments, Inc
   2. EMCO Flow Systems
   3. Davis Instruments

B. Orifice principle by-pass circuit with direct reading gauge, soldered or flanged piping connections for 125 psi working pressure, with shut off valves, and drain and vent connections.

C. Direct reading with insert pitot tube, threaded coupling, for 150 psi working pressure, maximum 240 degrees F, 5 percent accuracy.

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

E. Calibrated, plug type balance valve with precision machined orifice, readout valves equipped with integral check valves and gasketed caps, calibrated nameplate and indicating pointer.

F. Cast iron or bronze, globe style, balance valve with handwheel with vernier type ring setting and memory stop, drain connection, readout valves equipped with integral check valves and gasketed caps.

G. Portable meter consisting of case containing one, 3 percent accuracy pressure gauge with 0-60 feet pressure range for 500 psi maximum working pressure, color coded hoses for low and high pressure connections, and connectors suitable for connection to read-out valves.

H. Portable meter consisting of case containing two, 3 percent accuracy pressure gauges with 0-135 inches and 0-60 feet pressure ranges for 500 psi maximum working pressure, color coded hoses for low and high pressure connections, and connectors suitable for connection to read-out valves.

2.8 RADIATOR VALVES

A. Manufacturers:
   1. Armstrong International, Inc

2. ITT Bell & Gossett
3. Danfos
4. Watts

B. Angle or straight pattern, rising stem, inside screw globe valve for 125 psi working pressure, with bronze body and integral union for screwed connections, renewable composition disc, plastic wheel handle for shut-off service, and lockshield key cap and set screw memory bonnet for balancing service.

2.9 DIAPHRAGM-OPERATED SAFETY VALVES: ASME LABELED.

A. Manufacturers:
1. AMTROL, Inc.
2. Armstrong Pumps, Inc.
3. Bell & Gossett Domestic Pump.
4. Conbraco Industries, Inc.
5. Spence Engineering Company, Inc.
6. Watts Regulator Co.

B. Construction:
1. Body: Bronze or brass.
2. Disc: Glass and carbon-filled PTFE.
3. Seat: Brass.
4. Stem Seals: EPDM O-rings.
5. Diaphragm: EPT.
6. Wetted, Internal Work Parts: Brass and rubber.
7. Inlet Strainer: 304 or 316 stainless steel, removable without system shutdown.
8. Valve Seat and Stem: Noncorrosive.

C. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

2.10 THERMOMETERS

A. Manufacturers:
1. Trerice
2. Winters
3. Weiss

B. Thermometer: ASTM E1, adjustable angle, red appearing mercury, lens front tube, cast aluminum case with enamel finish, cast aluminum adjustable joint with positive locking device.
1. Size: Minimum 7 inch scale.
2. Window: Clear glass or Lexan.
3. Stem: Aluminum or Brass, length to suit installation.
4. Accuracy: ASTM E77 2 percent.
5. Calibration: Degrees F, or both degrees F and degrees C.

2.11 THERMOMETER SUPPORTS

A. Socket: Brass separable sockets for thermometer stems with or without extensions, and with cap and chain.

B. Flange: 3 inch outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

2.12 PRESSURE GAUGES

A. Manufacturers:
1. Trerice
2. Winters
3. Weiss

B. Gauge: ASME B40.1, with bourdon tube, rotary brass movement, brass socket, front calibration adjustment, black scale on white background.
1. Case: Sealed types, Aluminum or Stainless steel.
2. Movement: Mechanical, with link to pressure element and connection to pointer.
3. Dial Size: Minimum 4-1/2 inch diameter.
4. Mid-Scale Accuracy: Grade A, plus or minus one percent.
5. Scale: Psi, or both psi and kPa.

2.13 GLYCOL SOLUTION

A. Manufacturers:
1. DowFrost - Model - HD.
2. Houghton Chemical – Model – Safe-T-Therm.
3. Interstate Chemicals – Model – InterCool P300.
4. Substitutions: See Section 01 - Product Requirements.

B. Inhibited propylene glycol and water solution mixed 30 percent glycol - 70 percent water, suitable for operating temperatures from -40 degrees F to 250 degrees F.

PART 3 EXECUTION

3.1 INSTALLATION – HYDRONIC PIPING SPECIALTIES

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

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes. Install thermowells with extension on insulated piping. Fill thermowells with heat-transfer medium.

C. Install gauges and thermometers in locations where they are easily read from normal operating level.

D. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

E. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

F. Install direct-mounted pressure gauges in piping tees with pressure gauge located on pipe at the most readable position. Install valve and snubber in piping for each pressure gauge for fluids (except steam).

G. Install thermowells with socket extending one-third of pipe diameter or to center of pipe and in vertical position in piping tees.

H. Where large air quantities can accumulate, provide enlarged air collection standpipes.

I. Provide manual air vents at system high points and as indicated.

J. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.

K. Provide valved drain and hose connection on strainer blow down connection.

L. Provide radiator valves on water inlet to terminal heating units such as radiation, unit heaters, and fan coil units.

M. Provide radiator balancing valves on water outlet from terminal heating units such as radiation, unit heaters, and fan coil units.

N. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.

O. Pipe relief valve outlet to nearest floor drain.

P. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

Q. Clean and flush glycol system before adding glycol solution. Refer to Section 23 25 00 - HVAC Water Treatment.

R. Feed glycol solution to system through make-up line with pressure regulator, venting system high points. Set to fill at 40 times .433psi/ft + 5 psi.

S. Perform tests determining strength of glycol and water solution and submit written test results.

3.2 INSTALLATION - THERMOMETERS AND GAUGES

A. Install one pressure gauge for each pump, locate taps before strainers and on suction and discharge of pump; pipe to gauge.

B. Install pressure gauges with pulsation dampers. Provide needle valve or ball valve to isolate each gauge. Extend nipples to allow clearance from insulation.

C. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inches for installation of thermometer sockets. Allow clearance from insulation.

D. Install thermometer sockets adjacent to controls systems thermostat, transmitter, or sensor sockets.

E. Coil and conceal excess capillary on remote element instruments.

F. Provide instruments with scale ranges selected according to service with largest appropriate scale.

G. Install gauges and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.

H. Adjust gauges and thermometers to final angle, clean windows and lenses, and calibrate to zero.

3.3 THERMOMETER SCALE RANGE SCHEDULE

A. Scale Range for Heating, Hot-Water Piping: 20 to 240 deg F

B. Scale Range for Air Ducts: 0 to 150 deg F

3.4 PRESSURE GAUGE SCALE RANGE SCHEDULE

A. Scale Range for Heating, Hot-Water Piping: 0 to 200

3.5 MAINTENANCE

A. Provide service and maintenance of glycol system for one year from date of Substantial Completion at no extra charge to Owner.

B. Perform monthly visit to make glycol fluid concentration analysis on site with refractive index measurement instrument. Report findings in detail in writing, including analysis and amounts of glycol or water added.

C. Explain corrective actions to Owner's maintenance personnel in person.

END OF SECTION 23 2114

SECTION 23 3100 - HVAC DUCTS AND CASINGS

PART 1 GENERAL

1.1 SECTION INCLUDES:

A. Duct Materials.

B. Duct Liner

C. Non-Insulated Flexible ducts.

D. Insulated flexible ducts.

E. Single wall spiral round ducts.

F. Single wall spiral flat oval ducts.

G. Double wall spiral insulated round ducts.

H. Double wall spiral insulated flat oval ducts.

I. Transverse duct connection system.

1.2 RELATED SECTIONS

1. Drawings and general provisions of the contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this section.

1.3 REFERENCES

A. ASTM International:

1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel.
2. ASTM A90/A90M - Standard Test Method for Weight Mass of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
3. ASTM A240/A240M - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
4. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
5. ASTM A568/A568M - Standard Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for.
6. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
7. ASTM A1008/A1008M - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.

8. A1011/A1011M-07 Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
9. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
10. ASTM C14 - Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe.
11. ASTM C443 - Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
12. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

B. National Fire Protection Association:
1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.
2. NFPA 90B - Standard for the Installation of Warm Air Heating and Air Conditioning Systems.
3. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

C. Sheet Metal and Air Conditioning Contractors:
1. SMACNA - Fibrous Glass Duct Construction Standards.
2. SMACNA - HVAC Air Duct Leakage Test Manual.
3. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.

D. Underwriters Laboratories Inc.:
1. UL 181 - Factory-Made Air Ducts and Connectors.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" beef up duct hanger and support in this section.

C. Variation of duct configuration or sizes other than those of equivalent or lower loss coefficient is not permitted except by written permission. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts.

1.5 SUBMITTALS

A. Shop Drawings: Submit duct fabrication drawings, drawn to scale not smaller than 1/4 inch equals 1 foot, on drawing sheets same size as Contract Documents, indicating:

1. Fabrication, assembly, and installation details, including plans, elevations, sections, details of components, and attachments to other work.
2. Duct layout, indicating pressure classifications and sizes in plan view. For exhaust duct systems, indicate classification of materials handled as defined in this section.
3. Fittings.
4. Reinforcing details and spacing.
5. Seam and joint construction details.
6. Penetrations through fire rated and other walls.
7. Terminal unit, coil, and humidifier installations.
8. Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.

B. Product Data: Submit data for duct materials, duct liner, duct connectors.

C. Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA HVAC Air Duct Leakage Test Manual.

1.6 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

1.7 QUALITY ASSURANCE

A. Perform Work in accordance with SMACNA - HVAC Duct Construction Standards - Metal and flexible.

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

1.8 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

B. Installer: Company specializing in performing Work of this section with minimum three years documented experience.

1.9 ENVIRONMENTAL REQUIREMENTS

A. Do not install duct sealant when temperatures are less than those recommended by sealant manufacturers.

B. Maintain temperatures during and after installation of duct sealant.

1.10 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

PART 2 PRODUCTS

2.1 DUCT MATERIALS

A. Galvanized Steel Ducts: ASTM A653/A653M galvanized steel sheet, lock-forming quality, having G90 zinc coating of in conformance with ASTM A90/A90M.

B. Steel Ducts: ASTM A1008/A1008M, with oiled, matte finish for exposed ducts.

C. Aluminum Ducts: ASTM B209; aluminum sheet, alloy 3003-H14. Aluminum Connectors and Bar Stock: Alloy 6061-T6 or of equivalent strength. Mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

D. Stainless Steel Ducts: ASTM A480/A480M, Type [304.] [316.] Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article

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

F. Hanger Rod: ASTM A36/A36M; steel , galvanized; threaded both ends, threaded one end, or continuously threaded.

2.2 DUCT LINER

A. Fibrous-Glass Duct Liner
   1. Manufacturers:
      a. CertainTeed Corporation; Insulation Group.
      b. Johns Manville.
      c. Knauf Insulation.
      d. Owens Corning.
   2. Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
   3. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
   4. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
      a. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Flexible Elastomeric Duct Liner:
   1. Manufacturers:
      a. Aeroflex USA Inc.
      b. Armacell LLC
      c. K-Flex
   2. Description: Elastomeric foam duct liner, integral EPA registered antimicrobial agent, complying with NFPA 90A or NFPA 90B.

3. Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
5. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
   a. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.3 NON-INSULATED FLEXIBLE DUCTS

A. Manufacturers:
1. Thermaflex Technaflex
2. Tuttle + Bailey
3. Flexmaster

B. Product Description: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helical-wound spring steel wire.
1. Pressure Rating: 10 inches wg positive and 1.0 inches wg negative.
2. Maximum Velocity: 4000 fpm.
3. Temperature Range: -20 degrees F to 210 degrees F.

2.4 INSULATED FLEXIBLE DUCTS

A. Manufacturers:
1. Thermaflex
2. Technaflex
3. Tuttle + Bailey
4. Flexmaster

B. Product Description: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helical wound spring steel wire; fiberglass insulation; polyethylene or aluminized vapor barrier film.
1. Pressure Rating: 10 inches wg positive and 1.0 inches wg negative.
2. Maximum Velocity: 4000 fpm.
3. Temperature Range: -20 degrees F to 210 degrees F.
4. Thermal Resistance: 6square feet-hour-degree F per BTU.
5. Vapor Barrier Permeance: 0.05 perm per ASRM E96, Procedure A

2.5 SEALANTS AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:

1. General: Brush-on, water-resistant, mold and mildew resistant, indoor and outdoor use, compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. VOC: Maximum 75 g/L (less water).
5. Maximum Static-Pressure Class: 10-inch wg, positive and negative.

C. Flanged Joint Sealant: Comply with ASTM C 920.
1. General: Single-component, acid-curing, silicone, elastomeric.
2. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

E. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for10-inch wg static-pressure class, positive or negative.

2.6 SINGLE WALL SPIRAL ROUND DUCTS

A. Manufacturers include, but are not limited to:
1. McGill AirFlow Corporation
2. Semco Incorporated
3. Tangent Air Corp
4. Spiral Mfg. Co., Inc.

B. Product Description: UL 181, Class 1, round spiral lockseam duct constructed of galvanized steel.

C. Construct ducts and fittings gauge per the latest edition of SMACNA.

2.7 SINGLE WALL SPIRAL FLAT OVAL DUCTS

A. Manufacturers include, but are not limited to:
1. McGill AirFlow Corporation
2. Semco Incorporated
3. Tangent Air Corp
4. Spiral Mfg. Co., Inc.

B. Product Description: Machine made from round spiral lockseam duct constructed of galvanized steel; rated for 10 inches wg pressure.

C. Joints: Either fully welded or bolted flange with gasket material in accordance with manufacturer’s recommendations.

D. Construct duct with the following minimum gauges:

Major Axis Dimension	Gauge
7 inches to 24 inches	24
25 inches to 48 inches	22
50 inches to 70 inches	20
72 inches to 82 inches	18
84 inches and larger	16

E. Construct fittings with the following minimum gauges:

Major Axis Fitting Dimension	Gauge
7 inches to 36 inches	20
37 inches to 60 inches	18
62 inches and larger	16

2.8 DOUBLE WALL SPIRAL INSULATED ROUND DUCTS

A. Manufacturers include, but are not limited to:
1. McGill AirFlow Corporation
2. Semco Incorporated
3. Tangent Air Corp
4. Spiral Mfg. Co., Inc.

B. Product Description: Machine made from round spiral lockseam duct with light reinforcing corrugations, galvanized steel outer wall, 2 inch thick glass fiber insulation, perforated galvanized steel inner wall; fittings manufactured with perforated inner wall.

C. Construct round duct with the following minimum gages:

Diameter	Gauge
3 inches to 14 inches	26
15 inches to 26 inches	24
28 inches to 36 inches	22
38 inches to 50 inches	20
52 inches to 84 inches	18

D. Construct round fittings with the following minimum gages:

Diameter	Gauge
3 inches to 14 inches	24
15 inches to 26 inches	22
28 inches to 36 inches	20
38 inches to 50 inches	20
52 inches to 60 inches	18
62 inches to 84 inches	16

2.9 DOUBLE WALL SPIRAL INSULATED FLAT OVAL DUCTS

A. Manufacturers include, but are not limited to:
1. McGill AirFlow Corporation
2. Semco Incorporated
3. Tangent Air Corp
4. Spiral Mfg. Co., Inc.
5. United McGill

B. Product Description: Machine made from round spiral lockseam duct with light reinforcing corrugations, galvanized steel outer wall, 2 inch thick glass fiber insulation, perforated galvanized steel inner wall; fittings manufactured with perforated inner wall.

C. Construct flat oval duct with the following minimum gauges:

Major Axis Dimension	Gauge
7 inches to 24 inches	24
25 inches to 48 inches	22
50 inches to 70 inches	20
72 inches to 82 inches	18
84 inches and larger	16

D. Construct flat oval fittings with the following minimum gauges:

Major Axis Fitting Dimension	Gauge
7 inches to 36 inches	20
37 inches to 60 inches	18
62 inches and larger	16

2.10 TRANSVERSE DUCT CONNECTION SYSTEM

A. Manufacturers:
1. United McGill
2. Semco
3. ACME

4. Nufab

B. Product Description: SMACNA "E" rated, SMACNA "F" rated or SMACNA "J" rated rigidity class connection, interlocking angle and duct edge connection system with sealant, gasket, cleats, and corner clips.

2.11 DUCTWORK FABRICATION

A. Fabricate and support rectangular ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.

B. Fabricate and support round ducts with longitudinal seams in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible (Round Duct Construction Standards). Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.

C. TDC connections on all ductwork where any dimension exceeds 12 inches. Slip and drive connection acceptable on duct sizes less than 12” x 12”.

D. Construct T's, bends, and elbows with minimum radius 1-1/2 times centerline duct width. Where not possible and where rectangular elbows are used, provide airfoil turning vanes. Where acoustical lining is indicated, furnish turning vanes of perforated metal with glass fiber insulation.

E. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.

F. Fabricate continuously welded round and oval duct fittings two gages heavier than duct gages indicated in SMACNA Standard. Minimum 4 inch cemented slip joint, brazed or electric welded. Prime coat welded joints.

G. Provide standard 45-degree lateral wye takeoffs. When space does not allow 45-degree lateral wye takeoff, use 90-degree conical tee connections.

H. Seal joints between duct sections and duct seams with welds, gaskets, mastic adhesives, mastic plus embedded fabric systems.
1. Sealants, Mastics: Conform to UL 181A. Provide products bearing appropriate UL 181A markings.
2. Do not provide sealing products not bearing UL approval markings.

PART 3 EXECUTION

3.1 EXAMINATION

A. Division 01 - Administrative Requirements: Coordination and project conditions.

B. Verify sizes of equipment connections before fabricating transitions.

3.2 INSTALLATION

A. General:

1. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
2. Install and seal ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
3. During construction, install temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.
4. Use crimp joints with or without bead or beaded sleeve couplings for joining round duct sizes 8 inch and smaller.
5. Install duct hangers and supports in accordance with Section 23 05 29.
6. Use double nuts and lock washers on threaded rod supports.
7. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
8. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
9. Do not route ducts through transformer vaults or electrical equipment rooms and enclosures.
10. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
11. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23, Air Duct Accessories for fire and smoke dampers.

B. Buried Ducts

1. Slope underground ducts to plenums or low pump out points at 1: 500. Install access doors for inspection.

C. Flexible ductwork

1. When located above ceilings, support flexible duct from above; flexible duct shall not touch the ceiling.
2. Minimize kinks and sags
3. Flexible duct shall be located only where concealed and accessible.
4. Non-insulated flexible ductwork: Provide when the metal ductwork connected to is not insulated.
5. Insulated flexible ductwork: Provide when the metal ductwork connected to is insulated. R-value of flexible ductwork insulation shall meet or exceed the R-value of the metal ductwork insulation.
6. Elbow supports: Provide above flexible ductwork connections to ceiling diffusers. Use cable ties as indicated in the manufacturer’s installation instructions.
7. Connections to rigid ductwork: Provide both a drawband and two layers of duct tape lapped approximately 25% at each connection of flexible ductwork to rigid

ductwork. Drawbands shall be the non-metallic type listed and labeled in accordance with UL 181B. Duct tape shall be listed and labeled in accordance with UL 181B.

D. For outdoor ductwork, protect ductwork, ductwork supports, linings and coverings from weather.

3.3 DUCT SEALING

A. Duct Seal Level Description

Seal Level	Sealing Requirements*
A	All transverse joints, longitudinal seams, and duct wall penetrations. Pressure sensitive tape shall not be used as the primary sealant, unless it has been certified to comply with UL-181A or UL0181B by an independent testing laboratory and the tape is used in accordance with that certification
B	All transverse joints, longitudinal seams. Pressure sensitive tape shall not be used as the primary sealant, unless it has been certified to comply with UL-181A or UL0181B by an independent testing laboratory and the tape is used in accordance with that certification.
C	Transverse joints only.
Notes: Longitudinal seams are joints oriented in the direction of flow. Transverse joints are connections of two duct sections oriented perpendicular to airflow. Duct wall penetrations are openings made by any screw fastener, pipe, rod, or wire. Spiral lock seams in a round or flat oval duct need not be sealed. All other connections are considered transverse joints, including but not limited to spin-ins, taps, and other branch connections, access door frames and jambs, duct connections to equipment, etc.	

B. Minimum Duct Seal Levels

Duct Type				
Duct Location	Supply		Exhaust	Return
	2-in. or less (1)	Greater than 2-in. (1)		
Outdoor	A	A	C	A
Unconditioned Space (2)	B	A	C	B
Conditioned Space	C	B	B	C
Notes: Duct design static pressure classification				

Includes indirectly conditioned spaces such as return air plenums

3.4 INTERFACE WITH OTHER PRODUCTS

A. Install openings in ductwork where required to accommodate thermometers and controllers. Install pitot tube openings for testing of systems. Install pitot tube complete with metal can with spring device or screw to prevent air leakage. Where openings are provided in insulated ductwork, install insulation material inside metal ring.

B. Connect air terminal units to supply ducts directly or with five foot maximum length of flexible duct. Do not use flexible duct to change direction.

3.5 CLEANING

1. Division 01 - Execution and Closeout Requirements: Final cleaning.

B. Duct cleaning is required if test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems." do not meet the following criteria:
   1. Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

C. Clean duct system and force air at high velocity through duct to remove accumulated dust. To obtain sufficient air flow, clean one half of system completely before proceeding to other half. Protect equipment with potential to be harmed by excessive dirt with temporary filters, or bypass during cleaning.

D. Clean duct systems with high power vacuum machines. Protect equipment with potential to be harmed by excessive dirt with filters, or bypass during cleaning. Install access openings into ductwork for cleaning purposes.

3.6 DUCTWORK LEAKAGE TESTING

A. The following ductwork systems shall be pressure/leakage tested:
   1. All ductwork to be concealed in a sheetrock, concrete block or other permanent chase shall be pressure tested before ductwork is concealed.
   2. 2012 IECC REQUIREMENTS
      a. Representative sections totaling no less than 25% of ductwork systems listed below that are constructed and installed for 3” w.c. or more (positive or negative).
   3. For ductwork leakage testing: “Ductwork main” shall be defined as all ductwork serving more than one grille or diffuser.
   4. All ductwork outside of the building insulation envelope shall be pressure tested.

B. Testing shall conform to the following:
   1. Test static pressure must be the lower of 125% of the external static pressure of the air moving equipment or the construction static pressure class of the ductwork.

2. Test in accordance with SMACNA HVAC Air Duct Leakage Test Manual. Maximum Allowable Leakage shall be in accordance with Duct Pressure Class rating listed below and Leakage Class listed here-in.
3. For Ductwork Pressure Class 3" w.c: Leakage Class shall be 8.
4. For Ductwork Pressure Class 2" w.c or less: Leakage Class shall be 16.
5. Testing shall occur after ductwork has been cleaned, but before duct insulation is applied or ductwork is concealed.

C. Duct Leakage Test Report shall include:
1. Date of test.
2. Name of company and person conducting the test.
3. Name of company and person witnessing the test.
4. Description of ductwork tested. Provide drawings to indicate section of ductwork being tested. Labeling on the drawings shall correspond to labeling in the report.
5. Surface area (square feet) of section of ductwork being tested.
6. Duct design operating pressure (inches w.c.)
7. P = Duct design test static pressure (inches w.c.)
8. Duct capacity, air flow
9. CL= Specified Leakage Class.
10. F = Leakage factor (CFM / 100 sf of duct area)
11. Maximum allowable leakage (CFM)
12. Test apparatus
    a. Blower
    b. Orifice tube size
    c. Orifice size
    d. Calibrated
13. Test orifice differential pressure (inches w.c.)
14.

3.7 SCHEDULES

A. Ductwork Material Schedule:

AIR SYSTEM	MATERIAL
Supply (Heating Systems)	Galvanized Steel, Aluminum,
Supply (System with Cooling Coils)	Galvanized Steel, Aluminum,
Return, exhaust and Relief	Galvanized Steel, Aluminum
General Exhaust	Galvanized Steel, Aluminum
Fume Hood Exhaust	Stainless Steel
Outside Air Intake	Galvanized Steel

B. Ductwork Pressure Class Schedule:

AIR SYSTEM	PRESSURE CLASS

Supply Ductwork (upstream of VAV boxes terminal units and/or final balancing damper)	3 inch wg
Supply Ductwork (downstream of VAV boxes and terminal units)	1 inch wg regardless of velocity.
Return and Relief	2 inch wg regardless of velocity.
General Exhaust	1 inch wg regardless of velocity.
Fume Hood Exhaust	2 inch wg
All Others Not Identified	1.5x maximum anticipated system pressure

C. Ductwork Liner Schedule:

AIR SYSTEM	THICKNESS
10 ft downstream of VAV box	1 inch
10 ft upstream / downstream of fan coil unit	1 inch
First 10 ft of supply and return/ exhaust from AHU/ERV/DOAS	1 inch
Transfer air ducts	1 inch

END OF SECTION 23 3100

SECTION 23 3300 - AIR DUCT ACCESSORIES

PART 1 GENERAL

1.1 SECTION INCLUDES:

A. Back-draft dampers.

B. Combination fire-and-smoke dampers.

C. Duct access doors.

D. Dynamic fire dampers.

E. Volume control dampers.

F. Flexible duct connections.

G. Duct test holes.

1.2 RELATED SECTIONS:

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

B. Section 23 05 19 – Meters and Gauges

C. Section 23 04 00 – General Conditions for Mechanical Trades

D. Section 23 09 23 - Direct-Digital Control System for HVAC: Execution and Product requirements for connection and control of Combination Smoke and Fire Dampers for placement by this section.

E. Section 23 31 00 - HVAC Ducts: Requirements for duct construction and pressure classifications.

F. Section 26 05 03 - Equipment Wiring Connections: Execution requirements for connection of electrical Combination Smoke and Fire Dampers specified by this section.

1.3 REFERENCES (follow the most currently adopted amended version)

A. Air Movement and Control Association International, Inc.:
   1. AMCA 500 - Test Methods for Louvers, Dampers, and Shutters.

B. ASTM International:
   1. ASTM E1 - Standard Specification for ASTM Thermometers.

C. National Fire Protection Association:
   1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.
   2. NFPA 92A - Recommended Practice for Smoke-Control Systems.

D. Sheet Metal and Air Conditioning Contractors:
   1. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.

E. Underwriters Laboratories Inc.:
   1. UL 555 - Standard for Safety for Fire Dampers.
   2. UL 555C - Standard for Safety for Ceiling Dampers.
   3. UL 555S - Standard for Safety for Smoke Dampers.

1.4 SUBMITTALS

A. Shop Drawings: Indicate for shop fabricated assemblies including volume control dampers, duct access doors and duct test holes.

B. Product Data: Submit data for shop fabricated assemblies and hardware used.

C. Product Data: Submit for the following. Include where applicable electrical characteristics and connection requirements.
   1. Fire dampers including locations and ratings.
   2. Smoke dampers including locations and ratings.
   3. Backdraft dampers.
   4. Flexible duct connections.
   5. Volume control dampers.
   6. Duct access doors.
   7. Duct test holes.

D. Product Data: For fire dampers, smoke dampers, combination fire and smoke dampers submit the following:
   1. Include UL ratings, dynamic ratings, leakage, pressure drop and maximum pressure data.
   2. Indicate materials, construction, dimensions, and installation details.
   3. Damper pressure drop ratings based on tests and procedures performed in accordance with AMCA 500.

E. Manufacturer's Installation Instructions: Submit for Fire and Combination Smoke and Fire Dampers.

F. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.5 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of access doors test holes and dampers.

B. Operation and Maintenance Data: Submit for Combination Smoke and Fire Dampers.

1.6 QUALITY ASSURANCE

A. Dampers tested, rated and labeled in accordance with the latest UL requirements.

B. Damper pressure drop ratings based on tests and procedures performed in accordance with AMCA 500.

C. Maintain one copy of each document on site.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

1.8 PRE-INSTALLATION MEETINGS

A. Convene minimum one week prior to commencing work of this section.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect dampers from damage to operating linkages and blades.

B. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer and material.

C. Storage: Store materials in a dry area indoor, protected from damage.

D. Handling: Handle and lift dampers in accordance with manufacturer's instructions. Protect materials and finishes during handling and installation to prevent damage.

1.10 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.11 COORDINATION

A. Coordinate Work where appropriate with building control Work.

1.12 WARRANTY

A. Furnish five-year manufacturer warranty for duct accessories.

1.13 EXTRA MATERIALS

A. Fusible Links: Furnish quantity equal to 10 percent of number installed.

PART 2 PRODUCTS

2.1 BACK-DRAFT DAMPERS

A. Manufacturers:
   1. Ruskin CB series
   2. Price BDD Series
   3. Greenheck EM Series

B. Product Description: Multi-Blade, back-draft dampers: Parallel-action, gravity-balanced, extruded aluminum. Blades, maximum 6 inch width, center pivoted, with flexible vinyl sealed edges. Blades linked together in rattle-free manner with 90-degree stop, steel ball bearings, and plated steel pivot pin. Furnish dampers with adjustment device to permit setting for varying differential static pressure.

2.2 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers:
   1. Ruskin
   2. Price
   3. Greenheck
   4. Pottorff
   5. Nailor

B. Type: Dynamic, fabricate in accordance with NFPA 90A, UL 555, and UL 555S.

C. Fire Resistance: 1-1/2 hours through penetrations with fire resistance ratings of less than 3 hours and 3 hours through penetrations with fire resistance ratings of 3 hours or more.

D. Leakage Rating: Class II, maximum of 20 cfm at 4 inches wg differential pressure.

E. Damper Temperature Rating: 250 degrees F for all except smoke control systems. Smoke control systems must be 350 degrees F rated.

F. UL 555S Differential Pressure Rating: 6 in. wg.

G. UL 555S Velocity Rating: 2000 fpm

H. Frame: minimum16 gage, galvanized steel.

I. Blades:
   1. Style: Airfoil-shaped, single piece, double skin.
   2. Action: Opposed or parallel.
   3. Orientation: Horizontal.
   4. Material: Minimum 16 gage equivalent thickness, galvanized steel.
   5. Width: Maximum 6 inches.

J. Bearings: Stainless steel or Bronze Oilite pressed into frame.

K. Seals: Silicone blade edge seals and flexible stainless steel jamb seals.

L. Linkage: Concealed in frame.

M. Release Device: Electric resettable link to allow damper to be automatically reset with an open & closed indicator.

N. Actuator: shall be qualified in accordance with UL 555S to the temperature rating of the damper. Provide with damper

O. Operators: UL listed and labeled spring return electric type suitable for 120 volt, single phase, 60 Hz. Provide end switches to indicate damper position. Locate damper operator on exterior of duct and link to damper operating shaft.

P. Fusible Link Release Temperature: 165 degrees F.

Q. Finish: Mill galvanized.

R. Factory installed sleeve provided with mounting angles. Furnish silicone caulk factory applied to sleeve at damper frame to comply with leakage rating requirements. Provide out-of-partition type dampers with fire rated sleeve where conditions do not allow installation of damper within partition.

S. Smoke Detector: Duct mounted smoke detectors shall be furnished by Div. 28, installed by Div. 23. Power wiring by Div. 26, control wiring by Div. 28.

2.3 DUCT ACCESS DOORS

A. Manufacturers:
1. Ruskin
2. Elgen
3. Greenheck
4. Buckley
5. Kees
6. Pottorff

B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

C. Fabrication: Rigid and close fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, furnish minimum 1 inch thick insulation with sheet metal cover.
1. Less than 12 inches square, secure with sash locks.
2. Up to 18 inches Square: Furnish two hinges and two sash locks.
3. Up to 24 x 48 inches: Three hinges and two compression latches.
4. Larger Sizes: Furnish additional hinge.
5. Access panels with sheet metal screw fasteners are not acceptable.

D. Materials

1. Aluminum construction: Minimum 0.032" thick aluminum double wall door, minimum 0.032" thick aluminum frame. Provide for aluminum duct.
2. Steel construction: Minimum 24 gauge galvanized double wall door, minimum 24 gauge galvanized frame. Provide for galvanized steel duct.
3. Stainless steel construction: Minimum 24 gauge stainless steel double wall door, minimum 22 gauge stainless steel frame. Provide for stainless steel or aluminum duct.

E. Low Pressure Rectangular (Non-Grease-Ducts):
1. Door: For insulated ducts, provide double wall door with 1" or 2" insulation cavity – as necessary to accommodate required insulation. For non-insulated ducts, provide single wall door.
2. Gasket: Closed cell neoprene.
3. Hardware: Double (opposite side) cam latches or single cam latch with full length (piano style) hinge.
4. Insulation: Glass fiber type, 1" thick for ductwork with up to 1" thick acoustical lining or insulation wrap, 2" thick for ductwork with 1-1/2" and over acoustical lining or insulation wrap.

F. Low Pressure Round & Oval Duct (Non-Grease Ducts),
1. Insulated duct, low pressure (3" wg): Welded construction, 18 gauge galvanized steel, 24 gauge galvanized double wall door, double cam latches or single cam latch with full length (piano style) hinge, 2" thick glass fiber insulation.
2. Non-Insulated duct, low pressure (6" wg): 16 gauge galvanized door, plated steel full length (piano style) hinge, zinc plated draw latch(es) and keeper(s), closed cell neoprene gasket.

G. High pressure (10" wg): 18 gauge galvanized steel, 24 gauge galvanized double wall door, double cam latches or single cam latch with full length (piano style) hinge, 2" thick glass fiber insulation.
1. Hardware:
a. Cam latch type: Cam latches on (4) sides - (1) cam latch per side for 6"x6", (2) cam latches per side for 8"x8" and over.
b. Hinge type: Cam latches on (3) sides, (1) cam latch per side for up to 16"x16", (2) cam latches per side for 18"x18" and over.
2. Application: For ductwork rated over 3" pressure class positive or negative, provide high pressure access doors.

2.4 DYNAMIC FIRE DAMPERS

A. Manufacturers:
1. Ruskin
2. Price
3. Greenheck
4. Nailor
5. Pottorff

B. Fabricate in accordance with NFPA 90A and UL 555.

C. Fire Resistance: 1-1/2 hours through penetrations with fire resistance ratings of less than 3 hours and 3 hours through penetrations with fire resistance ratings of 3 hours or more.

D. Dynamic Closure Rating: Dampers classified for dynamic closure to 2000 fpm and 4 inches wg static pressure.

E. Construction:
   1. Integral Sleeve Frame- Galvanized steel in gauges required by manufacturer's UL listing. Length: Minimum 20 gage formed Sleeve length shall extend approximately 3" on either side of the wall or floor to facilitate joining the collar to the duct.
   2. Blades:
      a. Style: Curtain type, blades outside of airstream.
      b. Action: Spring or gravity closure upon fusible link release.
      c. Material: Minimum 24 gage roll formed, galvanized steel.
   3. Closure Springs: Type 301 stainless steel, constant force type, if required.

F. Fusible Link Release Temperature: 165 degrees F.

G. Mounting: Vertical or horizontal as indicated on Drawings.

H. Finish: Mill galvanized.

2.5 VOLUME CONTROL DAMPERS

A. Manufacturers:
   1. Ruskin
   2. Nailor
   3. Greenheck
   4. Flexmaster
   5. McGill Airflow
   6. Nailor
   7. Pottorff

B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.

C. Splitter Dampers:
   1. Material: Same gage as duct to 24 inches size in both dimensions, and two gages 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 3/8 inch diameter rod in self aligning, universal joint action, flanged bushing with set screw.
   4. Single Blade Dampers: Fabricate for duct sizes up to 12 x 48 inch.

D. Multi-Blade Damper: Fabricate of opposed blade pattern with maximum blade sizes 8 x 72 inch. Assemble center and edge crimped blades in prime coated or galvanized frame channel with suitable hardware.

E. End Bearings: Except in round ductwork 12inches and smaller, furnish end bearings. On multiple blade dampers, furnish oil-impregnated nylon or sintered bronze bearings. Furnish closed end bearings on ducts having pressure classification over 2 inches wg..

F. Quadrants:
1. Furnish locking, indicating quadrant regulators on single and multi-blade dampers.
2. On insulated ducts mount quadrant regulators on standoff mounting brackets, bases, or adapters.
3. Where rod lengths exceed 30 inches furnish regulator at both ends.

2.6 FLEXIBLE DUCT CONNECTIONS

A. Manufacturers:
1. Ventfabrics Inc. Ventglas
2. United McGill
3. Elgen
4. DuroDyne
5. Ventfabrics
6. Ductmate Industries

B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.

C. Materials: Flame-retardant or noncombustible fabrics.

D. Coatings and Adhesives: Comply with UL 181, Class 1.

E. Metal-Edged Connectors: Factory fabricated with a fabric strip minimum 3-1/2 inches wide attached to two strips of galvanized or aluminum sheet steel. Provide metal compatible with connected ducts.

F. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 480 lbf/inchin the warp and 360 lbf/inchin the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

G. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
1. Minimum Weight: 24 oz./sq. yd.
2. Tensile Strength: 530 lbf/inchin the warp and 440 lbf/inchin the filling.
3. Service Temperature: Minus 50 to plus 250 deg F

H. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
1. Minimum Weight: 16 oz./sq. yd.
2. Tensile Strength: 285 lbf/inchin the warp and 185 lbf/inchin the filling.

3. Service Temperature: Minus 67 to plus 500 deg F

I. High-Corrosive-Environment System, Flexible Connectors:Glass fabric with chemical-resistant coating.
   1. Minimum Weight: 14 oz./sq. yd.
   2. Tensile Strength: 450 lbf/inchin the warp and 340 lbf/inchin the filling.
   3. Service Temperature: Minus 67 to plus 500 deg F

J. Leaded Vinyl Sheet: Minimum 0.55 inch thick, 0.87 lbs. per sq ft, 10 dB attenuation in 10 to 10,000 Hz range.

2.7 DUCT TEST HOLES

A. Manufacturers:
   1. Dwyer
   2. Flow Kinetics
   3. Air Balance
   4. Substitutions: Division 01 - General Requirements.

B. Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Furnish extended neck fittings to clear insulation.

2.8 REMOTE DAMPER OPERATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following :
   1. Pottorff.
   2. Ventfabrics, Inc.
   3. Young Regulator Company.

B. Description: Cable system designed for remote manual damper adjustment.

C. Tubing: Brass, Copper or Aluminum.

D. Cable: Stainless steel.

E. Wall-Box Mounting: Recessed.

F. Wall-Box Cover-Plate Material: Painted steel.

2.9 TURNING VANES

A. Manufacturers:
   1. Ductmate Industries, Inc.
   2. Duro Dyne Inc.
   3. Elgen Manufacturing.
   4. METALAIRE, Inc.
   5. SEMCO Incorporated.
   6. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

D. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify rated walls are ready for fire damper installation.

B. Verify ducts and equipment installation are ready for accessories.

C. Check location of air outlets and inlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.

3.2 INSTALLATION.

A. Install in accordance with NFPA 90A, and follow SMACNA HVAC Duct Construction Standards - Metal and Flexible. Refer to Section 23 31 00 for duct construction and pressure class.

B. Install motorized back-draft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated on Drawings.

C. Access Doors: Install access doors of type suitable for application at the following locations:
1. Spaced every 50 feet of straight duct.
2. Upstream of each elbow.
3. Upstream of each reheat coil.
4. Before and after each duct mounted filter.
5. Before and after each duct mounted coil.
6. Before and after each duct mounted fan.
7. Before and after each automatic control damper.
8. Before and after each fire damper, smoke damper, combination fire and smoke damper.
9. Downstream of each VAV box.

D. Access Door Sizes: Install minimum 8 x 8 inch size for hand access, 18 x 18 inch size for shoulder access. Install 4 x 4 inch for balancing dampers only. Review locations prior to fabrication.

1. Mark access doors for fire and smoke dampers on outside surface, with minimum 1/2 inch high letters reading: FIRE/SMOKE DAMPER, SMOKE DAMPER, OR FIRE DAMPER.

E. Install temporary duct test holes and required for testing and balancing purposes. Cut or drill in ducts. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

F. Install fire dampers, combination fire and smoke dampers and smoke dampers at locations as indicated on Drawings and as indicated in specifications. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges. Install dampers and accessories with required clearance for access. Provide all power and control wiring for a complete and operable system.
1. Install smoke dampers and combination smoke and fire dampers in accordance with NFPA 92A.
2. Install dampers square and free from racking with blades running horizontally.
3. Do not compress or stretch damper frame into duct or opening.
4. Handle damper using sleeve or frame. Do not lift damper using blades, actuator, or jack shaft.
5. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Install bracing as needed.

3.3 DEMONSTRATION

A. Demonstrate re-setting of fire dampers to Owner's representative.

END OF SECTION 23 3300

SECTION 23 3700 - AIR OUTLETS AND INLETS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Diffusers.

B. Registers/grilles.

C. Door grilles.

1.2 RELATED REQUIREMENTS

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

B. Division 09: Painting

C. Section 23 04 00 – General Conditions for Mechanical Trades

D. Section 23 33 00 - Air Duct Accessories.

1.3 REFERENCE STANDARDS (follow the most currently adopted amended version)

A. AMCA 500-L - Laboratory Methods of Testing Louvers for Rating

B. AMCA 511 - Certified Ratings Program for Air Control Devices.

C. AMCA 540 – Debris Impact Resistance

D. AMCA 550 - Test Method for High Velocity Wind Driven Rain Resistant Louvers.

E. ASHRAE Std 70 - Method of Testing the Performance of Air Outlets and Inlets.

F. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.

G. ASTM B221M - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric).

H. SMACNA (ASMM) - Architectural Sheet Metal Manual.

I. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.

1.4 SUBMITTALS

A. Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.

B. Project Record Documents: Record actual locations of all air outlets and inlets.

C. Project Record Documents: Once the final Testing, Adjusting & Balancing Report is approved, record all typed airflow values on the as-built drawings.

D. Test Reports: Rating of air outlet and inlet performance.

E. Manufacturer's Certificate: Certify products meet or exceed specified requirements

1.5 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of air outlets and inlets.

1.6 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.

C. AMCA 540 – Debris Impact Resistance

D. AMCA 550 - Test Method for High Velocity Wind Driven Rain Resistant Louvers; 2015.

E. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

F. Maintain two copies of each document on site.

1.7 PRE-INSTALLATION MEETINGS

A. Convene minimum one week prior to commencing work of this section.

1.8 WARRANTY

A. Furnish five year manufacturer warranty for air outlets and inlets.

1.9 EXTRA MATERIALS

A. Furnish one of each type and size extra air outlets and inlets.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. The following list of manufacturers applies to all air terminal units unless otherwise noted in sections below.
   1. Price Industries
   2. Titus
   3. Krueger
   4. Nailor Industries
   5. Anemostat

2.2 ROUND CEILING DIFFUSERS

A. Type: Round, adjustable pattern, stamped or spun, multi-core diffuser to discharge air in 360 degree pattern, with directional baffles where indicated. Diffuser collar shall project not more than 1 inch above ceiling. In plaster ceilings, provide plaster ring and ceiling plaque.

B. Fabrication: Steel with baked enamel finish.

C. Color: As selected by Architect from manufacturer's standard range.

D. Accessories: Radial opposed blade damper and multi-louvered equalizing grid with damper adjustable from diffuser face.

2.3 RECTANGULAR CEILING DIFFUSERS

A. Type: Provide square, stamped, multi-core, square, adjustable pattern, stamped, multi-core, square and rectangular, multi-louvered, square and rectangular, adjustable pattern, multi-louvered, and diffuser to discharge air in 360 degree, one way, two way, three way, four way, and pattern with directional baffles where indicated.

B. Connections: Round.

C. Frame: Provide surface mount, snap-in, inverted T-bar, spline type. In plaster ceilings, provide plaster frame and ceiling frame.

D. Fabrication: Steel with baked enamel finish.

E. Color: As selected by Architect from manufacturer's standard range.

F. Accessories: Refer to schedule.

2.4 PERFORATED FACE CEILING DIFFUSERS

A. Type: Perforated face with fully adjustable pattern and removable face.

B. Frame: Surface mount type. In plaster ceilings, provide plaster frame and ceiling frame.

C. Fabrication: Steel with steel frame and baked enamel finish.

D. Color: As selected by Architect from manufacturer's standard range.

E. Accessories: Radial opposed blade damper and multi-louvered equalizing grid with damper adjustable from diffuser face.

2.5 CEILING SLOT DIFFUSERS

A. Type: Continuous wide slot, , with adjustable vanes for left, right, or vertical discharge, , refer to schedule

B. Fabrication: Aluminum extrusions with factory clear lacquer finish.

C. Color: To be selected by Architect from manufacturer's standard range.

D. Frame: Refer to schedule.

E. Plenum: Integral, galvanized steel, insulated.

2.6 CEILING SUPPLY REGISTERS/GRILLES

A. Type: Streamlined and individually adjustable curved blades to discharge air along face of grille, one-way deflection.

B. Frame: Refer to schedule.

C. Construction: Made of aluminum extrusions with factory enamel finish.

D. Color: As selected by Architect from manufacturer's standard range.

E. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

2.7 CEILING EXHAUST AND RETURN REGISTERS/GRILLES

A. Type: Frame: Refer to schedule.

B. Fabrication: Steel with 20 gage, 0.0359 inch minimum frames and 22 gage, 0.0299 inch minimum blades, steel and aluminum with 20 gage, 0.0359 inch minimum frame, or aluminum extrusions, with factory baked enamel finish.

C. Color: To be selected by Architect from manufacturer's standard range.

D. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face where not individually connected to exhaust fans.

E. Gymnasiums: Provide front pivoted or welded in place blades, securely fastened to be immobile.

2.8 CEILING LINEAR EXHAUST AND RETURN GRILLES

A. Type: Refer to schedule.

B. Frame: Refer to schedule.

C. Fabrication: Steel with 20 gage, 0.0359 inch minimum frames and 22 gage, 0.0299 inch minimum blades, steel and aluminum with 20 gage, 0.0359 inch minimum frame, or aluminum extrusions, with factory baked enamel finish.

D. Color: To be selected by Architect from manufacturer's standard range.

E. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

2.9 CEILING EGG CRATE EXHAUST AND RETURN GRILLES

A. Type: Refer to schedule.

B. Fabrication: Refer to schedule.

C. Color: To be selected by Architect from manufacturer's standard range.

D. Frame: Refer to schedule.

E. Frame: Channel lay-in frame for suspended grid ceilings.

F. Accessories: Refer to schedule.

2.10 WALL SUPPLY REGISTERS/GRILLES

A. Type: Refer to schedule.

B. Frame: Refer to schedule.

C. Color: To be selected by Architect from manufacturer's standard range.

D. Damper: Integral, gang-operated opposed blade type with removable key operator, operable from face.

E. Gymnasiums: Provide front pivoted or welded in place blades, securely fastened to be immobile.

2.11 WALL SUPPLY REGISTERS/GRILLES

A. Type: Refer to schedule.

B. Frame: Refer to schedule.

C. Fabrication: Aluminum extrusions with factory clear lacquer finish.

D. Color: To be selected by Architect from manufacturer's standard range.

E. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

2.12 WALL EXHAUST AND RETURN REGISTERS/GRILLES

A. Type: Streamlined blades, 3/4 inch minimum depth, 3/4 inch maximum spacing, with spring or other device to set blades, vertical face.

B. Frame: 1-1/4 inch margin with countersunk screw mounting.

C. Fabrication: Steel frames and blades, with factory baked enamel finish.

D. Color: As shown on the drawings.

E. Color: To be selected by Architect from manufacturer's standard range.

F. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

G. Gymnasiums: Provide front pivoted or welded in place blades, securely fastened to be immobile.

2.13 WALL GRID CORE EXHAUST AND RETURN REGISTERS/GRILLES

A. Type: Fixed grilles of 1/2 by 1/2 by 1/2 inch louvers.

B. Fabrication: Aluminum with factory clear lacquer finish.

C. Color: As shown on the drawings.

D. Color: To be selected by Architect from manufacturer's standard range.

E. Frame: 1-1/4 inch margin with countersunk screw mounting.

F. Frame: Channel lay-in frame for suspended grid ceilings.

G. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

2.14 LINEAR WALL REGISTERS/GRILLES

A. Type: Streamlined blades with 0 degree deflection, 1/8 by 3/4 inch (3.2 by 19 mm) on 1/4 inch (6 mm) centers.

B. Frame: 1-1/4 inch (32 mm) margin with countersunk screw mounting and gasket.

C. Fabrication: Aluminum extrusions, with factory baked enamel finish.

D. Color: As shown on the drawings.

E. Color: To be selected by Architect from manufacturer's standard range.

F. Damper: Integral gang-operated opposed blade damper with removable key operator, operable from face.

2.15 LINEAR FLOOR SUPPLY REGISTERS/GRILLES

A. Type: Streamlined blades with 0 degree deflection, 1/8 by 3/4 inch on 1/4 inch (6 mm) centers, assembled on expanded tubes mandrel construction.

B. Frame: 1-1/4 inch heavy margin frame with countersunk screw mounting, and mounting frame.

C. Fabrication: Aluminum extrusions with factory baked enamel finish.

D. Color: As shown on the drawings.

E. Color: To be selected by Architect from manufacturer's standard range.

F. Damper: Integral gang-operated opposed blade damper with removable key operator, operable from face.

2.16 FLOOR SUPPLY REGISTERS/GRILLES

A. Individually adjustable blades, wide stamped border, single or double blade damper with set screw adjustment.

B. Fabricate of steel, welded construction, with factory baked enamel finish.

PART 3 EXECUTION

3.1 EXAMINATION

A. Division 01 - Administrative Requirements: Coordination and project conditions.

B. Verify inlet and outlet locations.

C. Verify ceiling, wall systems are ready for installation.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Comply with SMACNA (ASMM) for flashing/counter-flashing of roof penetrations and supports for roof curbs and roof mounted equipment.

C. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.

D. Install diffusers to ductwork with air tight connection.

E. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly. Refer to Section 23 33 00.

F. Paint ductwork visible behind air outlets and inlets matte black. Refer to Division 09.

3.3 AIR OUTLET AND INLET SCHEDULE

A. Refer to contract drawings/plans.

3.4 INTERFACE WITH OTHER PRODUCTS

A. Check location of outlets and inlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.

END OF SECTION 23 3700

SECTION 23 7413 - PACKAGED OUTDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes modular factory fabricated air-handling units and accessories.

B. Related Sections:
1. Section 23 04 00 – General Conditions for Mechanical Trades
2. Section 23 05 13 - Common Motor Requirements for HVAC Equipment: Product requirements for electric motors for placement by this section.
3. Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment: Product requirements for vibration isolators for placement by this section.
4. Section 23 07 00 - HVAC Insulation: Product requirements for insulation for placement by this section.
5. Section 23 09 23 - Direct-Digital Control System for HVAC: Controls remote from unit.
6. Section 23 09 53 - Pneumatic and Electric Control System for HVAC: Product requirements for pneumatic controls to interface with air handling units.
7. Section 23 09 93 - Sequence of Operations for HVAC Controls: Sequences of operation applying to units in this section.
8. Section 23 21 13 - Hydronic Piping: Product requirements for chilled water and hot water piping connections to air handling units.
9. Section 23 21 16 - Hydronic Piping Specialties: Product requirements for hydronic piping specialties for placement by this section.
10. Section 23 22 13 - Steam and Condensate Heating Piping: Product requirements for steam supply and steam condensate piping connections to air handling units.
11. Section 23 22 16 - Steam and Condensate Piping Specialties: Product requirements for steam supply and steam condensate piping specialties for placement by this section.
12. Section 23 23 00 - Refrigerant Piping: Product requirements for refrigerant piping connections to air handling units.
13. Section 23 33 00 - Air Duct Accessories: Product requirements for flexible duct connections for placement by this section.
14. Section 23 84 00 - Humidity Control Equipment: Product requirements for humidifiers and dehumidifiers for placement by this section.
15. Section 26 05 03 - Equipment Wiring Connections: Execution requirements for electric connections specified by this section.
16. Section 26 29 23 - Variable-Frequency Motor Controllers: Variable frequency controllers.

1.2 REFERENCES

A. American Bearing Manufacturers Association:
1. ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings.

2. ABMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

B. Air Movement and Control Association International, Inc.:
1. AMCA 99 - Standards Handbook.
2. AMCA 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
3. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
4. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
5. AMCA 500 - Test Methods for Louvers, Dampers, and Shutters.

C. Air-Conditioning and Refrigeration Institute:
1. ARI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils.
2. ARI 430 - Central-Station Air-Handling Units.
3. ARI 610 - Central System Humidifiers for Residential Applications.
4. ARI Guideline D - Application and Installation of Central Station Air-Handling Units.

D. ASTM International:
1. ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.

E. National Electrical Manufacturers Association:
1. NEMA MG 1 - Motors and Generators.

F. Sheet Metal and Air Conditioning Contractors:
1. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.

G. Underwriters Laboratories Inc.:
1. UL 900 - Air Filter Units.
2. UL - Fire Resistance Directory.

1.3 SUBMITTALS

A. Division 01 - Submittal Procedures: Submittal procedures.

B. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.

C. Product Data, Submit the following:
1. Published Literature: Indicate capacities, ratings, gages and finishes of materials, and electrical characteristics and connection requirements.
2. Filters: Data for filter media, filter performance data, filter assembly, and filter frames.
3. Fans: Performance and fan curves with specified operating point plotted, power, RPM.
4. Sound Power Level Data: Fan outlet and casing radiation at rated capacity.
5. Dampers: Include leakage, pressure drop, and sample calibration curves. Indicate materials, construction, dimensions, and installation details.

6. Electrical Requirements: Power supply wiring including wiring diagrams for interlock and control wiring. Indicate factory installed and field installed wiring.

D. Samples: Submit two of each type of replacement filter media with frame.

E. Manufacturer's Installation Instructions: Submit.

F. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.4 CLOSEOUT SUBMITTALS

A. Division 01 - Execution and Closeout Requirements: Closeout procedures.

B. Operation and Maintenance Data: Submit instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

1.5 QUALITY ASSURANCE

A. Outside Air Damper Leakage: Test in accordance with AMCA 500.

B. Maintain one copy of each document on site.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years [documented] experience.

B. Installer: Company specializing in performing Work of this section with minimum three years documented experience approved by manufacturer.

1.7 PRE-INSTALLATION MEETINGS

A. Division 01 - Administrative Requirements: Pre-installation meeting.

B. Convene minimum one week prior to commencing work of this section.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Division 01 - Product Requirements: Product storage and handling requirements.

B. Accept units and components on site in factory protective containers, with factory shipping skids and lifting lugs. Inspect for damage.

C. Protect units from weather and construction traffic by storing in dry, roofed location.

1.9 WARRANTY

A. Division 01 - Execution and Closeout Requirements: Product warranties and product bonds.

B. Furnish five year manufacturer warranty for air handling units.

1.10 EXTRA MATERIALS

A. Division 01 - Execution and Closeout Requirements: Spare parts and maintenance products.

B. Furnish one set of fan belts for each unit.

C. Furnish one set of filters for each unit.

PART 2 PRODUCTS

2.1 AIR HANDLING UNITS

A. Manufacturers:
1. Valent Air Corporation, LLC
2. Daikin
3. Trane
4. Aaon
5. Substitutions: Division 01 - Product Requirements.

B. Configuration: Fan section fan and coil section plus accessories, including:
1. DX evaporator Cooling coil section.
2. Packaged DX system.
3. Hot Gas reheat coil.
4. Indirect Gas fired heating section.
5. Filter assembly for exhaust air and intake air.
6. Combination filter/mixing box section.
7. Mixing box section.
8. Supply air blower assembly.
9. Face and bypass damper section.
10. Multi-zone damper section.
11. Motorized dampers.
12. Curb assembly. (with curb adaptor)
13. Energy Recovery Wheel.
14. Exhaust/relief air blower assembly.

C. Performance Base: Sea level pressure.

D. Fabrication: Conform to AMCA 99 and ARI 430.

E. Roof Curb: Refer to Section 23 05 48. Provide curb adaptor to transition from existing curb size to footprint of new DOAS-1 and DOAS-2.

2.2 CASING

A. Channel base and drain pan of welded steel. Assemble sections with gaskets and bolts.

B. Outside Casing:
   1. Unit's exterior shall be supplied from the manufacturer using G60 galvaneal steel with proprietary pre-painted material in the following finish color; Concrete Gray-RAL 7023. This has been subjected to a salt spray test per ASTM-B117 and evaluated using ASTM-D714 and ASTM-D610 showing no observable signs of rust or blistering until reaching 2,500 hours. Uncoated galvanized steel exterior is not acceptable.

C. Inside Casing:
   1. Internal assemblies: 22 gauge, galvanized (G90) steel except for motor supports which shall be minimum 14 gauge galvanized (G90) steel.

D. Floor Plate:
   1. Galvanized Steel: [1.382] [_____] inch thick.
   2. Stainless Steel: [0.1406] [_____] inch thick.

E. Cabinet Insulation: Comply with NFPA 90A and NFPA 90B and erosion requirements of UL 181.
   1. Materials: Rigid urethane injected foam. Foam board not acceptable.
      a. Thickness: 2 inch (50.8 mm)
      b. Thermal Resistance R13
      c. Thermally broken
      d. Meets UL94HF-1 flame requirements.
      e. Location and application: Full coverage of entire cabinet exterior to include walls, roof of unit, unit base, and doors.
   2. Materials: Fiberglass insulation. If insulation other than fiberglass is used, it must also meet the Fire Hazard Classification shown below.
      a. Thickness: 2 inch (50.8 mm)
   3. Thermal Resistance R8
   4. Fire Hazard Classification: Maximum flame spread of 25 and smoke developed of 50, when tested in accordance with ASTM C 411.
   5. Location and application: Divider panels between outdoor air and return air/exhaust air streams.

F. Roof Insulation: 2 inch (50.8 mm) fiberglass located above the 1 inch (25.4 mm) foam panel.

G. Access panels / doors: Unit shall be equipped with insulated, hinged doors or removable access panels to provide easy access to all major components. Doors and access panels shall be fabricated of 18 gauge galvanized G90 steel or painted galvannealed steel.

H. Lights: Located in accessible sections suitable for damp locations with wire guards, factory wired to weatherproof switch and duplex outlet mounted on casing exterior. In humidifier sections, furnish lights suitable for wet locations.

I. Bottom Inlet Units: Furnish steel or aluminum walking grate on structural supports.

J. Supply Air blower assemblies: Blower assembly shall consist of an electric motor and direct-drive fans. Assembly shall be mounted on heavy gauge galvanized steel rails and further mounted on 1.125 inch thick neoprene vibration isolators. Blower motors shall be capable of continuous speed modulation and controlled by a VFD.

K. Exhaust Air blower assemblies: Blower assembly shall consist of an electric motor and a direct-drive fan. Assembly shall be mounted on heavy gauge galvanized steel rails and further mounted on 1.125 inch thick neoprene vibration isolators. Blower motor shall be capable of continuous speed modulation and controlled by a VFD.

L. Evaporator Coil: Evaporator coil shall be (silver) soldered or brazed into the compressed refrigerant system. Coil shall be constructed of copper tubing, permanently bonded to aluminum fins and enclosed in a galvanized steel frame. If two compressors are used as components of the unit, then the evaporator coil shall be of "interlaced" configuration, permitting independent operation of either compressor without conflict with the other compressor.

M. Control panel / connections: Units shall have an electrical control center where all high and low voltage connections are made. Control center shall be constructed to permit single-point high voltage power supply connections. RTU shall be equipped with a Unit Disconnect Switch.

N. Condensate drain pan: Drain Pan shall be an integral part of the unit whenever a cooling option is included. Pan shall be formed of welded austenitic stainless steel sheet material and provided with a welded stainless steel drain connection at the front for connection to a P trap. Drain pan shall be sloped in two directions to provide positive draining and drain connector shall be sealed at penetration through cabinet wall.

O. P trap: If the unit is equipped with a condensate drain pan, contractor shall provide, or fabricate, and install an appropriate P trap, in accordance with all local and area codes and Best Practices.

P. Energy wheel: Unit energy wheel shall be sized for the full volume of outdoor and exhaust air without an energy wheel bypass damper(s). Energy wheel shall be of total enthalpy, rotary air-to-air type and shall be an element of a removable energy wheel cassette. The cassette shall consist of a galvanized steel framework (designed to produce laminar air flow through the wheel), an energy wheel as specified and a motor and drive assembly. The cassette shall incorporate a pre-tensioned urethane drive belt or a link style belt with a five-year warranty. The wheel media shall be a polymer film matrix in a stainless-steel framework and be comprised of individual segments that are removable for servicing. Non-segmented energy wheels are not acceptable. Silica gel desiccant shall be permanently bonded to the polymer film and is designed and constructed to permit cleaning and servicing. The energy wheel is to have a five-year warranty. Performance criteria are to be as specified in AHRI Standard 1060, complying with the Combined Efficiency data in the submittal.

Q. Modulating frost control. Control system shall include an outdoor air thermostat and pressure sensor on the wheel assembly to initiate frost control sequence.

R. Reheat coil with factory installed modulating hot gas reheat valve.

S. Indirect gas furnace

1. Shall be ETL Certified as a component of the unit.

2. Shall have an integral combustion gas blower.

3. Shall be ETL Certified for installation downstream of a cooling coil.

4. Shall have fault sensors to provide fault conditions to optional digital controller or building controls.

5. Shall have 4-pass tubular heat exchangers, constructed of type 409 stainless steel. Heat exchanger tubes shall be installed on the vest plate by means of swaged assembly, welded connections are not acceptable. Heat exchanger tubes shall be supported by a minimum of two fabricated assemblies that support the tubes and also permit expansion and contraction of the tubes.

6. Heat exchanger shall have a 25 year extended warranty.

7. Furnace control shall be HighTurndown 12:1 Modulating.

8. Shall be encased in a weather-tight metal housing with intake air vents. Large, metal lift-off door shall provide easy access to the enclosed vest plate, control circuitry, gas train, burner assembly and exhaust blower.

9. Shall have solid state controls permitting stand-alone operation or control by building controllers.

T. Packaged DX System: Unit shall have an integral compressor(s) and evaporator coil located within the weather-tight unit housing. Condenser coils and appurtenant condenser fan assemblies shall be factory installed as integral subassemblies of the unit and mounted on the exterior of the unit. Lead condenser fan shall have EC motor to maintain condenser pressure at part load conditions. Motors shall be UL Recognized and CSA Certified. The lead refrigerant compressor(s) shall be digital hermetic scroll-type and shall be equipped with liquid line filter drier, thermostatic expansion valves (TXV)(s), manual reset high pressure and low pressure cutouts and all appurtenant sensors, service ports and safety devices. Compressed refrigerant system shall be fully charged with R-410A refrigerant. Compressors shall be mounted within an insulated access compartment and on a raised cabinet shelf to reduce sound and vibration. Each compressor shall be factory-equipped with an electric crankcase heater to boil off liquid refrigerant from the oil.

U. Condenser Fans: Fan blades must be constructed of aluminum or a composite material and have a geometry designed and documented to reduce sound and energy when compared to a traditional rectangular blade fan. Traditional rectangular blade fans are not allowed due to increased noise generated and increase power utilized. Condenser fan motors shall be three phase, external rotor, type 56 frame, open air over and shaft up. Each condenser fan motor shall have a vented frame, rated for continuous duty and be equipped with an automatic reset thermal protector. Lead condenser fan(s) will have an electronically commutated (EC) motor that will modulate to maintain a head pressure set point.] Motors shall be UL Recognized and CSA Certified. Single condenser fan running

at max RPM and design static pressure shall not exceed an A-weighted sound power level of 75 db at free inlet/outlet test conditions.

V. Packaged DX Control and Diagnostics: The Packaged DX system shall be controlled by an onboard digital controller (DDC) that indicates both owner-supplied settings and fault conditions that may occur. The DDC shall be programmed to indicate the following faults:

1. Global alarm condition (active when there is at least one alarm)
2. Supply Air Proving alarm
3. Compressor Trip alarm
4. Compressor Locked Out alarm
5. Supply Air Temperature Low Limit alarm
   a. Sensor #1 Out of Range (outside air temperature)
   b. Sensor #2 Out of Range (supply air temperature)
   c. Sensor #3 Out of Range (cold coil leaving air temperature)

W. Phase and brownout protection: Unit shall have a factory-installed phase monitor to detect electric supply phase loss and voltage brown-out conditions. Upon detection of a fault, the monitor shall disconnect supply voltage to all motors.

X. Motorized dampers / Intake Air, Motorized dampers of low leakage type shall be factory installed.

Y. Curb Assembly: A curb assembly made of 14 gauge galvanized steel shall be provided by the factory for assembly and installation as part of this division. The curb assembly shall provide perimeter support of the entire unit and shall have duct adapter(s) for supply air and return air. Curb assembly shall enclose the underside of the unit and shall be sized to fit into a recess in the bottom of the unit. Contractor shall be responsible for coordinating with roofing contractor to ensure curb unit is properly flashed to provide protection against weather/moisture penetration. Contractor shall provide and install appropriate insulation for the curb assembly. The curb shall be the height of 14 in. Horizontal connections through unit only. Plenum curb for horizontal connections is not acceptable. Provide curb adaptor to transition from existing curb size to new footprint of unit.

Z. Service receptacle: 120 VAC GFCI service outlet shall be factory-provided and installed by this contractor in a location designated by the A / E. Service outlet requires a dedicated single phase electric circuit. Unit contains a 120 VAC transformer to provide power to service outlet.

AA. 24V/120V Smoke detector: Duct smoke detector is shipped loose for field mounting and wiring in the supply or return air duct. The air duct smoke detector housing shall be UL listed per UL 268A specifically for use in air handling systems. The air duct smoke detector housing shall be suitable for mounting indoors. The detector shall operate at air velocities of 100 feet per minute to 4000 feet per minute (0.5 to 20.32 meters/second). The power supply voltage shall be 20-29 VDC, 24 VAC 50-60 Hz, and 120 VAC 50-60 Hz. The detector shall consist of an alarm initiation contact and two DPDT auxiliary

contact closures. WARNING: Duct smoke detectors are NOT a substitute for open area smoke detectors; NOT a substitute for early warning detection; NOT a replacement for a building's regular fire detection system. Refer to NFPA 72 and 90A for additional information.

2.3 BLOWER

A. Blower section construction, Supply Air: direct drive motor and blower shall be assembled on a 14 gauge galvanized steel platform and shall be equipped with 1.125 inch thick neoprene vibration isolation devices.

B. Blower assemblies: Shall be statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and horsepower.

C. Fan: Direct drive, airfoil plenum fan with aluminum wheel statically and dynamically balanced. Prop or belt-drive fan not acceptable due to low static capabilities.

D. Blades: Welded aluminum blades only.

E. Blower section motor source quality control: Blower performance shall be factory tested for flow rate, pressure, power, air density, rotation speed and efficiency. Ratings are to be established in accordance with AMCA 210, "Laboratory Methods of Testing Fans for Rating".

2.4 MOTORS

A. General: Blower motors greater than 1/2 horsepower shall be "NEMA Premium" unless otherwise indicated. Compliance with EPAct minimum energy-efficiency standards for single speed ODP and TE enclosures is not acceptable. Motors shall be heavy-duty, permanently lubricated type to match the fan load and furnished at the specified voltage, phase and enclosure.

B. Motors shall be 60 cycle, 3 phase 208 volts.

2.5 UNIT CONTROLS

A. The unit shall be constructed so that it can function as a stand-alone heating and cooling system controlled by factory-supplied controllers, thermostats and sensors or it can be operated as a heating and cooling system controlled by a Building Management System (BMS). This unit shall be controlled by a factory-installed microprocessor programmable controller (DDC) that is connected to various optional sensors.

B. Unit shall incorporate a DDC controller with integral LCD screen that provides text readouts of status. DDC controller shall have a built-in keypad to permit operator to access read-out screens without the use of ancillary equipment, devices or software. DDC controllers that require the use of equipment or software that is not factory-installed in the unit are not acceptable. Alarm readouts consisting of flashing light codes are not acceptable. Owner-specified ventilating conditions can be input by means of pushbuttons.

C. Unit supply fan shall be configured for Constant Volume (ON/OFF).

D. Unit exhaust fan shall be configured for Constant Volume (ON/OFF).

E. Outside Air / Return Air damper control shall be

F. Economizer control shall be temperature / enthalpy.

G. Operating protocol: The DDC shall be factory-programmed for BACNetIP.

H. Variable Frequency Drive (VFD): unit shall have factory installed variable frequency drive for modulation of the supply and exhaust air blower assemblies. The VFD shall be factory-programmed for unit-specific requirements and shall not require additional field programming to operate.

I. Airflow monitoring required in the supply, and exhaust airstreams.

2.6 FILTERS

A. Unit shall have permanent 2 inch (50.8 mm) aluminum filters located in the outdoor air intake and shall be accessible from the exterior of the unit. MERV 8 disposable pleated filters shall be provided in the supply air stream. MERV 8 and MERV 13 disposable pleated filters shall be provided in the supply final air stream and MERV 8 filters in the exhaust air stream

2.7 OUTSIDE AIR MEASURING AND MODULATION DEVICE

A. Factory mounted in outside air and return air openings.

B. Damper and airflow measurement assembly sized to accommodate minimum outside airflow as indicated on Drawings.

C. Construction:
   1. Frame: Extruded aluminum.
   2. Blades:
      a. Modulating Air Control:
         1) Style: Airfoil-shaped, single-piece.
         2) Action: Parallel.
         3) Orientation: Horizontal.
         4) Material: Heavy gage 6063-T5 extruded aluminum.
         5) Width: Maximum 5 inches.
      b. Stationary Sensing:
         1) Style: Airfoil-shaped, single-piece.
         2) Orientation: Horizontal.
         3) Material: Heavy gage 6063-T5 extruded aluminum.
         4) Width: Maximum 5-1/4 inches.
         5) Finish: Anodized.
   3. Bearings: Self-lubricating molded synthetic sleeve, turning in extruded hole in frame.

4. Seals:
   a. Blade: Extruded rubber. Mechanically attached to blade edge.
   b. Jamb: Stainless steel, flexible metal compression type.
   c. Linkage: Concealed in frame.
   d. Axles: Minimum 1/2 inch diameter plated steel, hex-shaped, mechanically attached to blade.
   e. Mounting: Vertical.
   f. Electric Actuator: 24 V, 60 Hz, modulating, with position feedback.
5. Digital Controller: Application specific controller. Programming logic and calibration in nonvolatile EPROM. Controller uses generic 0 - 10 vdc inputs and outputs for interface to building automation system.
6. Air Straightener Section: 3 inches deep section contained in 5 inch long sleeve attached to damper-airflow monitor frame.
7. Finish: Mill aluminum.

D. Performance Data:
1. Temperature Rating: Withstand -40 to 140 degrees F.
2. Accuracy: Plus or minus 5 percent.
3. Leakage: Maximum of 2.0 cfm per square foot at 1.0 inches wg pressure differential.
4. Measures from 15 percent to 100 percent of unit nominal air flow.
5. Adjusts air flow for temperature variations.
6. Provides 2 to 10 volt DC signal corresponding to actual air flow.

E. Accessories:
1. Actuator Heater: Allow actuator operation in ambient temperatures to -40 degrees F.

2.8 CAPACITY

A. As per schedules on Drawings.

2.9 ELECTRICAL CHARACTERISTICS AND COMPONENTS

A. As per schedules on Drawings.

B. Disconnect Switch: Factory mount on equipment.

PART 3 EXECUTION

3.1 EXAMINATION

A. Division 01 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify roof curbs are installed and dimensions are as shown on shop drawings.

3.2 PREPARATION

A. Furnish roof curbs to Section 23 05 48 for installation.

3.3 INSTALLATION

A. Install in accordance with ARI 430.

B. Install flexible connections between unit and inlet and discharge ductwork. Install metal bands of connectors parallel with minimum 1 inch flex between ductwork and fan while running. Refer to Section 23 33 00.

C. Install assembled units with vibration isolators. Install isolated fans with resilient mountings and flexible electrical leads. Install restraining snubbers as required. Adjust snubbers to prevent tension in flexible connectors when fan is operating. Refer to Section 23 05 48.

D. Install condensate piping with trap and route from drain pan to splash block on roof [nearest roof drain. Refer to Section 23 21 13.

E. Provide fixed sheaves required for final air balance.

F. Insulate coil headers located outside airflow as specified for piping. Refer to Section 23 07 00.

G. Connect humidifiers to water supply. Install gate valve on water supply piping. Install 3/4 inch hose bibb accessible from interior. Pipe drain and overflow to nearest floor drain.

3.4 INSTALLATION REFRIGERANT COILS

A. Install sight glass in liquid line within 12 inches of coil. Refer to Section 23 23 00.

B. Install piping specialties in accordance with Section 23 23 00.

3.5 MANUFACTURER'S FIELD SERVICES

A. Division 01 - Quality Requirements: Requirements for manufacturer’s field services.

B. Furnish initial start-up and shutdown during first year of operation, including routine servicing and checkout.

C. Furnish services of factory trained representative for minimum of one days to leak test, refrigerant pressure test, evacuate, dehydrate, charge, start-up, calibrate controls, and instruct Owner on operation and maintenance.

3.6 CLEANING

A. Division 01 - Execution and Closeout Requirements: Requirements for cleaning.

B. Vacuum clean coils and inside of unit cabinet.

C. Install temporary filters during construction period. Replace with permanent filters at Substantial Completion.

3.7 DEMONSTRATION

A. Division 01 - Execution and Closeout Requirements: Requirements for demonstration and training.

B. Demonstrate unit operation and maintenance.

C. Furnish services of manufacturer's technical representative for one 8 hour day to instruct Owner's personnel in operation and maintenance of units. Schedule training with Owner, provide at least 7 days notice to Architect/Engineer of training date.

3.8 PROTECTION OF FINISHED WORK

A. Division 01 - Execution and Closeout Requirements: Requirements for protecting finished Work.

B. Do not operate units until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

3.9 SCHEDULES

A. As per Drawings.

END OF SECTION 23 7413