VOLUME 3 – ENGINEERING

Owego Apalachin Central School District

1 Sheldon Guile Boulevard, Owego NY 13827

Capital Project Phase 4

Owego Free Academy / Middle School

SED#: 60-06-01-06-0-009-034

Apalachin Elementary School

SED#: 60-06-01-06-0-008-018

HIGHLAND ASSOCIATES
architecture | engineering | interior design

TamCo LLC MANAGEMENT GROUP

"The design of this project conforms to all applicable provisions of the New York State Uniform Fire Prevention and Building Code, the New York State Energy Conservation Code, and the building standards of the New York State Education Department."

HA PN: 2024-240P

APRIL 10, 2026

OWEGO APALACHIN CENTRAL SCHOOL DISTRICT
CAPITAL PROJECT PHASE 4
OWEGO FREE ACADEMY/MIDDLE SCHOOL SED#: 60-06-01-06-0-009-034
APALACHIN ELEMENTARY SCHOOL SED#: 60-06-01-06-0-008-018
BID DOCUMENTS

APRIL 10, 2026

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SECTION 22 00 00 - PLUMBING SCOPE OF WORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 REQUIREMENTS

A. The conditions as defined in Division 22 – Common Work Results for Plumbing, shall apply to all Division 22 specifications.

B. This contractor shall carefully read the above-mentioned documents and study the drawings of all trades. He shall be responsible for neglect to read, or attend to any paragraph or items contained herein.

1.3 INTENT

A. It is the intent of this specification and accompanying drawings to provide Plumbing systems, as specified herein and as shown on the contract drawings. The drawings show the general arrangement and extent of the work to be done. Exact location and arrangement of all components shall be determined as the work progresses. Plans are subject to such modification as may be necessary at the time of installation in order to meet construction conditions. Any adjustments shall be made by the Contractor, without extra charge.

B. The project is to be completed during normal working hours.

1.4 WORK INCLUDED

A. These specifications and accompanying drawings are intended to cover the furnishing by this Contractor of all labor, material and equipment of every kind necessary for the complete installation of the various systems and such other material and equipment as hereinafter specified and shall not be limited to the following:

1. Provide domestic hot water and cold water piping.
2. Provide domestic water recirculation pumps.
3. Provide pipe and pipe fittings for the various systems.
4. Provide valves and cocks for the various systems.
5. Provide sanitary sewer and vent piping.
6. Provide storm water piping.
7. Provide natural gas piping.
8. Provide painting of piping systems

9. Provide pipe insulation of plumbing systems.
10. Provide backflow preventer for domestic service.
11. Provide O.S. & Y valve.
12. Provide reduced pressure zone backflow prevention devices.
13. Provide double check backflow prevention devices.
14. Provide gas, valves, supply valves, supply piping, and return piping.
15. Provide plumbing fixtures. Provide drainage specialties: floor drains, cleanouts, etc.
16. Provide natural gas piping to all equipment requiring gas.
17. Provide electric heat trace for exposed piping.
18. Provide drains for HVAC equipment.
19. Provide excavation and backfill for below grade work.
20. Provide expansion joints, loops, anchors and guides.
21. Provide vibration bases, steel supports and hangers for all equipment and piping.
22. Provide disinfection and flushing of all water piping.
23. Provide testing, adjusting and placing in service all systems and equipment installed.

B. The above list is presented for general guidance only and does not necessarily cover the entire requirement of the project as shown on the drawings and/or specified hereafter.

C. The following items of work related to Plumbing will be performed by others as follows:

1. The General Contractor shall provide all foundations and pads for equipment, paint all piping in finished areas, provide all base flashing on roof, and build in all sleeves, unless otherwise noted.
2. The General Contractor shall install all access panels furnished by the Plumbing Contractor.
3. The Plumbing Contractor shall provide valved make up water outlets and gas outlets for heating and air conditioning equipment for final connection to equipment by the HVAC Contractor.
4. The Plumbing Contractor shall provide floor drains for HVAC equipment. Drainage piping from equipment to drains shall be by the HVAC Contractor.
5. The Electrical Contractor shall do all power wiring for equipment.

1.5 ADDITIONAL MATERIALS AND INSTALLATION INCLUDED

A. This contractor shall, as part of his base bid, provide the following materials and installations for the complete systems installation.

1. The contractor shall provide one double offset for <u>each</u> 80'-0" of run for <u>each</u> piped service in the building. One offset shall consist of four (4) elbow fittings, 12’ of additional pipe, and three (3) hangers of the same joining method and materials as the piping system the offset is to be installed in.
2. The contractor shall provide one offset for <u>each</u> 80'-0" of run for <u>each</u> piped service in the building. One offset shall consist of two (2) elbow fittings, 6’ of additional pipe, and one (1) hanger of the same joining method and materials as the piping system the offset is to be installed in.
3. The contractor shall provide three (3) additional 3/4" ball valves for installation at locations to be determined during the construction.

4. The contractor shall provide three (3) additional 1-1/2" ball valves for installation at locations to be determined during the construction.
5. The contractor shall provide two (2) additional 3/4" check valves for installation at locations to be determined during the construction.
6. The contractor shall provide three (3) additional 3/4" unions for installation at locations to be determined during the construction.
7. The contractor shall provide three (3) additional 1-1/2" unions for installation at locations to be determined during the construction.
8. The contractor shall provide three (3) additional 3/4" dielectric unions for installation at locations to be determined during the construction.
9. The contractor shall provide three (3) additional 1-1/2" dielectric unions for installation at locations to be determined during the construction.
10. The contractor shall provide two (2) additional 3/4" balancing valve assemblies (consisting of a balancing valve, a check valve and a ball valve) for installation at locations to be determined during the construction.
11. The contractor shall provide two (2) additional Type (A) Floor Drains for installation at locations to be determined during the construction.
12. The contractor shall provide two (2) additional Floor Cleanouts for installation at locations to be determined during the construction.
13. The contractor shall provide two (2) additional Lavatory Supply Trap and Tailpiece Insulation kits for installation at locations to be determined during the construction.
14. Provide expansion loops with anchors in domestic hot water and hot water return piping per the requirements of ASPE and ASHRAE.

B. The contractor shall provide a cost break-down for each of the items listed in paragraph A, above. The cost shall be broken down to indicate material, accessories and labor required for the installation of the items listed above. Upon projected completion of work, contractor shall submit a credit to the owner for additional material and installation which is unused.

1.6 WORK AS A SUBCONTRACTOR

A. When the Plumbing work is subcontracted, the exact scope of work may be limited or added to at the discretion of the General Contractor. A subcontractor shall, therefore, verify the extent of his work with the General Contractor.

1.7 RELATED WORK SPECIFIED ELSEWHERE

The following related work items are included in separate divisions and Sections as follows:

A. General Requirements, Division 01.

B. Site Work – Division 02.

C. Concrete – Division 03.

D. Roof Flashing – Division 07.

E. Painting – Division 09.

F. Common Work Results for Plumbing – Division 22.

G. Common Work Results for Fire Suppression – Division 21.

H. Electrical – Division 26.

1.8 REFERENCES

A. 2020 Plumbing Code of New York State with International Plumbing Code 2018 with Amendments.

B. 2020 Building Code of New York State with International Building Code 2018 with Amendments.

C. National Fire Codes (NFPA)

D. All State and Local Rules and Regulations

E. ASPE Guidelines

F. CISPI Guidelines

PART 2 - PRODUCTS

2.1 As specified in the following related sections.

PART 3 - EXECUTION

3.1 All Plumbing systems shall be complete and fully operational.

END OF SECTION 22 00 00

SECTION 22 05 00 - COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This section includes the general requirements that apply to the Plumbing and Plumbing Controls.

B. The following work is specified under other Divisions, unless otherwise noted or specified hereinafter:

1. Painting except as herein specified, Division 09.
2. Electrical Power, Division 26.
3. Installation of starters, contractors, thermal overload switches and remote push buttons, Division 26.

1.3 INTENT

A. Requirements specified herein shall govern applicable portions of Plumbing whether so stated therein or not.

B. It is the intent of this specification and accompanying drawings to describe and indicate the general manufacture, erection and installation of the equipment and connection to same specified herein and shown on the drawings. It is not intended that the specifications and drawings describe and indicate each piece if equipment required for installation, for where items are intended or required for satisfactory installation and are considered to be the accepted practice of the trade, they shall be considered to be both specified and indicated. Drawings are diagrammatic in nature; for piping systems; water piping is tapped off the bottom of the pipe and steam and steam condensate piping is tapped off the top of the pipe; provide all tees, elbows and swing joints as required for hookup to coils or branch piping as required for this work whether they are indicated on the drawings or not.

C. It shall be understood that the Contractor as hereinafter mentioned shall be the Plumbing Contractor unless specifically noted otherwise.

D. The Contractor shall furnish all plant, labor and material necessary for the complete and satisfactory installation of all Plumbing work for this contract.

E. The Contractor shall assume the entire responsibility for the materials, workmanship and satisfactory operation of the various mechanical systems, and other work as specified herein and/or as shown on the drawings.

F. The Contractor shall schedule and coordinate all work in close cooperation with all trades working on this project.

G. All drawings and portions of the drawings, all floor plans, risers, details, schematics and specifications indicated shall apply and are part of the plumbing contract.

H. Any discrepancy or conflict noted between or within the above referenced documents shall be brought to the attention of the Architect/Engineer, in writing, a minimum of three (3) days prior to submittal of bids. The Architect/Engineer shall resolve issues prior to bid submittal.

I. This Contractor shall carefully read the above mentioned documents and study the drawings of all trades. He shall be responsible for neglect to read, or attend to, any paragraph or items contained therein. Failure to bring any conflicts or discrepancies to the attention of the Architect/Engineer, in writing, prior to bid submittal shall not constitute grounds for extras and/or change orders. Costs resultant from this failure shall be borne by this Contractor.

1.4 DEFINITIONS

A. Following definition of terms and expressions used in this section are in addition to listing given in Supplementary Conditions:

1. "Provide" shall mean "furnish and install" unless otherwise indicated.
2. "Herein" shall mean the contents of a particular section where this term appears.
3. "Indicated" shall mean "Indicated on contract drawings".
4. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawl spaces, and tunnels.
5. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
6. Exposed, Exterior Installations: Exposed to view outdoors, or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
7. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
8. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants, but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
9. The following are industry abbreviations for plastic materials:

    a. ABS: Acrylonitrile-butadiene-styrene plastic
    b. CPVC: Chlorinated polyvinyl chloride plastic
    c. NP: Nylon plastic
    d. PE: Polyethylene plastic
    e. PVC: Polyvinyl chloride plastic

10. The following are industry abbreviations for rubber materials:

    a. CR: Chlorosulfonated polyethylene synthetic rubber
    b. EPDM: Ethylene propylene dieneterpolymer rubber

11. For additional abbreviations see the Abbreviations and Symbols Drawings.

1.5 CONTRACTOR'S RESPONSIBILITY

A. The Contractor shall be responsible for establishing grades and elevations, and checking of all interferences, and shall verify all dimensions and locations in the field.

B. Contract drawings for mechanical work are in part diagrammatic, intended to convey the scope of work and indicate general arrangement of equipment, ducts, piping and approximate sizes and locations of equipment outlets. Mechanical trades shall follow these drawings in layout of their work, consult general construction, structural and electrical drawings to familiarize themselves with all conditions affecting their work, and shall verify spaces in which their work will be installed.

C. The Contractor shall verify with the A/E before bidding any item of piping or piping arrangement which may be incomplete, incorrect or indefinite. After contract is let, the A/E's decision shall be final.

D. All trades shall cooperate and confer with each other as to locations of their materials and equipment before erecting work, so as to avoid interference as much as possible, and in such a manner that will in no way retard progress of construction. In instances where interferences develop, the contractor shall relocate the work as required by the A/E regardless of which work was installed first.

E. Where job conditions require reasonable changes to indicate locations and arrangement, make such changes without extra cost to Owner. This is not to be construed to permit redesigning of the various systems.

F. Additional and supplementary drawings may, from time to time, be furnished, and the same, when made, are to constitute a part of the original contract. These drawings will be made to clarify the contract drawings and will not depart materially therefrom.

G. The A/E specifically reserves the right, up to the time of roughing-in, to exactly define the position of the equipment to be installed and connected to and arrangement of these connections.

H. Special attention is called to the contract drawings and specifications involving general construction, electrical work and details thereon. Bidders are notified to carefully scrutinize these documents for the details affecting the performance of the mechanical trades.

1. Install all supply piping with adequate stops on each supply to all fixtures and or equipment to be connected to distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures and or equipment. Install stops in locations where they can be easily reached for operation.

I. Exception: Use ball, gate, or globe valves if supply stops are not specified with fixture or equipment. Valves are specified in Divisions 22 and 23.

1.6 WORK INCLUDED

A. These specifications, and accompanying drawings are intended to cover the furnishing by this Contractor of all labor, material and all equipment of every kind necessary for the complete installation of the various systems, and such other materials and equipment as hereinafter specified, and shall include, but not be limited to the following:

1. Cold water system from water service from Water Service Room to all fixtures and equipment requiring cold water. Cold water piping to domestic water heaters.
2. Cold water supply to fill heating and cooling systems complete with a Reduced Pressure Zone backflow preventer and terminating with gate valve or ball valve.
3. Domestic hot water system includes valves, supply valves, supply piping, and return piping to fixtures and equipment requiring hot water as indicated.
4. Water supply specialties including water meter, shock absorbing devices, backflow preventers, wall hydrants, thermometers, etc.
5. Sanitary drainage and vent system, and stormwater system within the building.
6. Sanitary sewerage system from building to points indicated.
7. Drainage specialties, including floor drains, cleanouts, etc.
8. Domestic hot water recirculating system within the building as indicated.
9. Natural gas piping to all equipment requiring gas. Terminate at heating equipment or water heating equipment with gas cock.
10. Electric heat trace for exposed piping.
11. Provide drains for HVAC equipment.
12. All excavation and backfilling required for the above work.
13. All pipe and fittings for the various systems.
14. All necessary valves, gas cocks and shutoffs.
15. All expansion joints, loops, anchors and guides.
16. All vibration bases, steel supports and hangers for all equipment and piping.
17. Insulation for piping and equipment as herein specified.
18. All plumbing fixtures as hereinafter specified, including handicapped fixtures compliance with the handicapped code.
19. All painting of pipe and equipment in the mechanical rooms and other unoccupied areas, and all painting of piping in no ceiling areas.
20. Flush all water pipe and disinfect as specified.
21. Setting of all sleeves and inserts in place.
22. Testing, adjusting and placing in service all systems and equipment installed.
23. Install all supply piping with adequate stops on each supply to all fixtures and or equipment to be connected to distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures and or equipment. Install stops in locations where they can be easily reached for operation.

    a. Exception: Use ball, gate, or globe valves if supply stops are not specified with fixture or equipment. Valves are specified in Divisions 22 and 23.

24. All plumbing fixtures, drains, floor drains, equipment, piping, fittings, valves, etc. shall be commercial grade for schools.

B. The above is presented for general guidance only and does not necessarily cover the entire requirement of the project as shown on the drawings and/or as specified hereinafter.

1.7 SCHEDULE OF WORK

A. The Contractor shall schedule all of his work to conform to the Job Progress Schedule as submitted by the General Contractor or Construction Manager, and approved by the A/E.

1.8 PREMIUM TIME WORK

A. The following work shall be performed at night or weekends other than holiday weekends, as directed and coordinated with the Owner:

1. Tie connections to all existing systems.
2. All work in the existing building finished space.

1.9 RELATED WORK SPECIFIED ELSEWHERE

A. The following related work items are included in separate Divisions as follows:

1. General Requirements – Division 01
2. Site Work – Division 02
3. Concrete – Division 03
4. Roof Flashing – Division 07
5. Painting – Division 09
6. HVAC – Division 23
7. Fire Protection – Division 21
8. Electrical – Division 26

B. The following items of work related to plumbing will be performed by others as follows:

1. The General Contractor shall provide all foundations and pads for equipment, paint all piping in finished areas, provide all base flashing on roof, build in all sleeves, unless otherwise noted.
2. The Electrical Contractor shall do all power wiring for plumbing equipment unless otherwise noted.
3. The General Contractor shall install all access panels furnished by the Plumbing Contractor.
4. The General Contractor shall install all roof drains provided by the plumbing contractor and indicated on the Plumbing Drawings.
5. The HVAC Contractor shall provide make-up water connections to heating and air conditioning equipment from valved outlets left by the Plumbing Contractor.

6. The HVAC Contractor shall provide drainage piping from his equipment to drains provided by the Plumbing Contractor.
7. The HVAC Contractor shall provide condensate drainage piping from all air conditioning equipment to points of connection provided by the Plumbing Contractor.
8. The Electrical Contractor shall furnish and install the emergency generator.

1.10 WORK AS A SUBCONTRACTOR

A. When the plumbing work is subcontracted, the exact scope of work may be limited or added to at the discretion of the General Contractor. A subcontractor shall, therefore, verify the extent of his work with the General Contractor.

1.11 INTERFERENCE WITH THE OWNER'S NORMAL OPERATION

A. All work shall be performed in such a manner as not to interfere with the normal work operations in adjacent spaces or buildings.

B. In no way shall the Contractor:

1. Block or restrict the means of egress for adjacent spaces.
2. Decrease the fire rating of walls, partitions, ceilings, doors or combination thereof of adjacent spaces or of means of egress.
3. Interrupt safety systems or in any way adversely affect the safety of people or materials in adjacent spaces.

C. The Contractor shall provide acoustical isolation of the work area via temporary doors, partitions, etc., adequate to allow normal work functions.

D. The Contractor shall provide exhaust fans, dust proof temporary partitions and any containment measure required to prevent dirt, dust, or fumes from reaching adjacent work spaces.

E. All personal traffic and material delivery shall be routed so as to absolutely minimize travel through adjacent work area.

F. For healthcare applications follow guidelines to limit infectious construction debris and duct in accordance with the job specific IERA Construction Containment Plan.

1.12 VISIT TO SITE

A. The Contractor shall visit the site and thoroughly acquaint himself with all existing conditions relative to type and source of service available. He shall verify location and extent of these services and consider routing, interferences and excavation required by the contract and any and all other difficulties that may be encountered.

B. Submission of a proposal shall be construed as evidence that such an examination has been made.

C. Failure to visit the site shall not constitute sufficient reason to warrant claims for extra monies for difficulties not apparent in the contract documents.

1.13 MANNING THE PROJECT

A. The Contractor shall, upon initiation of construction, keep a suitable force of men on the site at all times in order to lace all sleeves, inserts, outlet boxes, fixtures and provide all other openings as are required for the satisfactory installation of equipment.

1.14 FEES AND PERMITS

A. The Contractor shall secure all permits and pay all fees, required by local and state governing bodies, necessary to complete his phase of the construction. Failure to investigate all applicable payments before the bid submission shall not constitute grounds for additional monies from the Owner. The Owner shall be furnished with all certificates of approval.

B. The Contractor shall provide insurance and bonding as required by the Building Owner or as stated in the General Conditions.

1.15 CODES AND STANDARDS

A. The design, construction and installation of all materials and equipment shall be in compliance with the latest edition of all national, state and local codes or standards.

B. The codes and standards referred to are minimum standards. Where the requirements of these specifications and the accompanying drawings exceed those of the codes and standards, the drawings and specifications shall be followed.

1.16 BASIS OF DESIGN

A. The layout is based upon the use of particular items of equipment, identified by manufacturer's make and model number. Dimensions, arrangements and service connections required for these particular items have been considered in making the layout. The contractor may use the equipment of any manufacturer whose name is approved for substitution on that item of equipment after he had ascertained that all provisions of MATERIAL SUBSTITUTIONS will be complied with and that all required service connections will be made at no additional cost to the Owner.

B. Except where dimensions are shown, the drawings are diagrammatic and shall not be scaled. Exact location of fixtures, apparatus, duct work and piping shall be determined by dimensions on the site. Contractor shall refer to architectural plans and details for exact dimensions.

C. The drawings indicate the locations of apparatus, fixtures, and piping shall be followed as closely as possible. If before the installation it is found necessary to change the location to accommodate conditions at the building, such changes shall be made at no additional cost to the Owner, and as approved by the Architect/Engineer.

D. Equipment requiring operation, service or maintenance during the life of the system shall be made easily accessible.

E. Piping shall not be run within 48" of switchboards, panelboards or motor control centers.

F. No piping shall be run in the dedicated equipment space as defined in the N.E.C. (NFPA 70). The dedicated equipment space is the space equal to the width and depth of the equipment and extending from the floor to a height of 6ft. Refer to the National Electrical Code section 110.26 (E) for further information. No piping, ducts, sprinklers, leak protection apparatus, or other equipment foreign to the electrical installation shall be located in this zone. It is this contractor's responsibility to coordinate with the electrical contractor for all phases of this project.

G. Use of open-flame devices in work shall be accompanied by fire extinguishing apparatus within 25 feet of work location. Provide Fire Watch review of the work during each shift.

1.17 QUALITY OF MATERIALS

A. Where a specific model and manufacturer of equipment is specified, the Contractor shall provide what is specified without substitution. Where specified as "or approved equal", the Contractor may substitute equipment except that the burden is upon the Bidder to prove such equality. If the Bidder elects to prove such equality, he must request the Architect's approval in writing to substitute such item for the specified item, stating the cost difference involved with supporting data, and samples, if required, to permit a fair evaluation of the proposed substitute with respect to quality, serviceability, warranty and cost.

B. Where a specific model of equipment is specified along with an approval equal manufacturer, no substitution will be allowed. The Contractor shall submit one of the manufacturers listed.

C. Final approval of competitive equipment is reserved by the Engineer when, in the Engineer's opinion, the equipment does not correspond to that specified.

1.18 MATERIAL SUBSTITUTIONS

A. Material substitutions shall be allowed only where "or equal" is stated.

B. Material substitution submittals shall, include complete description of the proposed substitute, the name of the material or equipment for which it is to be substituted, drawings, cuts, performance, test data and evidence that the proposed manufacturer or his established representative maintains a qualified service organization including spare parts and is available for competent service on short notice.

C. Each bidder by submitting his bid represents that the proposal of such article, device, product, material, fixture, form or type of construction by name, make, catalog number of manufacturer which varies with the equipment specified shall be incorporated into the project without claims against the Owner for additional cost. The bidder shall be responsible for all additional costs incurred by others due to the substitutions.

D. The Architect/Engineer shall have the final approval of all submitted substitutions.

1.19 SUBMITTALS

A. Approval shall be obtained for all equipment and material before delivery to the job site. Delivery, storage or installation of equipment or material which has not had prior approval will not be permitted at the job site.

B. All submittals shall bear a stamp or notation indicating that the Contractor has reviewed and approved the submittals.

C. All submittals shall include adequate descriptive literature, catalog cuts, shop drawings and other data necessary to ascertain that the proposed equipment and materials comply with specification requirements. Catalog cuts submitted for approval shall be legible and shall clearly identify equipment being submitted.

D. Submittals shall be marked to show specification reference including the section and paragraph numbers.

E. Submit each section separately and include the following:

1. Information which confirms compliance with contract requirements. Include the manufacturer's name, model or catalog numbers, catalog information, technical data sheets, shop drawings, pictures, nameplate data and test reports as required.
2. Submittals on all pumps shall be complete with performance curves marked with the design points.
3. Submittals on electrical equipment shall be complete with all power and control wiring diagrams.
4. Vibration isolators shall include operating weight and load distribution at each mounting point.

F. The Contractor agrees that failure of manufacturer's submittal to conform to the above will result in a manufacturer's disqualification on this project.

G. Submit samples as directed of items called for in the specifications; samples of the materials which the manufacturer will actually ship shall be submitted for approval after award of contract and properly labeled on this project.

1.20 PRODUCT HANDLING

A. Following is in addition to Protection of Work and Property, General Requirements:

1. Responsibility for care and protection of mechanical work rests with the Contractor until it has been tested and accepted.
2. After delivery, before, during and after installation, protect equipment and materials against theft, injury and damage from all causes.

3. Protective covers, skids, plugs, caps and coating shall be provided to protect equipment materials from damage during construction.
4. All equipment and material shall be stored under cover and off the ground.
5. For outdoor storage, protective covers of sheet plastic shall be provided. Covers shall be of gauge required for the area involved and shall be reinforced to withstand wind, rain, sleet and snow. Equipment and material shall be set on skids or platforms of sufficient height to avoid deterioration from spattering and ground water.
6. Plug open ends of pipes when work is stopped to prevent debris from entering the pipes.
7. Protect plumbing fixtures and other equipment with enamel or glazed surface, from damage by covering and/or coating, as recommended in Bulletin "Handling and Care of Enameled Cast Iron Plumbing Fixtures," issued by Plumbing Fixture Manufacturers' Association.
8. Coat polished or plated metal parts with Vaseline immediately after installation.

B. The Contractor shall receive, properly house, handle, hoist, and deliver to proper location, equipment and other materials required for the contract.

C. In the event of damage, immediately make all repairs and replacements necessary to the approval of the Architect/Engineer and at no additional cost to the Owner.

1.21 COORDINATION DRAWINGS

A. Detailed layout shop drawings on all systems as required in Division 01 – Project Coordination, Division 21, 22, 23, and 26, must be coordinated with field erection drawings for Architectural, HVAC, Plumbing, Fire Protection, and Electrical Systems by the respective contractors.

B. Prepare coordination drawings for all areas by building, floor area and/or phase, of the project. Close attention should be implemented where limited space availability necessitates maximum utilization of space for efficient installation of different components.

C. Mechanical, Electrical and Plumbing Prime Contractors are responsible to prepare coordination drawings to a Scale of ¼" = 1'-0" or larger; detailing major elements, components, and systems of mechanical and electrical 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 limited to the following:

1. Proposed locations of ductwork, piping, conduit, equipment, and materials.
2. Clearances for installing and maintaining insulation.
3. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
4. Equipment connection and support details.
5. Exterior wall and foundation penetrations.
6. Fire rated wall, floor, ceiling, and roof penetrations.
7. Sizes and location of required concrete pads and bases.
8. Valve stem movement.
9. Sleeves.

D. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations. Clearly define relationships between sleeves, piping, ductwork, conduit, ceiling grid, lighting, fire sprinkler, HVAC equipment and other mechanical, plumbing, and electrical equipment with other components of the building such as beams, columns, ceilings, and walls.

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

F. Resolve conflicts between trades prepare composite coordination drawings and obtain signatures from all affected Prime Contractors on original composite drawings. Submit coordination drawings to the Architect/Engineer and Construction Manager for approval.

G. Mechanical, Electrical and Plumbing Prime Contractors are to first submit their respective shop drawings for approval, to the Architect/Engineer, in order to make any necessary changes prior to going through the coordination process.

H. Coordination drawings to be signed off by affected Contractors within 45 days of Notice to Proceed. A Coordination drawing timeline schedule shall be developed and tracked.

I. The coordination drawings shall be coordinated with the construction and phasing schedule.

J. The routing process will begin with the HVAC Contractor who shall take the lead in the coordination of their work with all affected trades.

K. The HVAC Contractor shall prepare CAD drawings to be used as the basis for coordination drawings in all areas or as determined by the Construction Manager (Scale: ¼" = 1'-0" or larger). These drawings shall be completed in digital format. All architectural features shall be accounted for in preparation of this drawing; i.e., permanent, casework, interior columns, partitions, finish ceiling and height, lighting and roof elevations, etc. The HVAC Contractor will provide CAD files and drawings showing all of the approved ductwork. HVAC Contractor is to locate all piping with orange lines. Forward drawings to the Plumbing Contractor.

L. The Plumbing Contractor is to locate the plumbing lines with blue lines and sprinkler lines and head locations with red lines, and resolve all conflicts and determine locations and elevations, and forward drawing to the Electrical Contractor.

M. The Electrical Contractor to indicate all lighting fixtures, panels with associated clearances, duct banks, bus duct, conduit racks and all individual conduits 1 ½" and larger in with green lines, and resolve all conflicts and determine locations and elevations and forward to the General Construction Contractor.

N. The General Construction Contractor will have the last coordination review. Provide overlaid coordination drawings for all General Construction work and resolve all conflicts. All architectural features shall be detailed clearly, i.e. permanent casework, interior columns, partitions, finish ceiling and roof elevations, etc. Provide a ceiling layout detailed coordination drawing showing ceilings, lights, diffusers, etc.

O. Contractors to provide underground coordination drawings for all underground utilities; show exact location of piping stub ups, floor drains, etc. as required.

P. Prime Contractors shall be responsible for all costs associated with creating CAD files.

Q. All coordination meetings will be held in the Construction Manager's field office or as required by the Architect/Engineer. As each coordination drawing is completed, Contractors are to meet with the Construction Manager to review and resolve all conflicts on the coordination drawings. Contractors are required to distribute shop drawings, cut sheets and submittals to other Prime Contractors where appropriate. Approved coordination drawings will also be available for reviewing at the Construction Managers field office.

R. All Contractors shall provide a hard copy of the coordination drawings for review by the Architect/Engineer.

S. Once complete and signed off, the HVAC, Plumbing and Electrical Contractors will submit dimensioned wall and slab penetration drawings and housekeeping pad drawings to the appropriate parties.

T. If the coordination drawing process is not complete, Mechanical, Electrical and Plumbing Contractors will provide wall penetration drawings to the General Construction Contractor no later than five (5) days prior to wall erection.

U. All Prime Contractors must install the work in accordance with the coordinated drawings at no additional cost to the Owner. No additional compensation will be made for extra ductwork offsets, piping and/or conduit or retrofit work due to improper component location, or lack of Contractor(s) coordination.

V. All Prime Contractors shall take special care in verifying with the Electrical Contractor that the equipment matches the characteristics of the power being supplied. The Electrical Contractor is similarly bound.

W. The Mechanical, Electrical and Plumbing Drawings are schematic in nature and are not intended to show every offset and detail. The Mechanical, Electrical and Plumbing Contractors will make adequate provisions in their bid to accommodate the actual conditions, provide all required ductwork, piping and conduit offsets per the coordination drawings, without additional cost to the Owner.

X. The Mechanical, Electrical and Plumbing Contractors shall hang streamers from all above ceiling equipment that will require access. This is in addition to any specification requirements for tags, labels, etc. Shop drawings should also highlight these areas for Architect/Engineer's review. In addition, the Contractors shall notify the Construction Manager and Architect/Engineer of all areas where equipment maintenance access is difficult. Coordinate architecturally placed access doors with points of mechanical/electrical systems requiring that access.

Y. Specific Requirements – Required Information to be provided on Coordination Drawings:

1. General Construction/Structural Work Information including but not limited to:

a. Openings and sleeve locations required in slabs, walls, beams, and other structural elements, including required openings not indicated on the Contract Documents.
b. Slab edge locations
c. Embed locations, as described above. Note embedded steel angles at edges of sump and sewage ejector pits, to accept basin covers.
d. Wall and chase spaces for housing HVAC, Plumbing, or Electrical items.
e. Access doors in coordination with the respective contractor systems.
f. Other specific/critical conditions unique to this Project, not noted above but necessary to assure proper coordination.

2. HVAC Work Information including but not limited to:

a. Sizes and bottom elevations of rectangular ductwork, including angle bracing, flanges, and support systems.
b. Sizes and centerline elevations of round ductwork, piping and conduit runs.
c. Acoustical lining in ductwork.
d. Identification of ductwork pressure class.
e. Dimensions of major components, such as dampers, valves, diffusers, registers, cleanouts, coils, VAV boxes, HVAC equipment, and electrical distribution equipment.
f. Fire-rated enclosures around ductwork.
g. Access panels required.
h. Other specific/critical conditions unique to this Project, not noted above but necessary to assure proper coordination.

3. Plumbing and Fire Protection Information including, but not limited to:

a. Sizes and centerline elevations of piping runs.
b. Locations of plumbing valves, equipment, and fixtures.
c. Locations of standpipes, floor control assemblies, fire hose valves, mains, piping, branch lines, pipe drops, sprinkler heads, fire pumps/controllers, and jockey pumps.
d. Other specific/critical conditions unique to this Project, not noted above but necessary to assure proper coordination.

4. Electrical Work Information including, but not limited to:

a. Runs of vertical and horizontal conduit, 1 ¼" diameter and larger
b. Light fixture locations
c. Exit light locations
d. Smoke detector and other fire alarm locations
e. Panelboards, switchboards, switchgear, transformers, busways, generators and motor control center, exit signs, and emergency battery pack locations.
f. Locations of pull boxes and junction boxes, dimensioned from column centerlines
g. Access panels required.
h. Other specific/critical conditions unique to this Project, not noted above but necessary to assure proper coordination.

5. Ceiling Systems and Plenum Space Information including, but not limited to:

   a. For HVAC, Plumbing, Fire Protection, Fire Alarm, Electrical, Controls and Telecommunications Work penetrating acoustical ceilings, show locations of each item (including sprinkler heads, diffusers, grilles, access doors, light fixtures, smoke detectors exit signs, speakers, and other visible ceiling mounted devices) relative to the acoustical ceiling grid.
   b. Locate components within ceiling plenums to accommodate layout of light fixtures indicated on Drawings. Clearly indicate areas of conflict between light fixtures and other components on Coordination drawings.
   c. Other specific/critical conditions unique to this Project, not noted above but necessary to assure proper coordination.

Z. The Sheet Metal Contractor shall prepare his work on reproducibles and submit 1/4" scale CAD drawings of the sheet metal duct field erection shop drawings for the coordination procedures, and each Contractor will supply the necessary qualified personnel for these procedures which will be conducted by the General Contractor. The HVAC, Plumbing and Fire Suppression work to the drawings where conflicts are noted and achieve solutions to any conflicts that may exist.

AA. The General Contractor will be required to signify his acceptance of the results of the coordination procedures by signing and dating the master coordination print.

BB. Each Contractor will be required to correct his field erection drawing(s) used as a basis for the coordination procedures to complement the results of the procedures prior to submitting same for approval. No field erection shop drawings will be accepted for approval without having been coordinated.

CC. As part of the coordination procedures, applicable "Approval" or "Approved as Noted" copies of other trades' shop drawings will be transmitted to the Contractor. It will be each Contractor's responsibility to check these shop drawings to ascertain what effect, if any, these shop drawings have on that portion of the work under his direct responsibility. Each contractor will advise the General Contractor within forty-eight (48) hours of receipt of the shop drawings, in writing, indicating receipt of same and whether or not they have any effect on the work of his contract.

1.22 ELECTRICAL

A. Power Wiring

1. For the purpose of this specification, power wiring shall be defined as follows:

   a. All wiring from the power source panelboards (or switchboard) to the disconnect switch to the equipment, and final connection to the equipment.
   b. All wiring to control panels as indicated in the Electrical and Plumbing Contract Documents. (All control panels not indicated on the Electrical Contract Documents as receiving power shall do so by jumpers from other control panels, this wiring shall be considered control wiring as defined below).

2. All power wiring from the power source to the above noted switches and wiring from these switches to the equipment, including final connection to same, shall be provided under Division 26, Electrical.

B. Control Wiring

1. All other wiring required, whether line voltage or low voltage, internal or external to provide for the operation of the equipment shall be considered as control wiring.
2. All control wiring throughout the building, including wiring installed at piping, or as specified shall be provided under this Division 22.

C. The Contractor shall furnish all motors, mounts, motor starters and remote mounted push-button controls for all electrically operated equipment furnished as part of the contract. The Contractor shall furnish all safety disconnects where described hereinafter. The Contractor shall furnish all speed control switches for all multi-speed motors. All motors shall have copper windings. (Aluminum windings will not be acceptable).

D. This Contractor is completely responsible for the coordination with all other trades as to the correct voltage for all equipment requiring power. Equipment and or changes required to meet the project voltages will be the responsibility of this contractor.

E. All push-button switches and starters shall be mounted under Division 26, Electrical.

F. The Contractor shall provide all controls and control devices, all mounting for controls and all other electrical devices as specified and necessary for the complete installation and satisfactory operation of all electrically operated controls furnished under this Division.

G. All locally mounted starters shall be furnished under Division 22, except as noted below. Where indicated hereinafter, starters shall be furnished as an integral part of equipment. Starters furnished in motor control centers shall be provided in Division 26, Electrical (refer to Electrical Drawings). Control of starters in motor control centers feeding plumbing equipment shall be provided under Division 23.

H. Starting equipment of each motor shall be of the proper voltage and HP rated for the motor it is to serve. All starters shall be of the enclosed type; NEMA Type 1, for general-purpose enclosures; NEMA Type 4 for watertight enclosures, and NEMA Type 12 for the dust-tight enclosures. Location of motor shall determine type of enclosure to be used.

I. Manual motor starters for single-phase motors shall be one or two poles as required, consisting of a snap switch combined with a thermal overload device. It shall be impossible for the switch to be held in a closed position under a sustained motor overload. For resetting the overload mechanism, the switch lever shall be of a design where it has to be moved to the "off" position. Starter shall be enclosed in type of enclosure for area in which it is to be used.

J. Magnetic starters for 3-phase motors shall be furnished with 110 volt holding coils, 120 volt fused transformers, normally open and normally closed auxiliary contact and overload relay heater elements in all three phases. Provide hand/off/auto selector switch along with running status lights and external reset button.

K. Locate starters and associated starter controls in accessible locations wherever possible. Location of starters for roof mounted equipment above ceilings shall be located at accessible locations above ceiling. Locations shall be coordinated with furniture and equipment layouts for the optimum accessible location for installation and maintenance means.

L. The Contractor shall be completely responsible for the coordination control system with control interlocks between various items of plumbing equipment.

1.23 SCAFFOLDING

A. The Contractor shall furnish and install scaffolding, ladders and runways required in connection with his work.

1.24 TEMPORARY OPENINGS

A. Temporary openings not indicated, which may be required for purpose of bringing equipment into building, shall be as approved. General Contractor will perform work of providing and maintaining openings, and of restoring structure; but Contractor for whom temporary openings are provided shall bear costs thereof, and for restoring structure. Ample notice shall be given of size and location of such openings by Contractor requiring same.

B. Holes provided in General Construction work to permit installation of lines for temporary services will, after removal of such lines, be patched as specified under Division 01.

1.25 TEMPORARY SERVICE

A. Temporary services are specified under Division 01, "General Requirements".

1.26 EXCAVATION

A. All excavation is unclassified. The Contractor shall inspect the site and make allowance in his bid for soil to be excavated since no compensation will be given where rock is encountered.

B. The Contractor, unless otherwise noted on the drawings, shall do all excavations for trenches, foundations, and pits of whatever kind necessary for the installation of this work. Bottom of trenches shall have the proper uniform grade wherever possible, or unless otherwise directed.

C. Trenches are to be excavated to the widths, lines and grades indicated on the drawings and/or specified in the appropriate sections of these specifications. Trenches for piping are to be excavated to a minimum width of one (1) foot plus the outside diameter of the pipe. The trench shall be excavated in a manner such that the pipe will be located in the center of the trench with the trench bottom having the proper uniform grade in the direction of flow. Trenches shall be deep enough to provide a minimum of four (4) feet fill over the piping except as may be otherwise indicated on the drawings.

D. In each excavation, trenches shall be carried to six inches below invert of pipe. Pipe shall be surrounded in all directions by a six-inch layer of selected crushed stone or gravel. If rock is encountered, carry trench to a point six inches below pipe invert. No pipe shall be bedded directly upon rock but shall be cushioned by a six-inch layer of selected crushed stone or gravel.

E. The Contractor shall do any shoring, bracing, etc., necessary to maintain the banks of his excavation, shall make good and damage done to property of adjoining premises or work of other contractors due to his failure to properly shore his excavation. The Contractor shall do all pumping required to keep his excavations free of water including rental of pumps, temporary power and labor.

F. All excavations shall be left open until work has been tested and inspected and approved by the Construction Manager/General Contractor. Sufficient time shall be allowed after notice is given that work is ready for inspection for making all examinations and tests. Under no circumstances shall excavated material be left even temporarily, where it will interfere with the building or other Contractor's operations.

G. Excavations which pass under or within eighteen (18) inches of columns or wall foundations shall be backfilled up to the level of columns or wall foundations with concrete mixed in proportions to one part cement, three parts sand and five parts coarse aggregate. Excavations shall not undermine foundations at a slope of 1:1 or greater.

H. All earth backfilling shall be made in layers not to exceed eight (8) inches and each layer shall be thoroughly tamped into place before the next layer is placed. Backfilling shall be clean earth, free of stone, pieces of concrete, rubbish and other foreign materials. Material frozen in lumps or material softer than the adjoining soil shall not be used in backfilling. The Contractor shall distribute on the premises as directed, all earth remaining after the backfilling.

I. Any necessary blasting shall be performed by experienced and competent personnel in the most careful manner. All local ordinances and laws relating to blasting and storing of explosives must be strictly observed. No explosives shall be stored in the project properly. All contractors shall be notified prior to any blasting.

J. Explosives used shall be subject to approval of the Architect. The blasting shall be properly covered with blasting mats.

K. Any rock encountered within five (5) feet of pipes of building walls shall be removed without blasting. Any blasting required shall be performed at such times as to meet reasonable request of the Architect.

L. The Contractor will do all patching of bituminous surfaces, concrete walks, driveways, streets, etc., necessary to complete his work. All patching shall match the existing surfaces. Painting shall be done by personnel skilled in their trades.

M. Provide adequate temporary crossovers for pedestrian and vehicular traffic including guard rails, lamps, and flags, as directed; remove same when necessity for such protection ceases.

1.27 CUTTING AND PATCHING

A. The Contractor shall provide all floor and wall cuts as required for piping penetrations of existing construction.

B. No cutting of bearing walls, beams, etc., shall be done without the approval of the Architect. All patching and finishing, etc., shall match the surroundings. All cutting and patching shall be done by workmen skilled in the trades and in the employ of the General Contractor for the project. All cutting shall be done with saw type edges to give a neat and workmanlike appearance. All pipe holes shall be core drilled unless specified otherwise.

C. Should it be necessary to do any cutting and patching due to the failure of this Contractor to give proper information to the General Contractor, it shall be done at the expense of the Plumbing Contractor.

1.28 PAINTING AND FINISHING

A. Except as specified herein, the finished painting of Plumbing Work within the building and on the roof shall be as specified under Division 09.

B. All mechanical equipment shall have a factory-applied prime and finish coat of paint. Galvanized surfaces shall be considered as finished surfaces for equipment rooms and items concealed from view. Plastic products shall be acceptable without a finish coat of paint. All items of equipment marred or rusted, even though factory finished, shall be repainted; steel angles and steel supports for ductwork, piping or miscellaneous equipment shall have a prime coat of paint before installation.

C. Paint all exposed piping, equipment, and trim that does not have a factory applied finish. Refer to Division 09 "Painting" for paint materials, surface preparation and application of paint. Paint shall be semi-gloss, acrylic-enamel paint. Coat components with two (2) coats of finish paint over two (2) coats of rust inhibitive metal primer or approved equivalent based on component type.

1.29 CONCRETE WORK

A. Concrete work shall be in accordance with Division 03.

1.30 SUSPENSION SUPPORT FOR EQUIPMENT

A. All pipes and equipment that are suspended shall be connected directly to the building steel. Where hangers are required between building steel points, supplementary steel members shall be added by the Contractor as required to adequately support the load.

B. Pipes and ducts shall not be supported from other pipes, ducts, or equipment.

C. Hangers from joists shall be attached at the panel points. Pipes and ducts with weights of 50 pound per foot (total for single or multiple runs) routed parallel with bar joists shall be supported from a minimum of 3 joists at each hanger point (channel members between joists).

1.31 ACCESS PANELS – BUILDING

A. Valves and equipment located concealed in walls or above ceilings, and are otherwise inaccessible shall be furnished with an access panel for each location. A hinged inconspicuous type access panel complete with frame, of such size and so located as to provide proper access for service and maintenance.

B. The minimum size of each access panel shall be 18" x 18" unless physical restraints require a smaller door.

C. Where such equipment is located above removable concealed spline push up type acoustical tile or metal pan ceilings, it shall be considered as accessible if the acoustical material is arranged for access to the space above the ceilings.

D. Access panels shall be Milcor "DW", or equal, for drywall locations and Milcor "K", or equal, elsewhere.

E. Panels and frames shall be prime painted.

F. Panels shall be furnished under this Division and installed under another Division of this Specification.

G. Panel material shall be steel except that construction shall be all aluminum in bathroom applications.

H. When access panels or doors are installed in fire rated construction, they shall be fire rated to match the construction.

1.32 FIRESTOP PENETRATION PROTECTION SEALING SYSTEM

A. Where pipes pass through fire partitions, firewalls, floors or ceilings, install a firestop that provides an effective barrier against the spread of fire, smoke, gases and water. Fire-stop material shall be packed tight, and completely fill clearances between pipe, sleeves and structure. All crack voids or holes (up to 4" diameter) shall be sealed using 3M brand Fire Barrier Caulk CP25 or putty 303 or an approved equal. Larger diameter or square holes, 3M system 7902, 7904, 7902R or 7904R or approved equal shall be in accordance with manufacturer's instructions.

B. Fire-stopping material shall maintain its integrity while preventing the passage of flame, smoke, gases or water. Fire-stopping material shall be a one-part, intumescent elastomer noncombustible, noncorrosive and compatible with synthetic cable jackets as defined by ASTM E814 (UL 1479); and in addition for insulation materials, melting points shall be a minimum of 1700 degrees F for one-hour protection and 1850 degrees F for 2-hour protection.

1.33 RECORD DRAWINGS

A. The Contractor shall furnish record as-built drawings to the Architect at completion and acceptance of the job. Transparencies of the original drawings with corrections shall be submitted as specified in the General Requirements.

B. Record all changes from installation originally indicated. Record final location of underground lines by depth from finished grade and by offset distances in feet and tenths to surface improvement such as buildings, curb, or edges of walks. Where work appears on two or more drawings, Contractor shall mark changes on all drawings. Contractor shall mark changes on all drawings. At completion, furnish the above required transparencies to the A/E for approval and record. Drawings shall be certified to be record of work installed and signed by the Contractor. Work shall not be accepted until such drawings have been delivered to the A/E.

1.34 GUARANTEE

A. In addition to the requirements stated in the specifications, the Contractor must guarantee all equipment, materials, and appurtenances installed by him to be free from all defects for a period of one year from date of final acceptance.

B. Upon written notice from the A/E, the Contractor shall promptly correct all defects without additional cost to the Owner. This Contractor shall adjust each part of the entire installation for proper working order. Reports are to be submitted to the A/E and adjustments repeated until the entire system is satisfactory. This Contractor must make good, at his own expense, any defects in materials or workmanship that may appear.

1.35 CLEAN UP

A. The Contractor shall be held responsible for the general clean up of all areas affected by the work in the Contract. All rubbish and accumulative material shall be removed from the premises and the premises left "broom clean" upon completion.

B. All stickers, rust, stains, labels and temporary covers shall be removed before final acceptance.

C. Foreign matter shall be blown, vacuumed or flushed out of piping, pumps, fans, motors, devices, switches, panels, and equipment.

D. Identification plates on equipment shall be free of excess paint and shall be polished.

1.36 OPERATION AND MAINTENANCE MANUALS

A. Submit to the Engineer for approval three manuals covering details of operation maintenance for all apparatus requiring service. The Contractor shall arrange formal instruction sessions by competent representatives of the manufacturer for the Owner's operating personnel to cover the following:

1. Service telephone number, fax number, websites, email addresses, business and service addresses and mobile telephone numbers of the installing contractor, and manufacturer and supplier and parts counters of pumps, water heaters, backflow preventers, and other components comprising the systems.
2. Manufacturer's operating and maintenance manuals, including detailed parts lists with numbers, power and wiring diagrams for each piece of equipment and accessory requiring services or maintenance, the guarantee period and the name, address and phone number of the nearest sales and service organization for each item. Both on print and CD's (min 3 copies) form (PDF/MS Word).
3. Cross out options that are not used on equipment sheets, highlight options selected.
4. Step-by-step procedure for starting, stopping, setpoint adjustment, monitoring and alarm enunciation for each system.
5. Copies of inspection certificates provided by the City, County, State and insurance companies.
6. Routine maintenance procedures for all plumbing equipment.

B. Obtain written statements from the Owner's representative acknowledging satisfactory completion of each item of the manuals.

1.37 INSTRUCTION TO OPERATIONAL PERSONNEL

A. Furnish the services of competent instructors to give full instruction to the designated Facilities personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system on the Contract Documents. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work.

B. Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Owner for regular operation. Provide 8 man-hours each of instruction for, pumps, water heaters, compressors, air dryers, vacuum pumps, and other equipment required by the Owner's personnel.

C. Instruction shall cover routine maintenance, wiring and power wiring diagrams and component analysis, preventative maintenance and scheduling, starting and stopping, alarm resets, trend-logging, setpoint adjustment, emergency and normal shutdown/startup, relative pressure control system for the morgue, alarm date stamping and all else required by the Owner for complete usage/maintenance/adjustment of equipment in their intended systems.

D. Obtain written statements from the Owner's representative acknowledging satisfactory completion of each item of instructions.

PART 2 - PRODUCTS - (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. Materials and equipment shall be in accordance with the specifications as outlined in each specification section describing plumbing components, fixture valves, piping, etc.

B. All components shall be according to ASTM, ANSI, CISPI, NFPA and Code standards.

C. Electrical equipment shall bear the underwriter label.

3.2 SITE INSPECTION

A. Before starting work under this section, carefully inspect the site and installed work of other trades and verify that such work is complete to the point where installation of materials and accessories under this section can begin.

B. Verify that all materials and accessories can be installed in accordance with project drawings and specifications and material manufacturers' recommendations.

C. Verify, by inspecting product labeling, submittal data, and/or certifications which may accompany the shipments, that all materials and accessories to be installed on the project comply with applicable specifications and standards and meet specified thermal and physical properties.

3.3 PROJECT MANAGEMENT AND COORDINATION

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

1. Schedule construction operations in sequence required to obtain the best results where installation of one part of the work depends on installation of other components, before or after its own installation.
2. Coordinate installation of different components with other contractors to ensure maximum accessibility for required maintenance, service, and repair.
3. Make adequate provisions to accommodate items scheduled for later installation.
4. Where availability of space is limited, coordinate installation of different components to ensure maximum performance and accessibility for required maintenance, service, and repair of all components, including mechanical and electrical.

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

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

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

1. Preparation of Contractor's Construction Schedule
2. Preparation of the Schedule of Values
3. Installation and removal of temporary facilities and controls
4. Delivery and processing of submittals
5. Progress meetings
6. Pre-installation conferences
7. Project closeout activities
8. Startup and adjustment of systems
9. Project closeout activities

D. Conservation: Coordinate construction activities to ensure that operations are carried out with consideration given to conservation of energy, water, and materials.

1. Salvage materials and equipment involved in performance of, but not actually incorporated into the work. Refer to other Sections for disposition of salvaged materials that are designated as Owner's property.

3.4 SUBMITTALS

A. Coordination Drawings: Prepare Coordination Drawings if limited space availability necessitates maximum utilization of space for efficient installation of different components or if coordination is required for installation of products and materials fabricated by separate entities.

1. Content: Project-specific information, drawn accurately to scale. Do not base Coordination Drawings on reproductions of the Contract Documents or standard printed data. Include the following information, as applicable:

   a. Indicate functional and spatial relationships of components of architectural, structural, civil, mechanical, and electrical systems.
   b. Indicate required installation sequenced.
   c. Indicate dimensions shown on the Contract Drawings and make specific note of dimensions that appear to be in conflict with submitted equipment and minimum clearance requirements. Provide alternate sketches to Architect for resolution of such conflicts. Minor dimension changes and difficult installations will not be considered changes to the Contract.

2. Number of Copies: Submit three opaque copies of each submittal. Architect, through Construction Manager, will return one copy.

   a. Submit five copies where Coordination Drawings are required for operation and maintenance manuals. Architect and Construction Manager will retain two copies; remainder will be returned. Markup and retain one returned copy as a Project Record Drawing.

3. Refer to individual Sections for Coordination Drawing requirements for work in those Sections.

B. Key Personnel Names: Within 15 days of starting construction operations, submit a list of key personnel assignments, including superintendent and other personnel in attendance at Project Site. Identify individuals and their duties and responsibilities; list addresses and telephone numbers, including home and office telephone numbers. Provide names, addresses, and telephone numbers of individuals assigned as standbys in the absence of individuals assigned to Project.

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

3.5 ADMINISTRATIVE AND SUPERVISORY PERSONNEL

A. General: In addition to Project Superintendent, provide other administrative and supervisory personnel as required for proper performance of the work.

3.6 PROJECT MEETINGS

A. General: Attend meetings and conferences at Project Site, unless otherwise indicated.

1. Agenda: Be prepared for the meeting agenda. Distribute the agenda to all invited attendees.
2. Minutes: Record significant discussions and agreements achieved. Distribute the meeting minutes to everyone concerned, including Owner and Architect, within three days of the meeting.

B. Preconstruction Conference: Attend a preconstruction conference before starting construction, at a time convenient to Owner, Construction Manager, and Architect, but no later than 15 days after execution of the Agreement. Hold the conference at Project site or another convenient location. Conduct the meeting to review responsibilities and personnel assignments.

1. Attendees: Authorized representatives of Owner, Construction Manager, Architect, and their consultants; Contractor and its superintendent; major subcontractors; suppliers; and other concerned parties shall attend the conference. All participants at the conference shall be familiar with Project and authorized to conclude matters relating to the work.
2. Agenda: Discuss items of significance that could affect progress, including the following:

a. Tentative construction schedule
b. Phasing
c. Critical work sequencing and long-lead items
d. Procedures for processing field decisions and Change Orders
e. Procedures for requests for interpretations (RFIs)
f. Procedures for testing and inspecting
g. Procedures for processing Applications for Payment

h. Submittal procedures
i. Preparation of Record Documents
j. Use of the premises and existing building
k. Work restrictions
l. Owner's occupancy requirements
m. Responsibility for temporary facilities and controls
n. Construction waste management and recycling
o. Parking availability
p. Office, work, and storage areas
q. Equipment deliveries and priorities
r. First aid
s. Security
t. Progress cleaning
u. Working hours

3. Minutes: Record and distribute meeting minutes.

C. Pre-installation Conferences: Attend a pre-installation conference at Project Site before each construction activity that requires coordination with other construction.

1. Attendees: Installer and representatives of manufacturers and fabricators involved in or affected by the installation and its coordination or integration with other materials and installations that have preceded or will follow, shall attend the meeting. Advise Architect and Construction Manager of scheduled meeting dates.

2. Agenda: Review progress of other construction activities and preparations for the particular activity under consideration, including requirements for the following:

a. The Contract Documents
b. Deliveries
c. Review of mockups
d. Possible conflicts
e. Time schedules
f. Manufacturer's written recommendations
g. Acceptability of substrates
h. Temporary facilities and controls
i. Coordination with other work
j. Protection of construction and personnel

3. Record significant conference discussions, agreements, and disagreements, including required corrective measures and actions.
4. Reporting: Distribute minutes of the meeting to each party present and to parties who should have been present.
5. Do not proceed with installation if the conference cannot be successfully concluded. Initiate whatever actions are necessary to resolve impediments to performance of the work and reconvene the conference at earliest feasible date.

D. Progress Meetings: Attend progress meetings at biweekly intervals. Coordinate dates of meetings with preparation of payment requests.

1. Attendees: In addition to representatives of Owner, Construction Manager, and Architect, each contractor, subcontractor, supplier, and other entity concerned with current progress or involved in planning, coordination, or performance of future activities shall be represented at these meetings. All participants at the conference shall be familiar with Project and authorized to conclude matters relating to the work.
2. Agenda: Review and correct or approve minutes of previous progress meeting. Review other items of significance that could affect progress. Include topics for discussion as appropriate to status of Project.

    a. Contractor's Construction Schedule: Review progress since the last meeting. Determine whether each activity is on time, ahead of schedule, or behind schedule, in relation to Contractor's Construction Schedule. Determine how construction behind schedule will be expedited; secure commitments from parties involved to do so. Discuss whether schedule revisions are required to ensure that current and subsequent activities will be completed within the Contract Time.

        1) Review schedule for next period.

    b. Review present and future needs of each entity present, including the following:

        1) Interface requirements
        2) Status of submittals
        3) Off-site fabrication
        4) Site utilization
        5) Hazards and risks
        6) Progress cleaning
        7) Status of correction of deficient items
        8) Requests for interpretations (RFIs)
        9) Status of proposal requests
        10) Pending changes
        11) Status of Change Orders
        12) Pending claims and disputes
        13) Documentation of information for payment requests

3. Minutes: Record the meeting minutes.
4. Reporting: Distribute minutes of the meeting to each party present and to parties who should have been present.

    a. Schedule Updating: Revise Contractor's Construction Schedule after each progress meeting where revisions to the schedule have been made or recognized. Issue revised schedule concurrently with the report of each meeting.

E. Equipment locations: All plumbing equipment shall be located to provide for manufacturer’s recommended clearances, clearance for routine maintenance, clearance per code requirements and locations/clearances required for removal/replacement in the future.

1. Manufacturer's recommended clearances shall include space for proper airflow and non-short circuiting airflow pathway (plumbing equipment, etc), clearance for pumps (18" minimum around pumps), 30" clearance or complete access door swings clearances for tube pulls (heat exchangers, coil pulls, etc); locate piping to be clear of these locations.

2. Provide minimum 36" clearance around water heaters, heat exchangers and other pressure vessels; note this is a minimum requirement, provide excess wherever possible. Provide minimum 48" clearance from power panels per the latest edition NEC having jurisdiction; include requirements for piping and ductwork at such locations.
3. Locate equipment in mechanical rooms to allow for future removal and replacement. Include heights to overhead piping where applicable. Wherever possible, clearances shall include removal/replacement as a whole entity without knock-down.
4. Access platforms with metal grating shall be provided for equipment located outdoors such for power and control panels for equipment located on dunnage. This access system shall provide for maintenance and requirements per codes having jurisdiction. Platforms shall include stairs and handrails per OSHA regulations.
5. Locate roof mounted equipment minimum 10' away from edges of roof. Where equipment is located closer, provide handrail system at roof edge as required per codes having jurisdiction. Maintain clearances from handrail system to power panels.
6. Locate air intakes 25' away from exhaust outlets and plumbing vents for healthcare facilities.
7. Locate air intakes for kitchen air intakes min 10' away from exhaust outlets and plumbing vents from kitchen exhaust fans.

3.7 CONNECTION TO EXISTING UTILITIES

A. If connecting to an existing piping system (water, gas, oil, sewer, steam, condensate, etc.). It shall be the responsibility of this contractor to verify the integrity of the piping system being connected. Coordinate all system shutdowns with the owner. All applicable testing and acceptance will apply.

B. Existing Pipe Testing: The contractor shall remove a section of piping at the point of connection between new and existing. The contractor shall determine the integrity of the existing piping after analysis of the piping section for tube wall thickness, scaling and corrosion. The analysis shall determine the ability for tie-in, pressure testing ability and remaining useful life. The contractor shall guarantee the piping integrity at the point of tie-in and subsequent acceptance. For existing piping not currently being used; the contractor shall pressure test in order to determine integrity and subsequent acceptance. Report all results in writing to the Architect/Engineer.

END OF SECTION 22 05 00

SECTION 22 05 10 - PLUMBING DEMOLITION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other and Division 22 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Demolition and removal of selected portions of Division 22 systems.
2. Salvage of existing items to be reused or recycled.

B. Related Sections include the following:

1. Division 22 Sections for demolishing, cutting, patching, or relocating plumbing items.

1.3 DEFINITIONS

A. Remove: Detach items from existing construction and legally dispose of them off-site, unless indicated to be removed and salvaged or removed and reinstalled.

B. Remove and Salvage: Detach items from existing construction and deliver them to Owner.

C. Remove and Reinstall: Detach items from existing construction, prepare them for reuse, and reinstall them where indicated.

D. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.4 MATERIALS OWNERSHIP

A. Except for items or materials indicated to be reused, salvaged, reinstalled, or otherwise indicated to remain Owner's property, demolished materials shall become Contractor's property and shall be removed from Project site.

1. Coordinate with Owner's personnel, who will establish special procedures for removal and salvage.

1.5 SUBMITTALS

A. Proposed Dust-Control and Noise-Control, Infectious Containment Measures: Submit statement or drawing that indicates the measures proposed for use, proposed locations, and proposed time frame for their operation. Identify options if proposed measures are later determined to be inadequate.

B. Schedule of Selective Demolition Activities: Indicate the following:

1. Detailed sequence of selective demolition and removal work, with starting and ending dates for each activity. Ensure Owner's building manager's and other tenants' on-site operations are uninterrupted.
2. Interruption of utility services. Indicate how long utility services will be interrupted.
3. Coordination for shutoff, capping, and continuation of utility services.
4. Use of elevator and stairs.
5. Locations of proposed dust- and noise-control temporary partitions and means of egress, including for other tenants affected by selective demolition operations.
6. Coordination of Owner's continuing occupancy of portions of existing building and of Owner's partial occupancy of completed Work.

C. Inventory: After selective demolition is complete, submit a list of items that have been removed and salvaged.

D. Predemolition Photographs or Videotapes: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by selective demolition operations. Comply with Division 1 Section "Photographic Documentation." Submit before Work begins.

E. Landfill Records: Indicate receipt and acceptance of hazardous waste by a landfill facility licensed to accept hazardous wastes.

1.6 QUALITY ASSURANCE

A. Demolition Firm Qualifications: An experienced firm that has specialized in demolition work similar in material and extent to that indicated for this Project.

B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning selective demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.

C. Standards: Comply with ANSI A10.6 and NFPA 241.

D. Predemolition Conference: Conduct conference at Project site to comply with requirements herein. Review methods and procedures related to selective demolition including, but not limited to, the following:

1. Inspect and discuss condition of construction to be selectively demolished.
2. Review structural load limitations of existing structure.

3. Review and finalize selective demolition schedule and verify availability of materials, demolition personnel, equipment, and facilities needed to make progress and avoid delays.
4. Review requirements of work performed by other trades that rely on substrates exposed by selective demolition operations.
5. Requirements of system downtime and scheduling with site personnel.

1.7 PROJECT CONDITIONS

A. Owner will occupy portions of building immediately adjacent to selective demolition area. Conduct selective demolition so Owner's operations will not be disrupted. Provide not less than 72 hours' notice to Owner of activities that will affect Owner's operations.

B. Maintain access to existing walkways, corridors, and other adjacent occupied or used facilities.

1. Do not close or obstruct walkways, corridors, or other occupied or used facilities without written permission from authorities having jurisdiction.

C. Owner assumes no responsibility for condition of areas to be selectively demolished.

1. Conditions existing at time of inspection for bidding purpose will be maintained by Owner as far as practical.

D. Hazardous Materials: It is not expected that hazardous materials will be encountered in the Work.

E. Storage or sale of removed items or materials on-site is not permitted.

F. Utility Service: Maintain existing utilities indicated to remain in service and protect them against damage during selective demolition operations.

1. Maintain fire-protection facilities in service during selective demolition operations.

1.8 WARRANTY

A. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during selective demolition, by methods and with materials so as not to void existing warranties.

1. If possible, retain original Installer or fabricator to patch the exposed Work listed below that is damaged during selective demolition. If it is impossible to engage original Installer or fabricator, engage another recognized experienced and specialized firm.

a. Processed concrete finishes.
b. Stonework and stone masonry.
c. Ornamental metal.
d. Matched-veneer woodwork.
e. Preformed metal panels.
f. Roofing.

g. Firestopping.
h. Window wall system.
i. Stucco and ornamental plaster.
j. Terrazzo.
k. Finished wood flooring.
l. Fluid-applied flooring
m. Aggregate wall coating.
n. Wall covering.
o. Swimming pool finishes.
p. HVAC enclosures, cabinets, or covers.

PART 2 - PRODUCTS

2.1 REPAIR MATERIALS

A. Use repair materials identical to existing materials.

1. If identical materials are unavailable or cannot be used for exposed surfaces, use materials that visually match existing adjacent surfaces to the fullest extent possible.
2. Use materials whose installed performance equals or surpasses that of existing materials.

B. Comply with material and installations requirements specified in individual Specification Sections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that utilities have been disconnected and capped.

B. Survey existing conditions and correlate with requirements indicated to determine extent of selective demolition required.

C. Inventory and record the condition of items to be removed and reinstalled and items to be removed and salvaged.

D. When unanticipated mechanical, electrical, or structural elements that conflict with intended function or design are encountered, investigate and measure the nature and extent of conflict. Promptly submit a written report to Architect/Engineer.

E. Engage a professional engineer to survey condition of building to determine whether removing any element might result in structural deficiency or unplanned collapse of any portion of structure or adjacent structures during selective demolition operations.

F. Perform surveys as the Work progresses to detect hazards resulting from selective demolition activities.

3.2 UTILITY SERVICES

A. Existing Utilities: Maintain services indicated to remain and protect them against damage during selective demolition operations.

B. Do not interrupt existing utilities serving occupied or operating facilities unless authorized in writing by Owner and authorities having jurisdiction. Provide temporary services during interruptions to existing utilities, as acceptable to Owner and to authorities having jurisdiction.

1. Provide at least 72 hours' notice to Owner if shutdown of service is required during changeover.

C. Utility Requirements: Locate, identify, disconnect, and seal or cap off indicated utility services and mechanical/electrical systems serving areas to be selectively demolished.

1. Owner, Building Manager, or Construction Manager will arrange to shut off indicated services/systems when requested by Contractor.
2. Arrange to shut off indicated utilities with utility companies.
3. If services/systems are required to be removed, relocated, or abandoned, before proceeding with selective demolition provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.
4. Cut off pipe or conduit in walls or partitions to be removed. Cap, valve, or plug and seal remaining portion of pipe or conduit after bypassing.

D. Utility Requirements: Refer to Division 21, 22, 23 and 26 Sections for shutting off, disconnecting, removing, and sealing or capping utilities. Do not start selective demolition work until utility disconnecting and sealing have been completed and verified in writing.

3.3 PREPARATION

A. Site Access and Temporary Controls: Conduct selective demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.

1. Comply with requirements for access and protection specified in Division 1 Section "Temporary Facilities and Controls."

B. Temporary Facilities: Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.

1. Provide protection to ensure safe passage of people around selective demolition area and to and from occupied portions of building.
2. Provide temporary weather protection, during interval between selective demolition of existing construction on exterior surfaces and new construction, to prevent water leakage and damage to structure and interior areas.
3. Protect walls, ceilings, floors, and other existing finish work that are to remain or that are exposed during selective demolition operations.

4. Cover and protect furniture, furnishings, and equipment that have not been removed.
5. Comply with requirements for temporary enclosures, dust control, heating, and cooling specified in Division 1 Section "Temporary Facilities and Controls."

C. Temporary Shoring: Provide and maintain shoring, bracing, and structural supports as required to preserve stability and prevent movement, settlement, or collapse of construction and finishes to remain, and to prevent unexpected or uncontrolled movement or collapse of construction being demolished.

1. Strengthen or add new supports when required during progress of selective demolition.

3.4 SELECTIVE DEMOLITION, GENERAL

A. General: Demolish and remove existing construction only to the extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations and as follows:

1. Proceed with selective demolition systematically, from higher to lower level. Complete selective demolition operations above each floor or tier before disturbing supporting members on the next lower level.
2. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction. Use hand tools or small power tools designed for sawing or grinding, not hammering and chopping, to minimize disturbance of adjacent surfaces. Temporarily cover openings to remain.
3. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.
4. Do not use cutting torches until work area is cleared of flammable materials. At concealed spaces, such as duct and pipe interiors, verify condition and contents of hidden space before starting flame-cutting operations. Maintain fire watch and portable fire-suppression devices during flame-cutting operations.
5. Maintain adequate ventilation when using cutting torches.
6. Remove decayed, vermin-infested, or otherwise dangerous or unsuitable materials and promptly dispose of off-site.
7. Remove structural framing members and lower to ground by method suitable to avoid free fall and to prevent ground impact or dust generation.
8. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.
9. Dispose of demolished items and materials promptly. Comply with requirements in Division 01 Section "Construction Waste Management."
10. Return elements of construction and surfaces that are to remain to condition existing before selective demolition operations begun.
11. Provide demolition on an on-going basis, schedule permitting. Demolition of existing systems or portions there to shall be performed without interruption of the operation of the central heating plant.
12. Remove demolition debris on a continuous and daily basis as work proceeds. Do not leave debris in the room.

13. Schedule and locate dumpster space as required by the project and coordinate location with Owner's personnel.
14. Remove from site boilers and other large pieces of equipment immediately upon movement. Coordinate schedule of removal trains and cranes with Owner's personnel so that removal minimizes impact on-site traffic movement.
15. Maintain the operation of the central heating plant due to requirements of site steam while demolition is in progress. Where conditions cannot be met, coordinate and schedule with Owner's personnel and other requirements to minimize down-time.

B. Reuse of Building Elements: Project has been designed to result in end-of-Project rates for reuse of building elements as follows. Do not demolish building elements beyond what is indicated on Drawings without Architect's approval.

C. Removed and Salvaged Items:

1. Clean salvaged items.
2. Pack or crate items after cleaning. Identify contents of containers.
3. Store items in a secure area until delivery to Owner.
4. Transport items to Owner's storage area designated by Owner.
5. Protect items from damage during transport and storage.

D. Removed and Reinstalled Items:

1. Clean and repair items to functional condition adequate for intended reuse. Paint equipment to match new equipment.
2. Pack or crate items after cleaning and repairing. Identify contents of containers.
3. Protect items from damage during transport and storage.
4. Reinstall items in locations indicated. Comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make item functional for use indicated.

E. Existing Items to Remain: Protect construction indicated to remain against damage and soiling during selective demolition. When permitted by Architect, items may be removed to a suitable, protected storage location during selective demolition and cleaned and reinstalled in their original locations after selective demolition operations are complete.

F. Concrete: Demolish in sections. Cut concrete full depth at junctures with construction to remain and at regular intervals, using power-driven saw, then remove concrete between saw cuts.

G. Masonry: Demolish in small sections. Cut masonry at junctures with construction to remain and at regular intervals, using power-driven saw, then remove concrete between saw cuts.

H. Concrete Slabs-on-Grade: Saw cut perimeter of area to be demolished, then break up and remove.

I. Resilient Floor Coverings: Remove floor coverings and adhesive according to recommendations in RFCI-WP and its Addendum.

1. Remove residual adhesive and prepare substrate for new floor coverings by one of the methods recommended by RFCI.

J. Roofing: Remove no more existing roofing than can be covered in one day by new roofing. Refer to applicable Division 7 Section for new roofing requirements.

K. Air-Conditioning Equipment: Remove equipment without releasing refrigerants or by properly reclaiming refrigerant before removal of equipment.

3.5 DISPOSAL OF DEMOLISHED MATERIALS

A. General: Except for items or materials indicated to be recycled, reused, salvaged, reinstalled, or otherwise indicated to remain Owner's property, remove demolished materials from Project site and legally dispose of them in an EPA-approved landfill.

1. Do not allow demolished materials to accumulate on-site.
2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
3. Remove debris from elevated portions of building by chute, hoist, or other device that will convey debris to grade level in a controlled descent.
4. Comply with requirements specified in Division 1 Section "Construction Waste Management."

B. Burning: Do not burn demolished materials.

C. Disposal: Transport demolished materials off Owner's property and legally dispose of them.

3.6 CLEANING

A. Clean adjacent structures and improvements of dust, dirt, and debris caused by selective demolition operations. Return adjacent areas to condition existing before selective demolition operations began.

END OF SECTION 22 05 10

SECTION 22 05 16 - EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Flexible pipe connections.

B. Expansion joints and compensators.

C. Pipe loops, offsets and swing joints.

D. Pipe guides.

E. Pipe anchors.

1.2 RELATED WORK

A. Division 22 – Scope or Work

B. Division 22 – Common Work Results for Plumbing

C. Division 22 – Plumbing Piping

D. Division 22 – Pipe Insulation Building Plumbing Systems

1.3 REFERENCES

A. Conform to Standards of Expansion Joint Manufacturer's Association.

1.4 DESIGN CRITERIA

A. Base expansion calculations on 40°F installation temperature to 210°F for hot water heating and 140°F for domestic hot water and glycol system, plus 30 percent safety factory.

1.5 SUBMITTALS

A. Submit shop drawings under provisions of Division 01 and 22.

B. Flexible pipe connector shop drawing data to include maximum allowable temperature and pressure rating, overall 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.

C. Expansion joint shop drawings to include maximum allowable.

1.6 QUALITY ASSURANCE

A. Engineering Responsibility: Design and preparation of Shop Drawings and calculations for expansion fittings and loops by a qualified professional engineer.

1. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of expansion fittings and loops that are similar to those indicated for this Project in material, design, and extent.

B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Flexonics

B. Metraflex

C. Keflex

D. Grinnell

2.2 FLEXIBLE PIPE CONNECTIONS

A. For steel piping construct with stainless steel inner hose and braided exterior sleeve.

B. For copper piping construct with stainless steel inner hose and braided exterior sleeve.

C. Use connectors suitable for minimum 125 psi WSP and 450°F and 200 psi WSG and 250°F.

D. Construct spool pieces to extract size for insertion of flexible connection.

2.3 EXPANSION JOINTS

A. Steel Piping 3 inch and Under: Stainless steel bellows type with anti-torque device, limit stops and internal guide, screwed ends except 3 inch which shall have flanged ends.

B. Steel Piping over 3 inch: External ring controlled type with hydraulically formed 2-ply stainless steel bellows, flanged ends.

C. Copper Piping: All bronze type with two-ply phosphor bronze bellows, anti-torque device limit stops, internal guides and solder joint end.

D. Use joints suitable for minimum 125 psi WSP and 400°F, and 200 psi WOG and 250°F.

2.4 PIPE GUIDES

A. Provide factory fabricated guides of heavy steel consisting of bolted two section outer cylinder and base with two section guiding spider bolted tight to pipe. Single guide and spiders to clear pipe and insulation and cylinder. Provide guides of length recommended by manufacturers to allow indicated travel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install flexible pipe connectors on pipes connected to equipment supported by vibration isolation.

B. Provide pipe guides at expansion locations so that movement takes place along axis of pipe only. Support guide from minimum two joists or beams.

C. Install connections between piping mains and terminal units at least four (4) pipe fittings including tee in the main.

D. Install expansion fittings according to manufacturer’s written instructions. Install expansion fittings in sizes matching pipe size in which they are installed. Align expansion fittings to avoid end-loading and torsional stress.

E. Install pipe bends and loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

F. Attach pipe bends and loops to anchors:

1. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer’s written instructions.

3.2 ANCHOR INSTALLATION

A. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.

C. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.

D. Install pipe anchors according to expansion fitting manufacturer's written instructions if expansion fittings are indicated.

E. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

3.3 PAINTING

A. Touching Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

END OF SECTION 22 05 16

SECTION 22 05 19 - PLUMBING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 WORK INCLUDED

A. Floor Drains

B. Backflow Preventers

C. Cleanouts.

D. Shock Absorbers

E. Hose Bibbs

F. Pressure gauges

G. Strainers

H. Silent check valve

I. Flap valve

J. Access valve boxes

1.3 RELATED WORK

A. Division 22 – Common Work Results for Plumbing

B. Division 22 – Plumbing Piping

C. Division 22 – Pipe Insulation Building Plumbing System

D. Division 22 – Plumbing Equipment

1.4 REFERENCES

A. ANSI A112.21.1 - Floor Drains.

B. ANSI A112.21.2 - Roof Drains

1.5 QUALITY ASSURANCE

A. Manufacturer: For each product specified, provide components by same manufacturer throughout.

1.6 SUBMITTALS

A. Submit shop drawings and product data under provisions of Division 01 and 22 – Common Work Results for Plumbing.

B. Include component sizes, rough-in requirements, service sizes and finishes.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS - FLOOR DRAINS / PROMENADE DECK DRAINS

A. J.R. Smith

B. Zurn

C. Wade

2.2 FLOOR DRAINS

A. Type (A) Floor Drains: ANSI A112.21.1: Duco-coated cast-iron two-piece body with double drainage flange, weep holes, reversible clamping collar, and round adjustable nickel-bronze strainer, trap primer connection, heel-proof strainer; Model 2005-A-HP-P050 manufactured by J.R. Smith.

2.3 SHOCK ABSORBER DEVICES

A. Provide where indicated or required, shock absorbing devices which will protect water supply piping from water hammer. They shall be one of the following types and manufacturers:

1. Sealed air chamber metal bellows type shall be Smith "Hydrotrol", Wade Mfg. Co., "Wade Wacor Shock Stop", or Zurn Mfg. Co. "Shocktrol".
2. Elastic tube and insert type shall be Josam Mfg. Co., "Shock Absorber".
3. Provide adequate support for shock absorbing devices, as approved, to prevent stain on piping.

2.4 HOSE BIBBS, HOT AND COLD, (SEE DRAWINGS)

2.5 STRAINERS (NON-WATER METER USE)

A. Provide pipeline strainers at inlets to pressure reducing valves, temperature regulating valves, at other points where indicated.

B. Strainers shall be Y pattern, full size of connecting pipe. Strainers screens shall be brass or other corrosion resistant metal with perforations as recommended by the manufacturer for the intended service. Strainer screens shall be removable without disconnecting any piping.

C. Bodies on strainers 2 inches in size and smaller shall be bronze screwed design for 250 psi maximum pressure. Larger strainers shall have iron bodies designed for a working pressure of not less than 125 psi. Each strainer shall be provided with a brass plug.

D. Strainers shall be Sarco, Leslie Co., or Power Regulator Co.

2.6 SILENT CHECK VALVE

A. Wafer style silent check valves shall be of silent operating type that closes as flow is reduced and fully closes at zero velocity stopping reverse flow which reduces or eliminate water hammer stock.

B. The valve design shall incorporate a center guided, spring loaded poppet, guided at opposite ends and having a short linear stroke that generates a flow area equal to that of the pipe size.

C. The valve shall operate equally well in the vertical or horizontal position with the flow up or down.

D. All component parts shall be field replaceable and without the need of special tools. A replaceable guide bushing shall be provided and held in position by the valves spring. The cracking pressure shall be less than 1 psi.

E. The valve disc shall be convex in sizes up to 6” and concave in 8” and larger to the flow direction providing for disc stabilization, maximum strength and a minimal flow velocity to open the valve.

F. When specified, a rubber seal shall be furnished to provide a drip tight seal. The rubber seal shall be glued or chemically adhered.

G. Ductile Iron valve bodies shall be coated inside and out with NSF/ANSI 61 certified fusion epoxy.

H. The valve shall be equal in all respects to the Model 888/888R as manufactured by the Flomatic Corporation.

I. Silent Check Valve Ordering Information is as followed:

1. Quantity:
2. Type: 888, ST, S6, 888R, STR & S6R

3. Size: Available 2" thru 10"
4. Body Material: Stainless Steel
5. Internal Materials: Stainless Steel
6. End Type: ANSI class 125# or 250#
7. Seat Ring: Metal-to-Metal or Rubber

2.7 BACKFLOW PREVENTER DEVICES

A. Install a backflow prevention device at any point in the plumbing system where the potable water supply comes in contact with a potential source of contamination. Listed below is a partial list of connections to the potable water system which shall be protected against backflow or back siphonage.

B. Reduced pressure backflow preventer:

1. Incoming water service, connections to HVAC make-up water, pressure washer.

C. Dual check backflow preventer:

1. Water supply to ice makers, coffee makers, refrigerator and water coolers.

D. Atmospheric Vacuum Breaker:

1. Hose bibbs and sinks with threaded outlets.

E. Anti-Siphon Vacuum Breakers shall be Model No. 288A, No. 84, No. NF8 as manufactured by Watts, or approved equal.

F. Reduced-Pressure Zone Backflow Preventers (Incoming Domestic Water Service) shall be an ASSE 1047, FM approved, UL listed, and suitable for continuous pressure application. Include outside screw and yoke gate valves on inlet and outlet, and strainer on inlet. Include test cocks, pressure-differential relief valve with ASME A112.1.2 air-gap fitting located between two positive-seating check valves and reduced-pressure backflow preventer. These units shall be Watts Model No. 909, Wilkins or Ames.

G. Reduced pressure backflow preventers (HVAC make-up connections) shall be of bronze body construction, stainless steel internal parts and flange bolts, durable tight seating rubber check valve assembly, suitable for supply pressure up to 175 psi and for water temperature up to 210 degrees F furnished complete with strainer, test cocks and ball valves and shall conform to A.S.S.E. Standard 1013, Series 009QT as manufactured by Watts Regulator Co., Wilkins or Ames

H. The dual check backflow preventer shall meet the domestic requirements of ANSI/ASSE Standard 1024, and bear the seal of approval. It shall be bronze-bodied and include not less than one union, with the union nut drilled to accept a tamper-proofing lock wire. A brass identification tag indicating direction of flow shall be securely attached to the valve body by corrosion-resistant mechanical fasteners. The Lead Free* Dual Check Valve shall comply with state codes and standards, where applicable, requiring reduced lead content. The dual check shall be Watts Series LF7.

2.8 ACCEPTABLE MANUFACTURERS - CLEANOUTS

A. J.R. Smith

B. Zurn

C. Wade

2.9 CLEANOUTS

A. Pool Area: Zurn EZ1 Floor Cleanout, PVC solvent weld body, with gas and watertight threaded tapered plug and top assembly. EZ1 cleanout series is engineered to simplify product installation, comprised of concrete shield, up to 7/8" [22] of vertical post pour adjustment, pre-packaged shims for tilt correction, and integrated self-contained square or round light duty scoriated cover in stainless steel with rough-in cover for protection during the concrete pour. Cleanout is designed in accordance with ASME A112.36.2M. Model EZC-PV(3 or 4)-R6-SS.

B. Interior Finished Floor Areas: Duco-coated cast-iron, two-piece body and adjustable nickel-bronze scoriated cover in service areas and square with depressed cover to accept floor finish in finished floor areas; Model 4020 and Model 4200 manufactured by J. R. Smith.

C. Interior Finished Wall Areas: Line type with Duco-coated cast iron body and round epoxy coated gasketed cover, and round stainless-steel access cover secured with machine screw; Model 4452 manufactured by J. R. Smith.

D. Interior Unfinished Accessible Areas: Caulked or threaded type. Provide bolted stack cleanouts on vertical rainwater leaders.

2.10 ROOF STACK TERMINATION

A. Provide sleeves for stacks passing through roof. Flashing around base of stack shall be under Division 07.

2.11 FLAP VALVE, FOR RPZ DRAIN TERMINATION AT EXTERIOR WALL, (SEE DRAWINGS)

A. Duco Cast Iron Body with backwater flap valve. Back water valve flapper set at factory to hang in closed position. JR Smith model 7070 (basis of design), Zurn, or Wade.

2.12 PRESSURE GAUGES (SEE DRAWINGS)

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate cutting of floor construction to receive drains to required invert elevations.

3.2 INSTALLATION AND APPLICATION

A. Install specialties in accordance with manufacturer's instructions to permit intended performance.

B. Extended cleanouts to finished floor or wall surface. Lubricate threaded cleanout plugs with mixture of graphite and linseed oil. Ensure clearance at cleanout for rodding of drainage system.

3.3 CLEANOUTS, TEST TEES, ACCESS COVERS

A. Each vertical soil, waste and vent pipe and each downspout and roof drainage pipe which connects to horizontal drain piping below ground shall be fitted with test tees installed above the ground or floor. Where accessible space is available test tees may be installed in the horizontal pipe at the base of the vertical pipe.

B. Provide cleanouts where indicated and even if not indicated in the following locations.

1. At points of change in direction of horizontal drains.
2. At intervals of 50 feet in long horizontal drains of 4" diameter or less and no more than 80 feet apart for larger pipes.
3. At ends of branch drains where possible.
4. At or close to base of soil and waste stacks.

C. Cleanouts shall be installed in locations which shall make them accessible for easy removal and which will provide clearance for rodding.

D. All cleanouts shall be full size of pipe up to four inches (4") in diameter and four inches (4") for larger pipe size.

END OF SECTION 22 05 19

SECTION 22 05 29 - HANGERS & SUPPORTS FOR PLUMBING & EQUIPMENT

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This Section includes hangers, supports, anchors, sleeves, seals, flashing and sealing for mechanical system piping and equipment.

1.2 RELATED WORK

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

B. Related Sections include:

1. Division 05 Section "Metal Fabrications" for materials for attaching hangers and supports to building structure.
2. Division 21 Sections on fire-suppression piping for fire-suppression pipe hangers.
3. Division 22 Section "Plumbing Systems Vibration Controls and Seismic Restraints" for vibration isolation and seismic restraint devices.

1.3 REFERENCES

A. ASTM A 36/A 36M-00a: Specification for Carbon Structural Steel

B. ASTM A 780-00: Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

C. ASTM C 533-95: Specification for Calcium Silicate Block and Pipe Thermal Insulation

D. ASTM C 552-00 (Revised 2001): Specification for Cellular Glass Thermal Insulation

E. ASTM C 1107-99: Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink)

F. ASME B31.9-96: Building Services Piping

G. 2001 ASME Boiler and Pressure Vessel Code: Section II, “Materials”; Section IX, “Welding and Brazing Qualifications”

H. AWS D1.1-00: Structural Welding Code – Steel

I. MSS SP-58-93: Pipe Hangers and Supports – Materials, Design and Manufacture

J. MSS SP-69-96: Pipe Hangers and Supports – Selection and Application

K. MSS SP-89-98: Pipe Hangers and Supports – Fabrication and Installation Practices

L. MSS SP-90-00: (Reaffirmed 1991): Guidelines on Terminology for Pipe Hangers and Supports

M. MFMA-3-99: Metal Framing Standards Publication

N. MFMA-102-99: Guidelines for the Use of Metal Framing

O. SSPC-PA 1-2000: Paint Application Specification No. 1: Shop, Field and Maintenance Painting

P. IAPMO PS 42-96: Pipe Alignment and Secondary Support Systems

1.4 DEFINITIONS

A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.5 PERFORMANCE REQUIREMENTS

A. Design channel support systems for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

B. Design heavy-duty steel trapezes for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

C. Design seismic restraint hangers and supports for piping and equipment.

1.6 SUBMITTALS

A. Product Data: For each type of pipe hanger, channel support system component, and thermal-hanger shield insert indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer for multiple piping supports and trapeze hangers. Include design calculations and indicate size and characteristics of components and fabrication details.

C. Welding Certificates: Copies of certificates for welding procedures and operators.

1.7 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Engineering Responsibility: Design and preparation of Shop Drawings and calculations for each multiple pipe support, trapeze, and seismic restraint by a qualified professional engineer.

1. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of hangers and supports that are similar to those indicated for this Project in material, design, and extent.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Pipe Hangers:

a. B-Line Systems, Inc.
b. Carpenter & Patterson, Inc.
c. Grinnell Corp.

2. Channel Support Systems:

a. B-Line Systems, Inc.
b. Grinnell Corp.; Power-Strut Unit.
c. Unistrut Corp.

3. Thermal-Hanger Shield Inserts:

a. Carpenter & Patterson, Inc.
b. Michigan Hanger Co., Inc.
c. Pipe Shields, Inc.

4. Powder-Actuated Fastener Systems:

a. Gunnebo Fastening Corp.
b. Hilti, Inc.
c. ITW Ramset/Red Head.
d. Masterset Fastening Systems, Inc.

2.2 MANUFACTURED UNITS

A. Pipe Hangers, Supports, and Components: MSS SP-58, factory-fabricated components. Refer to "Hanger and Support Applications" Article in Part 3 for where to use specific hanger and support types.

1. Galvanized, Metallic Coatings: For piping and equipment that will not have field-applied finish.

2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

B. Channel Support Systems: MFMA-2, factory-fabricated components for field assembly.

1. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

C. Thermal-Hanger Shield Inserts: 100-psi minimum compressive-strength insulation, encased in sheet metal shield.

1. Material for Cold Piping: ASTM C 552, Type I cellular glass with vapor barrier.
2. Material for Hot Piping: ASTM C 552, Type I cellular glass.
3. For Trapeze or Clamped System: Insert and shield cover entire circumference of pipe.
4. For Clevis or Band Hanger: Insert and shield cover lower 180 degrees of pipe.
5. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.3 MISCELLANEOUS MATERIALS

A. Powder-Actuated Drive-Pin Fasteners: Powder-actuated-type, drive-pin attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

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

D. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged, non-shrink and nonmetallic, dry, hydraulic-cement grout.

1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.
2. Properties: Non-staining, noncorrosive, and nongaseous.
3. Design Mix: 5000-psi, 28-day compressive strength.

2.4 HANGER RODS

A. Steel Hanger Rods: Threaded both ends, threaded one end, or continuous threaded.

2.5 INSERTS

A. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustable, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit hanger rods. Inserts not allowed on piping 2 inches and larger.

2.6 FLASHING

A. Metal Flashing: 26 gauge galvanized steel.

B. Lead Flashing: 5 lb./sq. ft. sheet lead for waterproofing; one lb./sq. ft. sheet lead for soundproofing.

C. Flexible Flashing: Thick sheet butyl; compatible with roofing.

D. Caps: Steel, 22 gauge minimum; 16 gauge at fire resistant elements.

2.7 SLEEVES

A. Sleeves for Pipes: Schedule 10, black steel.

B. Sleeves for Ductwork: 18 gauge, black steel.

C. Fire Stopping Insulation: Glass fiber type, non-combustible.

D. Caulk: Acrylic sealant.

2.8 FABRICATION

A. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.

B. Design hangers without disengagement of supported pipe.

C. Provide copper plated hangers and supports for copper piping.

2.9 SEALS

A. Mechanical Type; Inter-locking synthetic rubber links; pressure plates and compression bolts. Include sleeve from same manufacturer.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger requirements are specified in Sections specifying equipment and systems.

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

C. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Adjustable Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
7. Adjustable Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
9. Adjustable Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipe, NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.

19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

D. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

E. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

F. Building Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.

11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): 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. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where head room is limited.

G. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe, 360-degree insert of high-density, 100-psi minimum compressive-strength, water-repellent-treated calcium silicate or cellular-glass pipe insulation, same thickness as adjoining insulation with vapor barrier and encased in 360-degree sheet metal shield.

H. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): 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.

3.2 HANGER AND SUPPORT INSTALLATION

A. Pipe Hanger and Support 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. Channel Support System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled channel systems.

1. Field assemble and install according to manufacturer's written instructions.

C. Heavy-Duty Steel Trapeze Installation: Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated, heavy-duty trapezes.

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 D-1.1.

D. Install building attachments within concrete slabs or attach to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, and expansion joints, 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.

E. Install powder-actuated drive-pin fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.

F. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

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

J. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping," is not exceeded.

K. 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 B31.9.

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 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.

L. Supports shall secure pipes in place, shall prevent pipe vibration, maintain required grading by proper adjustment, provide for expansion and contraction and shall make a neat appearance. Supports shall be of strength and rigidity to suit loading, service and installed in a manner in which will not stress unduly the building construction. Hangers shall not be permitted from roof and floor slabs. Fasten hangers and supports to building framing wherever practicable. Where required, add supplementary steel members to support piping. Hangers shall be capable of vertical adjustment after piping is erected. Hanger rods shall not pierce ducts.

1. Support horizontal piping of steel as per following schedule:

Pipe Size (Inches)	Rod Diameter (Inches)	Max. Spacing (Feet)
Up to 1-1/2	3/8	6
2 and 3	1/2	10
4 and 5	5/8	12
6	3/4	12
8, 10 and 12	7/8	14

For horizontal piping larger than 12 inches, support piping from building steel at point indicated on drawings.

2. Support horizontal copper tubing as per following schedule:

Pipe Size (Inches)	Maximum Spacing (Feet)
Up to 1-1/2	6
2 to 3	10
3-1/2 and larger	12

Rod diameter shall be the same as specified for steel pipe. Support plastic piping in accordance with manufacturer's published recommendations.

3. Vertical Piping Supports

   a. Cast Iron and Steel: Support at each floor with a maximum spacing of 20 feet and not exceeding eight feet from ends of risers, unless otherwise required by expansion conditions.
   b. Copper Tubing: Support at each floor and between floors by stays or bracing to prevent rattling and vibration, unless otherwise required by expansion conditions.
   c. Plastic and Glass: Support in accordance with published manufacturer's recommendations.
   d. Support vertical lines which rise from lowest story with base fitting set on concrete or brick pier, or by hangers located on horizontal connections to riser.
   e. Bolt pipe riser clamps securely to pipe; rest clamp and extension on building structure. In special cases where directed, weld clamp to pipe and to building steel. Where required, provide supplementary steel members for clamp rest.

3.3 FLASHING

A. Provide flexible flashing and metal counter flashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.

B. Flash vent and soil pipes projecting 3 inches minimum above finished roof surface with lead worked one-inch minimum into hub, 8 inches sheet clear on sides with 24 x 24 inches sheet size. For pipes through outside walls, turn flanges back into wall and caulk metal counter flash and seal.

C. Seal floor, shower and mop sink drains watertight to adjacent materials.

D. Provide curbs for mechanical roof installations 14 inches minimum high above roofing surface. Flexible sheet flash and counter flash with sheet metal; seal watertight.

3.4 SLEEVES

A. Provide sleeves at all pipe penetrations of floor and walls.

B. Extend sleeves through floors one inch above finished floor level. Grout sleeves in place. Staff joint with fire stop insulation and caulk seal airtight.

C. Duct penetrations of non-rated floors and walls shall have the edge joint stuffed with insulation and the caulk sealed, airtight. No sleeve is required.

D. Duct penetrations of rated partitions and floor shall be sleeved with 12 gauge galvanized steel as per UL fire damper detail. Caulk all floor penetrations watertight between the floor and sleeve with fireproof caulk, airtight.

E. Install chrome plated steel escutcheons at finished surface.

F. Use mechanical seals at exterior wall pipe penetrations below grade.

3.5 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure above or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

3.6 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes and equipment supports.

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

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.7 ADJUSTING

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

3.8 PAINTING

A. Touching Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

C. Ceiling Plates: Where hanging rods or piping leave unsightly holes in ceilings in finished areas, provide plastic ceiling plates, Grinnell Figure 127 or cast-iron ceiling plates with setscrew, Grinnell Figure 395.

END OF SECTION 22 05 29

SECTION 22 05 53 - IDENTIFICATION FOR PLUMBING PIPING & EQUIPMENT

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This Section includes the following mechanical identification materials and their installation:

1. Equipment nameplates.
2. Access panel and door markers.
3. Pipe markers.
4. Valve tags.
5. Valve schedules.
6. Warning tags.

1.2 RELATED WORK

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. ASTM C 1036-91 (Reapproved 1997): Specification for flat glass.

B. ASTM D 709-92 (Reapproved 1997): Specification for laminated thermo-setting materials.

C. ASME A13.1-96: Scheme for the identification of piping systems.

1.4 SUBMITTALS

A. Submit product data.

B. Submit list of wording, symbols, letter size and color coding for mechanical identification.

C. Submit valve chart and schedule, including valve tag number, location, function and valve manufacturer’s name and model number. (also include maintenance manuals)

D. Submit manufacturer’s installation instructions.

1.5 QUALITY ASSURANCE

A. ASME Compliance: comply with ASME A13.1, “Scheme for the Identification of Piping Systems”, for letter size, length of color field, colors and viewing angles of identification devices for piping.

1.6 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with location of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Color: Unless specified otherwise, conform the ANSI/ASME A13.1.

B. Plastic Nameplates: Laminated three-layer plastic with engraved black letters on light contrasting background.

C. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.

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

2.2 EQUIPMENT IDENTIFICATION DEVICES

A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.

1. Data:

a. Manufacturer, product name, model number and serial number.
b. Capacity, operating and power characteristics and essential data.
c. Labels of tested compliances.

2. Location: Accessible and visible.
3. Fasteners: As required to mount on equipment.

B. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive.

1. Terminology: Match schedules as closely as possible.
2. Data:

a. Name and plan number.
b. Equipment service.
c. Design capacity.
d. Other design parameters such as pressure drop, entering and leaving conditions and speed.

3. Size: 2-1/2 by 4 inches for control devices, dampers and valves; 4-1/2 by 6 inches for equipment.

C. Access Panel and Door Markers: 1/16-inch-thick, engraved laminated plastic with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch center hole for attachment. Markers for chemical fume or bio-hazard service shall be labeled accordingly.

1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.3 PIPING IDENTIFICATION DEVICES

A. Manufactured Pipe markers, General: Preprinted, color-coded, with lettering indicating service and showing direction of flow.

1. Colors: Comply with ASME A13.1, unless otherwise indicated.
2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
3. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers extending 360 degrees around pipe at each location.
4. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or strip-type markers at least three times letter height and of length required for label.
5. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.

B. Pre-tensioned Pipe Markers: Pre-coiled semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive.

C. Shaped Pipe Markers: Preformed semi-rigid plastic formed to partially cover circumference of pipe and to attach to pipe with mechanical fasteners that do not penetrate insulation vapor barrier.

2.4 VALVE TAGS

A. Valve Tags: Stamped or engraved with ¼-inch letters for piping system abbreviation and ½-inch numbers, with numbering scheme approved by Architect. Provide 5/32-inch hole for fastener.

1. Material: 0.032-inch-thick brass.
2. Valve-Tag Fasteners: Brass S-hook.

2.5 VALVE SCHEDULES

A. Valve Schedules: For each piping system, on standard-size bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.
2. Frame: Extruded aluminum.
3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

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: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.
4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

A. Products specified are for applications referenced in Division 22 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

3.2 EQUIPMENT IDENTIFICATION

A. Install and permanently fasten equipment nameplates on each major item of plumbing equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:

1. Fuel-burning units, including boilers, water heaters, heaters, stills, and absorption units.
2. Pumps, compressors, and similar motor-driven units.
3. Heat exchangers, coils, heat recovery units, and similar equipment.

B. Install equipment markers with permanent adhesive on or near each major item of mechanical equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated.

1. Letter Size: Minimum 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.
2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
3. Locate markers where accessible and visible. Include markers for the following general categories of equipment:

    a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
    b. Fire department hose valves and hose stations.
    c. Meters, gages, thermometers, and similar units.
    d. Fuel-burning units, including boilers, water heaters, heaters and stills.
    e. Pumps, compressors and similar motor-driven units.
    f. Heat exchangers, coils, and similar equipment.
    g. Tanks and pressure vessels.
    h. Strainers, filters, water-treatment systems, and similar equipment.

C. Install access panel markers with screws on equipment access panels.

3.3 PIPING IDENTIFICATION

A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.

1. Pipes with OD, Including Insulation: Pre-tensioned pipe markers. Use size to ensure a tight fit.

B. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior non-concealed 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 non-accessible 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 markers.

3.4 VALVE-TAG INSTALLATION

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

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following:

1. Valve-Tag Size and Shape:

    a. Cold Water: 1-1/2 inches round.
    b. Hot Water: 1-1/2 inches round.
    c. Gas: 1-1/2 inches round.
    d. Compressed air: 1-1/2 inches round.

2. Valve-Tag Color:

    a. Cold Water: Natural
    b. Hot Water: Natural
    c. Gas: Natural
    d. Compressed air: Natural

3. Letter Color:

    a. Cold Water: Black.
    b. Hot Water: Black.
    c. Gas: Black.
    d. Compressed air: Black.

3.5 VALVE-SCHEDULE INSTALLATION

A. Mount valve schedule on wall in accessible location in each major equipment room.

3.6 WARNING-TAG INSTALLATION

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

3.7 ADJUSTING

A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

3.8 CLEANING

A. Clean faces of mechanical identification devices and glass frames of valve schedules.

END OF SECTION 22 05 53

SECTION 22 05 83 - INSPECTION, TESTS, ADJUSTMENTS AND ACCEPTANCE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including Standard General Conditions, and other Division-1 Specification Sections, apply to this Section.

1.2 WORK INCLUDED

A. The work included under this section of the specification consists of the furnishing of all labor, materials, equipment and service necessary to complete the inspections and testing of all plumbing and drainage work as shown on the drawings and as called for in these specifications.

B. All work shall be tested to the satisfaction of the Architect/Engineer for leaks, faulty joints, improper operation and inefficiency. Provide test pump, gauges, meters, other instruments required in connection with tests.

C. All equipment and piping shall be thoroughly cleaned of iron cuttings and other refuse during assembly, installation and before testing.

D. Do not cover or paint any part of piping nor connect fixtures and equipment, before testing and obtaining approval.

PART 2 - PRODUCT – NOT USED

PART 3 - EXECUTION

3.1 GAS SUPPLY PIPING TEST

A. After installation of gas piping, before connecting meter or appliances, test system for gas-tightness with compressed air or nitrogen. Test pressure shall be 1-1/2 times the proposed maximum working pressure, but not less than 3 psig. The duration of the test shall be one-half 1/2 hour for each 500 cubic feet of pipe volume, cut not less than one-half hours.

B. After connecting appliances and when ordered to turn on gas supply, check for leakage with meter; purge gas line; follow instructions in NFPA Pamphlet 54 in doing this.

3.2 DISINFECTION OF DOMESTIC WATER PIPING

A. Prior to starting work, verify system is complete, flushed and clean.

B. Ensure PH of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).

C. Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/L residual.

D. Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15 percent of outlets.

E. Maintain disinfectant in system for 24 hours.

F. If final disinfectant residual tests less than 25 mg/L repeat treatment.

G. Flush disinfectant from system until residual equal to that of incoming water or 1 mg/L.

H. Take samples no sooner than 24 hours after flushing, from 10 percent of outlets and from water entry, and analyze in accordance with AWWA C601.

3.3 DOMESTIC HOT WATER SYSTEM PROCEDURE

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

B. Use calibrated (Venturi tubes, orifices, or other metered) fittings and pressure 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.

C. 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.

D. 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.

3.4 SANITARY SYSTEM TEST

A. The piping of plumbing drainage and venting systems shall be tested upon completion of the rough piping installation by water or air and proved water tight. Where required by the code official, the cleanout plugs shall be removed to ascertain if the pressure has reached all parts of the system. Either of the following methods shall be used.

1. Water Test: The water test shall be applied to the drainage system either in its entirety or in sections after rough piping has been installed. If applied to the entire system, all openings in the piping shall be closed except the highest opening, and the system filled with water to the point of overflow. If the system is tested in sections, each opening shall be plugged except the highest opening of the section under test, and each section shall be filled with water, but a section shall not be tested with less than a 10-foot head of water.

In testing successive sections, at least the upper 10 feet of the next preceding section shall be tested, so that a joint or pipe in the building (except the uppermost 10 feet of the system) shall not have been subjected to a test of less than a 10-foot head of water. The water shall be kept in the system or in the portion under test for a minimum of 15 minutes before inspection starts. The system shall then be tight at all points.

2. Air Test: The air test shall be made by attaching an air compressor or testing apparatus to an opening, and, after closing all other inlets and outlets to the system, forcing air into the system until there is a gauge pressure of 5 pounds per square inch (5 psi/34.47 kPa) or a minimum of 10-inch column of mercury. This pressure shall be held without introduction of additional air for a minimum period of 15 minutes.

3.5 FINISHED PLUMBING TEST

A. Where required by the code official, after the plumbing fixtures have been set and their traps filled with water, their connections shall be tested and proved gas and water-tight by one of the following test methods:

1. Final test for gas and water-tightness: The final test for gas and water tightness of the completed drainage and vent system shall be made by a smoke test or other approved method. The test shall be made by filing all traps with water and then introducing into the system smoke produced by one or more smoke machines. When the smoke appears at stack openings on the roof, the stack openings shall be closed and a pressure equivalent to a 1-inch water column shall be built and maintained for the period of the inspection.
2. After the plumbing fixtures have been set and their traps filled with water, their connections shall be tested and proven gas and water-tight by plugging the stack openings on the roof and building drain where the drain leaves the building, and with air introduced into the system equal to the pressure of a 1-inch water column. This shall be accomplished by the use of a "U" tube or manometer inserted in the trap of a water closet. Such pressure shall remain constant for the period of inspection without the introduction of additional air.

3.6 WATER SUPPLY SYSTEM TEST

A. Upon completion of a section or the entire water supply system, the system, or portion completed, shall be tested and proved tight under a water pressure not less than the working pressure under which it is to be used. The water used for tests shall be obtained from a potable source of supply.

B. All plumbing fixtures, piping, valves etc. used for potable water (drinking and cooking) shall comply with "lead free" requirements as per NSF 61/372.

C. The Contractor shall test the domestic water system both before and after providing plumbing fixtures, piping, valves etc. and shall be in compliance with the Department of Health lead in water regulation (10 NYCRR 67-4). Test results shall be submitted to SED prior to cutting into the domestic water system and final test results shall be submitted once all work is completed.

3.7 ADJUSTMENTS, REPAIRS, AND TESTS

A. This Contractor shall adjust, repair and test the plumbing systems as specified herein.

B. Correct defects disclosed by tests or inspection; replace defective parts when directed. In replacing defective parts use only new material; in case of pipe replace with same length as defective pieces. Caulking of screwed joints will not be permitted. Repeat tests after defects have been corrected and parts replaced, as directed, until pronounced satisfactory.

C. The cost of repairs and restoration of work of other trades damaged by the tests, or cutting that had to be done in connection with test shall be made at no extra cost to the owner.

3.8 PERFORMANCE TESTS AND ACCEPTANCE

A. Before final acceptance of the system, this Contractor shall test the various systems under normal conditions for one 8-hour day or longer when so directed to determine that they fulfill requirements of plans, specifications and they operate satisfactorily.

B. Any defects made manifest by those tests shall be immediately and promptly made good after which the system shall be retested as required and/or directed.

3.9 INSPECTION

A. The Contractor shall obtain all inspection required by laws, ordinances and regulations of the City of Johnson City and other authorities having jurisdiction. The Contractor shall obtain certificates of inspection and submit them to the Owner and shall pay for all fees, charges and other expenses in connection with the same, including same in Contract Price.

B. This Contractor shall furnish and install such test tees and plug fittings in his work as may be required by local authorities for their test, and any other test required, and shall ascertain information from local authorities as to all requirements before installation of work. No claims for extension of time will be entertained which arises from failure to obtain this information in time, or securing the necessary permits and arranging for required inspection.

3.10 TRAINING

A. Plumbing Contractor shall furnish qualified trained personnel for a period of 1 week minimum to properly instruct the Building personnel in all details of operation of the equipment installed under these specifications, and he shall supply personnel to operate them for a sufficient length of time to satisfy the Architect that the requirements of the drawings and specification have been fulfilled in all respects

END OF SECTION 22 05 83

SECTION 22 07 19 - PIPE INSULATION BUILDING PLUMBING SYSTEMS

PART 1 - GENERAL

1.1 REQUIREMENTS

A. The conditions as defined in Division 22, Common Work Results for Plumbing, shall apply to Division 22 of the specifications.

B. This Contractor shall carefully read the above-mentioned documents and study the drawings of all trades. He shall be responsible for neglect to read, or attend to, any paragraph or items contained therein.

1.2 WORK INCLUDED

A. Piping insulation.

B. Jackets and accessories.

1.3 RELATED WORK

A. Division 22 – Plumbing Scope of Work

B. Division 22 – Common Work Results for Plumbing

1.4 SCOPE

A. The work covered by this specification consists of furnishing all labor, equipment, materials and accessories, and performing all operations required, for the correct fabrication and installation of thermal insulation applied to the following commercial piping systems, in accordance with applicable project specifications and drawings, subject to the terms and conditions of the contract:

1. Domestic hot water and domestic hot water recirculation and service hot water systems, 105º F and up
2. Domestic Cold Systems, 40º F and up
3. Rainwater Conductor Piping, 0º F to 55º F
4. Compensate Drain Systems, 0º F to 55º F

B. The above temperature ranges are typical for these systems. However, if contract specifications call for service temperatures outside the above ranges, consult the manufacturer's published data to determine operating temperature limitations of the insulation product or products under consideration.

1.5 REFERENCES

A. Thermal insulation materials shall meet the property requirements of one or more of the following specifications as applicable to the specific product or end use:

1. American Society for Testing of Materials Specifications:

a. ASTM C 547, "Standard Specification for Mineral Fiber Preformed Pipe Insulation"
b. ASTM C 533, "Standard Specification for Calcium Silicate Pipe & Block Insulation"
c. ASTM C 585, "Recommended Practice for Inner and Outer Diameters of Rigid Pipe Insulation for Nominal Sizes of Pipe and Tubing (NPS System)"
d. ASTM C 795, "Thermal Insulation for Use Over Austenitic Stainless Steel"
e. ASTM C 1136, "Standard Specification for Barrier Material, Vapor," Type 1 or 2 (jacket only)

2. General Material Specifications:

a. ASTM E84 – Surface Burning Characteristics of Building Material.
b. NFPA 255 – Surface Burning Characteristics of Building Materials.
c. UL 723 – Surface Burning Characteristics of Building Materials.

B. Insulation materials, including all weather and vapor barrier materials, closures, hangers, supports, fitting covers and other accessories, shall be furnished and installed in strict accordance with project drawings, plans, and specifications.

1.6 DEFINITIONS

A. The term "mineral fiber" as defined by the above specifications includes fibers manufactured of glass, rock, or slag processed from a molten state, with or without binder.

1.7 SYSTEM PERFORMANCE

A. Insulation materials furnished and installed hereunder should meet the minimum economic insulation thickness requirements of the North American Insulation Manufacturers' Association (NAIMA) (formerly known as TIMA), to ensure cost-effective energy conservation performance. Alternatively, materials should meet the minimum thickness requirements of National Voluntary Consensus Standards 90.1 (1989), "Energy Efficient Design of New Buildings," of the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE). However, if other factors such as condensation control or personnel protection are to be considered, the selection of the thickness of insulation should satisfy the controlling factor.

B. Insulation materials furnished and installed hereunder shall meet the fire hazard requirements of any one of the following specifications:

1. American Society for Testing of Materials ASTM E 84

2. Underwriters' Laboratories, Inc. UL 723
3. National Fire Protection Association NFPA 255

C. Calcium silicate products shall include a visual identification system to permit positive field determination of their asbestos free characteristic.

1.8 QUALITY ASSURANCE

A. Insulation materials and accessories furnished and installed hereunder shall, where required, be accompanied by manufacturers' current submittal or data sheets showing compliance with applicable specifications listed in Section 1.02 above.

B. Insulation materials and accessories shall be installed in a workmanlike manner by skilled and experienced workers who are regularly engaged in commercial insulation work.

1.9 DELIVERY AND STORAGE OF MATERIALS

A. All of the insulation materials and accessories covered by this specification shall be delivered to the job site and stored in a safe, dry place with appropriate labels and/or other product identification.

B. The contractor shall use whatever means are necessary to protect the insulation materials and accessories before, during, and after installation. No insulation material shall be installed that has become damaged in any way. The contractor shall also use all means necessary to protect work and materials installed by other trades.

C. If any insulation material has become wet because of transit or job site exposure to moisture or water, the contractor shall not install such material, and shall remove it from the job site.

D. Applicator: Company specializing in piping insulation application with five (5) years minimum experience.

E. Materials: Flame spread/fuel contributed/smoke developed rating of 25/50 in accordance with ASTM E84.

1.10 SUBMITTALS

A. Submit product data under provisions of Division 01 and 22.

B. Include product description, list of materials and thickness for each service, and location.

PART 2 - PRODUCTS

2.1 PIPE INSULATION

A. Molded pipe insulation shall be manufactured to meet ASTM C 585 for sizes required in the particular system. It shall be of a type suitable for installation on piping systems as defined in Section 1.4 SCOPE above.

Molded fibrous glass pipe insulation shall comply with the requirements of ASTM C 547. One of the following types shall be used:

1. For indoor systems operating at temperatures from zero to +450º F:

a. Heavy density Fiberglass pipe insulation with factory applied all-service jacket (ASJ) and Doublesure* two-component adhesive closure system, rated for a maximum service temperature of 850º F. For large pipe sizes where SSL-II is not available, the single adhesive SSL closure may be substituted. Circumferential joints shall be sealed by butt strips having a two-component sealing system. Stapling is not required to complete the closure. When self sealing lap systems are used, sufficient thickness of insulation shall be used to maintain the outer surface temperature of the operating system below +150º F. Manufacturer's data regarding thickness constraints in relation to operating temperature shall be followed. When multiple layers are required, all inner layer(s) shall be unjacketed.

(*Trademark of Morgan Adhesive Company)

On cold systems, vapor barrier performance is extremely important. All penetrations of the ASJ and exposed ends of insulation shall be sealed with vapor barrier mastic.

If humidities in excess of 90% are expected, the ASJ shall be protected with either a mastic coating or a suitable vapor retarding outer jacket. Vapor seals at butt joints shall be applied at every fourth pipe section joint and at each fitting to provide isolation of water incursion.

2. For cold systems, operating either part or full time below ambient temperatures, but not less than zero F:

a. Heavy density Fiberglass pipe insulation jacketed with ASJ but without the self-sealing lap may be used, provided all laps and butt strips are sealed with a contact adhesive or suitable vapor barrier mastic reinforced with glass fabric. All penetrations of the ASJ and all exposed ends of the insulation shall be sealed with vapor barrier mastic.

If humidity in excess of 90% is expected, the ASJ shall be protected with either a mastic coating or a suitable vapor retarding outer jacket unaffected by surface condensation. Vapor seals at butt joints shall be applied at every fourth pipe section joint and at each fitting to provide isolation of water incursion.

B. For piping equal to or larger than 10" diameter, operating at temperatures up to +450º F (or above), and where moderate abuse resistance is required, the following may be installed:

1. Fiberglass pipe and tank insulation, heavy density mineral fiber insulation, maximum operating temperature of 650º F, end-grain factory-adhered to an ASJ all-service jacket. All joints shall be stapled, then (1) sealed with mastic or (2) closed with 3" pressure-sensitive tape matching the ASJ jacket.

C. Fittings and valves shall be insulated with pre-formed fiberglass fittings, fabricated sections of Fiberglass pipe insulation, Fiberglass pipe and tank insulation, Fiberglass blanket insulation, or insulating cement. Thickness shall be equal to adjacent pipe insulation. Finish shall be pre-formed PVC fitting covers or as otherwise specified on contract drawings.

1. Flanges, couplings and valve bonnets shall be covered with an oversized pipe insulation section sized to provide the same insulation thickness as on the main pipe section. An oversized insulation section sized to provide the same insulation thickness as on the main pipe section. An oversized insulation section shall be used to form a collar between the two insulation sections with low density blanket insulation being used to fill gaps. Jacketing shall match that used on straight pipe sections. Rough cut ends shall be coated with a suitable weather or vapor resistant mastic as dictated by the system location and service.
2. On hot systems where fittings are to be left exposed, insulation ends should be beveled away from bolts for easy access.
3. On cold systems, particular care must be given to vapor sealing the fitting cover or finish to the pipe insulation vapor barrier. All valve stems shall be sealed with caulking to allow free movement of the stem but provided a seal against moisture incursion.

D. All piping shall be supported in such a manner that neither the insulation nor the vapor/weather barrier is compromised by the hanger or the effects of the hanger. In all cases, hanger spacing shall be such that the circumferential joint may be made outside the hanger. On cold systems, vapor barrier shall be continuous, including material covered by the hanger saddle.

1. Piping systems 3" in diameter or less, insulated with Fiberglass insulation, may be supported by placing saddles of the proper length and spacing, as designated in Owens-Corning Pub. 1-IN-12534, under the insulation.
2. For hot or cold piping systems larger than 3" in diameter, operating at temperatures less than +200º F and insulated with fiber glass, high density inserts such as wood or foam with sufficient compressive strength shall be used to support the weight of the piping system.
   At temperatures exceeding +200º F, Owens-Corning Pink Calcium Silicate pipe insulation shall be used for high density inserts.
3. Owens-Corning Pink Calcium Silicate pipe insulation may be used to support the entire weight of the piping system provided the hanger saddle is designed so the maximum compressive load does not exceed 100 psi.
4. Where pipe shoes and roller supports are required, insulation shall be inserted in the pipe shoe to minimize pipe heat loss. Where possible, the pipe shoe shall be sized to be flush with the outer pipe insulation diameter.

5. Thermal expansion and contraction of the piping and insulation system can generally be taken care of by utilizing double layers of insulation and staggering both longitudinal and circumferential joints. Where long runs are encountered, expansion joints may be required where single layers of insulation are being used and should be so noted on the contract drawings.
6. On vertical runs, insulation support rings shall be used as indicated on contract drawing.

2.2 ACCESSORY MATERIALS

A. Accessory materials installed as part of insulation work under this section shall include (but not be limited to):

1. Closure Materials – Butt strips, bands, wires, staples, mastics, adhesives; pressure-sensitive tapes.
2. Field-applied jacketing materials – Sheet metal, plastic, canvas, fiberglass cloth, insulating cement; PVC fitting covers.
3. Support Materials – Hanger straps, hanger rods, saddles.

B. All accessory materials shall be installed in accordance with project drawings and specifications, manufacturer's instructions, and/or in conformance with the current edition of the Midwest Insulation Contractors Association (MICA) "Commercial & Industrial Standards."

PART 3 - EXECUTION

3.1 SITE INSPECTION

A. Before starting work under this section, carefully inspect the site and installed work of other trades and verify that such work is complete to the point where installation of materials and accessories under this section can begin.

B. Verify that all materials and accessories can be installed in accordance with project drawings and specifications and material manufacturers' recommendations.

C. Verify, by inspecting product labeling, submittal data, and/or certifications which may accompany the shipments, that all materials and accessories to be installed on the project comply with applicable specifications and standards and meet specified thermal and physical properties.

3.2 PREPARATION

A. Ensure that all pipe and fitting surfaces over which insulation is to be installed are clean and dry.

B. Ensure that insulation is clean, dry, and in good mechanical condition with all factory-applied vapor or weather barriers intact and undamaged. Wet, dirty, or damaged insulation shall not be acceptable for installation.

C. Ensure that pressure testing of piping and fittings has been completed prior to installing insulation.

3.3 INSTALLATION

A. General

1. Install all insulating materials and accessories in accordance with manufacturer's published instructions and recognized industry practices to ensure that it will serve its intended purpose.
2. Install insulation on piping subsequent to installation of heat tracing, painting, testing, and acceptance tests.
3. Installation insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other. But insulation joints firmly to ensure complete, tight fit over all piping surfaces.
4. Maintain the integrity of factory-applied vapor barrier jacketing on all pipe insulation, protecting it against puncture, tears or other damage. All staples used on cold pipe insulation shall be coated with suitable sealant to maintain vapor barrier integrity.

B. Fittings

1. Cover valves, fittings, and similar items in each piping system using one of the following:

   a. Mitered sections of insulation equivalent in thickness and composition to that installed on straight pipe runs.
   b. Insulation cement equal in thickness to the adjoining insulation.
   c. PVC fitting covers insulated with material equal in thickness and composition to adjoining insulation.

C. Penetrations

1. Extend piping insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise specified.

D. Joints

1. Butt pipe insulation against hanger inserts. For hot pipes, apply 3" wide vapor barrier tape or band over butt joints. For cold piping apply wet coat of vapor barrier lap cement on butt joints, and seal joints with 3" wide vapor barrier tape or band.
2. All pipe insulation ends shall be tapered and sealed, regardless of service.

E. Vertical Piping

1. If specified on contract drawings, all insulated, exposed vertical piping within the building and all insulated piping exposed to the outdoors shall be additionally jacketed with 0.016" thick (minimum) aluminum. Vertical piping shall be protected to a height of 8'-0" above the floor.

3.4 FIELD QUALITY ASSURANCE

A. Upon completion of all insulation work covered by this specification, visually inspect the work and verify that it has been correctly installed. This may be done while work is in progress, to assure compliance with requirements herein to cover and protect insulation materials during installation.

3.5 PROTECTION

A. Replace damaged insulation which cannot be satisfactorily repaired, including insulation with vapor barrier damage and moisture-saturated insulation.

B. The insulation contractor shall advise the general and/or the mechanical contractor as to requirements for protection of the insulation work during the remainder of the construction period, to avoid damage and deterioration of the finished insulation work.

3.6 SAFETY PRECAUTIONS

A. Insulation contractor's employees shall be properly protected during installation of all insulation. Protection shall include proper attire when handling and applying insulation materials, and shall include (but not be limited to) disposable dust respirators, gloves, hard hats, and eye protection.

B. The insulation contractor shall conduct all jobsite operations in compliance with applicable provisions of the Occupational Safety and Health Act, as well as with all State and Local safety and health codes and regulations that may apply to the work.

3.7 SCHEDULE: THICKNESS

MININUM PIPE INSULATION						
INSULATION THICKNESS FOR PIPE SIZES						
Piping System & Types	Fluid Temp Range	Less Than 1-1/2"	1-1/2" To 2"	2-1/2 To 4"	5 & 6 Inch	8" or Larger
Hot Water and Hot Water Recirculation	100-200	1.5	2.0	2.0	2.0	2.0
Low Temp Piping						
Cold Water, Condensate Drain and other Drain Lines	40-65	1.0	1.5	1.5	1.5	1.5

Rainwater Conductors	40-55	1.0	1.5	1.5	1.5	1.5

END OF SECTION 22 07 19

SECTION 22 10 00 - PLUMBING PIPING AND VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 WORK INCLUDED

A. Pipe and pipe fittings for the various systems.

B. Valves and cocks for the various piping systems.

C. Sanitary sewer and vent piping system.

D. Domestic cold and hot water piping system.

E. Natural Gas piping system.

F. Painting of piping systems.

1.3 RELATED WORK

A. Division 22 – Common Work Results for Plumbing

B. Division 22 - Supports and Anchors

C. Division 22 – Plumbing General

D. Division 22 – Piping Insulation

E. Division 22 - Plumbing Specialties

F. Division 22 - Plumbing Fixtures

G. Division 22 - Inspection, Tests, and Adjustments

1.4 REFERENCES

A. ANSI/ASME B16.3 - Malleable Iron Threaded Fittings Class 150 NS 300.

B. ANSI/ASME B16.23 - Cast Copper Alloy Solder Joint Drainage Fittings - DWV.

C. ANSI/ASME Sec. 9 - Welding and Brazing Qualification.

D. ANSI/ASTM B32 - Solder Metal.

E. ANSI/AWS D10.9 - Specifications for Qualification of Welding Procedures and Welders for Piping and Tubing.

F. ANSI/AWWA C110 - Ductile - Iron and Gray - Iron Fittings 3 in. through 48 in., for Water and Other Liquids.

G. ANSI/AWWA C111 - Rubber-Gasket Joints for Ductile Iron and Gray-Iron Pressure Pipe and Fittings.

H. ANSI/AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids.

I. ASTM A53 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless.

J. ASTM A74 - Cast Iron Soil Pipe and Fittings.

K. ASTM A234 - Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.

L. ASTM C564 - Rubber Gaskets for Cast Iron Soil Pipe and Fittings.

M. AWS A5.8 - Brazing Filler Metal.

N. AWWA C601 - Standard Methods for the Examination of Water and Wastewater.

O. CISPI 301 - Cast Iron Soil Pipe and Fittings for Hubless Cast Iron Sanitary Systems.

P. 2020 Building Code of NYS (International Building Code 2018) with Amendments

Q. 2020 Fire Code of NYS (International Fire Code 2018) with Amendments

R. 2020 Plumbing Code of NYS (International Plumbing Code of 2018) with Amendments

S. NFPA Codes

T. All State and Local rules and regulations.

1.5 QUALITY ASSURANCE

A. No welder shall be employed who has not been fully qualified and certified by an approved, nationally certified, welding bureau or similar recognized testing agency.

B. The competent and experienced welders who have qualified shall be retained at the job at all times when welding is done. Once qualified they shall not be removed from the job. Each welder shall be in possession of a stamp to identify work performed by him.

C. Welding material and labor shall be in accordance with the welding procedures of ANSI piping codes, A.P.I. (American Petroleum Institute), ASME Code and in accordance with requirements set forth in "Welding of Pipe Joints" of the "Code for Pressure Piping: and in accordance with the American Welding Society Welding handbook. Mark of welder shall be stamped on each welded joint of pipe.

D. Install piping systems to meet the requirements of all applicable state and local codes.

E. Each length of pipe or fitting furnished shall be marked with the manufacturer's name, brand and specification code designator to which it conforms.

F. All above ground pipe and fittings to be painted shall be bare or coated with an easily removed mill primer, while pipe and fittings to be insulated shall be provided with a regular mill preservative primer with insulation applied over this.

G. Valves: Manufacturer's name and pressure rating marked on valve body.

1.6 SUBMITTALS

A. Submit product data under provisions of Division 22 - Common Work Results for Plumbing.

B. Submit type of pipe, valves and fitting to be used for each service specified; obtain approval before installing.

C. Pipe supports, hangers and inserts:

1. Submit bulletins, catalog figure numbers or samples, as may be requested, of supports, hangers, inserts, wall seals, etc., proposed to be used for various conditions; obtain approval before installation.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store products on site under provisions of Division 22 – Common Work Results for Plumbing.

B. Properly protect all piping so as to prevent damage to the pipe or the introduction of foreign material into the pipe.

C. Cap or plug all openings in pipe and pipe fittings during installation.

D. During loading, transportation and unloading, use care to prevent injury to pipes and pipe fittings. Do not drop pipe or fittings. Examine all pipe and fittings before laying. Do not install any piece that is found to be defective.

E. Store and protect all materials from injury prior to installation. Do not store any materials directly on the ground or floor. Keep materials as clean and dry as possible and free from damage or deteriorating elements.

F. Remove and replace with sound pipe, any defective pipe and pipe fittings discovered after installation without additional expense to the Owner.

PART 2 - PRODUCTS

2.1 SOIL, WASTE AND VENT PIPING

A. Cast iron soil pipe and fittings, ASTM A74 and/or CISPI 301, service weight or extra heavy, shall be used for pipe buried in or in contact with earth within the building and to a point 5 feet outside of the building. Cast iron soil pipe and fittings, service weight, may be used for piping above ground where space within partitions involved can accommodate greatest diameter of pipe without any dimension deviations from the contract drawings. Pipe shall be bell and spigot, modified hub or plain end (no hub) as required by selected jointing method, except plain end (no hub) shall not be used below ground.

All cast iron pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute (CISPI) and be listed by NSF International.

1. Joints: Provide one of the following types to suit pipe furnished:

   a. For bell and spigot soil pipe, joints shall be packed with pure picked oakum, fill with molten lead at one pouring to a depth of one inch measured back from the face of the bell, caulk solid flush with hub rim.
   b. For modified hub, joints shall be double seal, compression-type molded neoprene gasket. Gaskets shall suit class of pipe being jointed. Dual-service gaskets will not be accepted.
   c. Joints for no-hub cast iron soil pipe and fittings shall consist of a neoprene gasket conforming to ASTM C-564 and stainless steel clamps series 300.
   d. Where no-hub is used, anchors shall be provided at the water closets to prevent pipe from twisting.
   e. Adapters: Where service weight pipe is connected to extra heavy pipe and extra heavy fittings of chair carriers, provide adapters or similar system to make tight, leak proof joints.

2. Coating: Provide a heavy coat of asphalt or bitumastic paint on pipe buried in earth or installed in cinders or concrete construction.

B. Steel pipe and fittings, except if optional material is provided, shall be used for piping above ground including equipment exhaust vents.

1. Pipe shall be galvanized steel Type E, electric resistance welded; Grade A, standard weight and shall conform to ASTM a-53.
2. Fittings:

   a. Soil and wastewater piping fittings shall be galvanized special heavy cast iron recessed long turn and banded drainage type and shall meet the requirements of ASTM A-126.

b. Sanitary and exhaust vent pipe fittings shall be galvanized malleable iron meeting requirements of ASTM A-197. Couplings may be standard couplings furnished with pipe.

C. Copper tube: May optionally be used for piping above ground except urinal drains.

1. Copper tubing shall be types "L", "K" or "DWV" seamless or use with solder type fittings and shall meet the requirements of ASTM B-88.
2. Fittings: Shall be cast bronze recessed drainage type.
3. Joints shall be 50-50 solid core solder using No. 50 noncorrosive flux for non-portable water only.

2.2 STORM WATER PIPING

A. Cast iron storm water pipe and fittings, ASTM A74 and/or CISPI 301, service weight or extra heavy, shall be used for pipe buried in or in contact with earth within the building and to a point 5 feet outside of the building. Cast iron storm water pipe and fittings, service weight, may be used for piping above ground where space within partitions involved can accommodate greatest diameter of pipe without any dimension deviations from the contract drawings. Pipe shall be bell and spigot, modified hub or plain end (no hub) as required by selected jointing method, except plain end (no hub) shall not be used below ground.

1. Joints: Provide one of the following types to suit pipe furnished:

a. For bell and spigot soil pipe, joints shall be packed with pure picked oakum, fill with molten lead at one pouring to a depth of one inch measured back from the face of the bell, caulk solid flush with hub rim.
b. For modified hub, joints shall be double seal, compression-type molded neoprene gasket. Gaskets shall suit class of pipe being jointed. Dual-service gaskets will not be accepted.
c. Joints for no-hub cast iron soil pipe and fittings shall consist of a neoprene gasket conforming to ASTM C-564 and stainless steel clamps series 300.

2. Coating: Provide a heavy coat of asphalt or bitumastic paint on pipe buried in earth or installed in cinders or concrete construction.

B. Steel pipe and fittings, except if optional material is provided, shall be used for piping above ground.

1. Pipe shall be galvanized steel Type E, electric resistance welded; Grade A, standard weight and shall conform to ASTM A-53.
2. Fittings:

a. Storm water piping fittings shall be galvanized special heavy cast iron recessed long turn and banded drainage type and shall meet the requirements of ASTM A-126.

2.3 INTERIOR WATER PIPING

A. Pipe: Shall be copper tubing type "L", seamless for use with solder type fittings and shall meet the requirements of ASTM B-88. The name or trademark of the manufacturer and mark indicative of the type shall be marked permanently on each tube at intervals not greater than 4-1/2 feet.

B. Fittings for copper tube shall be wrought copper or cast bronze solder joint type and couplings for jointing tube ends shall have center stops.

C. Adapters: Provide adapters for jointing screwed pipe to copper tubing.

D. Solder shall be lead-free, having a lead composition equal to or less than 0.2 percent lead and shall conform to ASTM B-32 for hot and cold water supply piping.

2.4 EXPOSED WATER AND WASTE PIPING

A. Finished Rooms: use full iron pipe size chrome plated brass piping connecting fixtures and equipment when not concealed by apron including those specified in other sections.

1. Pipe shall be seamless and meet the requirements of ASTM B-43 except that the minimum proportion of copper shall be 85 percent.
2. Fittings shall be cast brass chrome plated screwed. For waste, fittings shall be drainage pattern.
3. All exposed water and waste piping shall be painted. Color by Architect. See painting specification for paint type/application.

2.5 EXPOSED GAS PIPING

A. Finished Rooms: Use fill iron pipe size chrome plated brass piping connecting fixtures, casework, cabinets, equipment and reagent racks when not concealed by apron including those specified in other sections.

1. Pipe shall be seamless and meet the requirements of ASTM B-43 except that the minimum proportion of copper shall be 85 percent.
2. Fittings shall be cast brass chrome plated screwed.

2.6 INTERIOR AND EXTERIOR GAS PIPING

A. Pipe shall be black steel, electric resistance welded, Schedule 40, ASTM A-53.

B. Fittings: Malleable iron 150 psig class, ASTM A-197 or ANSI B16.9/ASTM A-234 welded.

C. Joints: Entire piping system shall consist of welded joints and fittings. Exception is screwed joints may be used at equipment connections and where conditions prevent use of welded joints. Do not use gas fitter's cement except on outlet caps. No threaded joints shall be concealed.

D. Provide all fittings required to accommodate angle changes when running gas piping parallel to a pitched roof at the high points and low points. Fittings shall include, but not limited to swing joints consisting of two elbows or mitered welded joints.

E. Where HVAC equipment, plumbing equipment or any other gas appliance is installed in spring isolators, or spring isolated curbs, or any other type of mounting that permits any movement, provide flexible connections to the equipment. Provide any and all additional piping supports required. Flexible connections shall be UL listed CGA approved for outdoor gas applications. Basis of design shall be Gastite CSST CGA approved for outdoor gas applications, Metraflex Model series GASCT (threaded) and GASCW (welded) "Flexible Connector for Gas Service" straight stainless-steel hose and braid, CSA approved natural gas/propane use or approved equal. Install in accordance with the manufacture's installation instruction.

F. Gas meter and pressure regulator shall be furnished and installed by Gas Utility Company unless otherwise noted.

G. All gas piping (exposed and concealed) shall be painted. Refer to Division 09 Section "Painting" for paint materials, surface preparation and application of paint. Paint all gas piping with "Yellow" semi-gloss, acrylic-enamel paint. Coat piping with two (2) coats finish over two (2) coats rust inhibitive metal primer.

2.7 NIPPLES

A. All pipe nipples installed throughout this work shall be extra heavy pipe of the same material as the pipe line in which installed.

2.8 UNION AND FLANGES

A. Provide unions, screwed or flanged, where indicated and in following locations, even if not indicated.

1. In by-pass around equipment.
2. In connections to pumps, and other equipment requiring disconnections for repairs, replacement, locate between shut-off and equipment. Do not conceal unions in walls, partitions or ceilings.
3. In drainage piping only on inlet side of fixture trap.

B. Unions 2 inches and smaller in lines of copper tubing shall be standard weight, all brass, ground joint, for solder type connections. When installed in brass or copper lines, they shall have ends for screwed connections. When installed in iron or steel lines, they shall be of the screwed malleable pattern suitable for 150 pounds water pressure. They shall be of the ground type with brass seat ring. The brass seat ring shall be pressed into the headpiece so that it cannot be pulled or forced out.

C. Unions 2-1/2 inches and larger in lines of copper tubing shall be standard weight, flanged pattern, gasket type, all brass, for solder type connections. When installed in iron or steel lines, they shall be standard weight, screwed cast iron flanged pattern, gasket type, black or galvanized to suit the piping which they are installed.

D. Brass flanged union connections shall be made up with brass bolts and nuts, galvanized unions with iron bolts and nuts and black flanged unions with black bolts and nuts.

E. Flanges shall be of the same weight as fittings in same service category; drilled for 125 psi as required.

F. Screwed flanges shall be cast iron. Welding flanges shall be steel welding neck type.

2.9 GASKETS

A. Gaskets for pipe flanges shall be ring type, 1/16 inches thick, of compressed non-asbestos fiber and special compound, suitable for service intended, factory cut for flange size, similar to Durable Manufacturing Company, "Durably", Garlock, Inc. "Garlock 961", or approved equal.

2.10 WALL SEALS

A. Provide mechanical wall seals in exterior walls below grade and other locations requiring lead caulking. Seals shall be modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and wall opening. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and nut. After the seal assembly is positioned in the sleeve, tightening of the bolts shall cause the rubber sealing elements to expand and provide an absolutely watertight seal between the pipe and wall opening. The seal shall be watertight between the pipe and wall opening. The seal shall be constructed so as to provide the electrical insulation between the pipe and wall, thus reducing the chances of cathodic reaction between these two members.

B. The pipe to wall penetration closures shall be "Link-Seal" as manufactured by Thunderline Corporation, Livonid, Michigan.

2.11 SLEEVES AND ESCUTCHEONS

A. Provide galvanized steel pipe sleeves for pipe passing through concrete beams, outside walls, foundations, footings and waterproofed floors, unless brass sleeves or wall seals are specified.

B. Provide brass pipe sleeves for piping passing through terrazzo or ceramic tile floors.

C. Provide galvanized No. 26 gauge sheet steel sleeves with lock seam joints for pipes passing through floors, interior walls and partitions. Sleeves shall not be installed in dry wall construction.

D. Sleeve flashing shall be 16 ounce soft sheet copper, or a 4 pound lead flashing.

E. Escutcheons shall be one piece with set screw except where otherwise noted, constructed of the following material:

1. Chrome plated cast brass for chrome plated piping.

2. Nickel plated cast iron for piping passing through toilet rooms.
3. White painted sheet brass or steel for pipes passing through white prefinished ceilings.
4. Cast iron, deep cup type for sleeves that project above finished floor.
5. Heavy, solid pattern steel or cast iron with set screw for all other piping.

2.12 HANGERS AND SUPPORTS

A. Products of Grinnell, B-Line Systems Inc., or Basic Engineering Inc., will be acceptable in place of a particular manufacturer's catalog figure number specified herein.

B. Overhead supports: Provide one of the following types of hanger for overhead support of horizontal piping:

1. For copper tubing where hangers are in direct contact with tubing, use clevis type steel hanger, copper plated, Grinnell Fig. CT-65, with supporting rod to suit.
2. For all other piping 4 inches and smaller, use slevis type hangers, Grinnell Fig. 260.
3. Hangers for hot water piping, where provisions for expansion and contraction is required, pipes over 4 inches shall be single pipe roll type hangers with two rods and adjustable sockets; Grinnell Fig. 171 or split single roller hanger with one rod, Grinnell Fig. 174.
4. Provide supporting rods for hangers of diameter as indicated and where not indicated, as specified under "Horizontal Pipe Supports Schedule" hereinafter, of lengths as required, with double lockouts for each.
5. For large piping on rollers as indicated, provide pipe roll stand constructed of cast iron Grinnell Fig. 271.
6. Where indicated, provide adjustable pipe supports from the floor. Support shall consist of a cast iron saddle with a factory assembled adjusting nipple and reducer. Grinnell Fig. 395.

C. Where hanger rods leave unsightly holes in ceilings in finished areas, provide plastic ceiling plates, Grinnell Fig. 127 or cast iron ceiling plates with setscrew, Grinnell Fig. 395.

D. Wall Supports: Provide one of the following to support horizontal piping from wall.

1. Where no provision for expansion and contraction is required and pipe can be located close to wall, use steel J-hook, suitable for pipe sizes up to 3 inches, Grinnell Fig. 126.
2. For hanger suspension, 750 lb. maximum loading, use light welded steel bracket with hole for one rod up to 3/4 inch diameter, Grinnell Fig. 194. For additional rod suspension, use with this bracket steel clip Fig. 193 for pipe sizes up to 3 inches.
3. For pipe roll stand support, use welded steel bracket, light for 750 pound maximum loading Grinnell Fig. 194, medium for 1500 maximum loading Fig. 195, heavy for 3000 pound maximum load Fig 199.

E. Vertical Piping Supports:

1. Where hangers are in direct contact with copper tubing, use copper tubing riser clamps Grinnell Fig. CT-121. For steel piping at intermediate floors, use steel extension pipe clamps, Grinnell Fig. 261.

F. Clamps:

1. Where beam clamps are required on piping 6 inches and smaller, use malleable iron "C" clamp with case hardened cup pointed setscrew and retaining strap; Grinnell Fig. 87. On piping 8 inches and larger, fasten hanger to structure with adjustable beam clamp. Grinnell Fig. 292.

G. Concrete Inserts:

1. Concrete inserts shall be black malleable iron universal type for threaded connection with lateral adjustment, stop slot for reinforcing rods, lugs for attaching to forms, Grinnell Fig. 282.

H. Pipe Covering Protection:

1. On hot and cold-water piping, provide galvanized steel pipe shields of length and thickness to distribute the piping load over the insulation at each support when pipe is erected, with support segment thickness equal to adjoining insulation when load applied, Grinnell Fig. 167.
2. Bottom half of insulation shall be rigid polyurethane foam insulation having a 4 pound density and a compressive strength of 125 psi. Top half of insulation shall be of specified insulation.

I. Roof Piping Supports:

1. Where piping is run on building roofs or other similar locations, provide roller supports models 6-RAH-12 series, 5-SB-H series and 6-H single and/or dual clevis models to suit the installation height. All supports shall be adjustable in height to accommodate the desired installed height as well as the pitch of the roof. Install in accordance with the manufacturer's installation requirements.

2.13 ACCEPTABLE MANUFACTURERS – GATE VALVES

A. Nibco

B. Stockham

C. Crane

D. Substitutions: Under provisions of Division 22 – Common Work Results for Plumbing.

2.14 GATE VALVES

A. Up to 2 Inches: Bronze body, rising stem and handwheel, inside screw, single wedge or disc, solder ends.

B. Over 2 Inches: Iron body, epoxy coated wetted surface conforming to NFS 61, bronze trim, rising stem and handwheel, OS&Y, solid wedge, flanged ends.

2.15 ACCEPTABLE MANUFACTURERS – BALL VALVES

A. Nibco

B. Stockham

C. Crane

D. Substitutions: Under provisions of Division 22 – Common Work Results for Plumbing

2.16 BALL VALVES

A. Up to 2 inches: Bronze body, standard port, stainless steel ball, teflon seats and stuffing box ring, lever handle, solder ends with union. Rated at 175 psig minimum.

B. Over 2 inches: Cast steel body, chrome plated steel ball, standard port, teflon seat and stuffing box seals, lever handle, flanged. Rated at 175 psig minimum.

2.17 ACCEPTABLE MANUFACTURERS – FULL PORT BALL VALVES

A. Nibco

B. Stockham

C. Crane

D. Substitutions: Under provisions of Division 22 – Common Work Results for Plumbing.

2.18 FULL PORT BALL VALVES

A. Up to 2 inches: Bronze body, full port, stainless steel ball, teflon seats and stuffing box ring, lever handle, solder ends with union. Rated at 175 psig minimum.

B. Over 2 inches: Cast steel body, chrome plated full port steel ball, teflon seat and stuffing box seals, lever handle, flanged. Rated at 175 psig minimum.

2.19 ACCEPTABLE MANUFACTURERS – SWING CHECK VALVES

A. Nibco

B. Stockham

C. Crane

D. Substitutions: Under provisions of Division 22 – Common Work Results for Plumbing.

2.20 SWING CHECK VALVES

A. Up to 2 Inches: Bronze 45 degree swing disc, screwed ends.

B. Over 2 Inches: Iron body, epoxy coated wetted surface conforming to NFS 61, bronze trim, 45 degree swing disc, renewable disc and seat, flanged ends.

2.21 ACCEPTABLE MANUFACTURERS – GAS COCKS

A. Nibco

B. Stockham

C. Muller Brass Co.

D. Substitutions: Under provisions of Division 22 – Common Work Results for Plumbing.

2.22 GAS COCKS

A. For shutoffs, use all bronze gas cocks with flat heads.

B. Gas cocks shall be service pattern straight way, flat head, i.p.s.

2.23 ACCEPTABLE MANUFACTURERS – BALANCING VALVES

A. Bell & Gossett, Circuit Setter Plus

B. Taco

C. Autoflow Incorporated

D. Substitutions: Under provisions of Division 22 – Common Work Results for Plumbing.

2.24 BALANCING VALVES

A. Furnish and install as shown on plans and with manufacturers recommendations, Bell & Gossett, "Circuit Setter Plus", Model CB calibrated balance valves.

B. Pre-Set Balance Feature - Valves to be designed to allow installing contractor to pre-set balance points for proportional system balance prior to system start-up in accordance with pre-set balance schedule.

C. Valve Design and Construction - All valves 2" to 3" pipe size to be of bronze body/brass ball construction with glass and carbon filled TFE seat rings. Valves to have differential read-out ports across valve seat area. Read-out ports to be fitted with internal EPT insert and check valve. Valve bodies to have 1/4" NPT tapped drain/purge port. Valves to have memory stop feature to allow valve to be closed for service and then reopened to set point without disturbing balance position. All valves to have calibrated name plate to assure specific valves settings. Valves to be leak-tight at full rated working pressure.

D. Preformed Insulation - All valves to be provided with molded insulation to permit access for balance and read-out.

E. Design Pressure Temperature

1. 1/2" - 3" NPT connections 300 psig at 250º F.
2. 1/2" and 3/4" sweat connections 200 psig at 250º F.

PART 3 - EXECUTION

3.1 PREPARATION

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

B. Remove scales and dirt, on inside and outside, before assembly.

C. Prepare piping connections to equipment with flanges or unions.

3.2 INSTALLATION

A. Provide non-conducting dielectric connections wherever jointing dissimilar metals.

B. Route piping in orderly manner 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. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

F. Provide clearance for installation of insulation and access to valves and fittings.

G. All piping shall be installed so as not to interfere with any electrical lighting outlet which must be accurately centered and located. Special attention shall be given to this provision regarding piping on ceilings which must be kept a sufficient distance from the outlets to permit the installation of the lighting fixtures and their reflectors. The mechanical trades shall consult with the electrical trades for exact locations of fixtures and equipment.

H. Arrange and install piping approximately as indicated straight, plumb, and as direct as possible, form right angles on parallel lines with building walls. Keep pipes close to walls, partitions and ceilings, offset only where necessary to follow walls, as directed.

I. Locate groups of pipes parallel to each other and space them at a distance to permit applying full insulation and to permit access for servicing valves. Risers shall not have couplings in runs from one floor outlet to the next.

J. Concealed piping:

1. Where so indicated or specified, conceal piping in building construction or underground. Install such piping in time so as not to cause delay to work of other trades and to allow time for tests and approvals; do not cover before approval is obtained.
2. Where furred spaces are indicated, keep pipes as close to structural members as possible so as to require minimum furring; in case of furred beams, obtain approval of resulting headroom clearance before installing pipe. This contractor is cautioned to check clearance on General Construction Drawings.

K. Pipes over electrical equipment:

1. Avoid running piping in Electric Equipment Rooms and Elevator Machine Rooms.

L. Establish elevations of buried piping outside the building to ensure not less than 5'-0" of cover.

M. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc primer to welding.

N. Prepare pipe, fittings, supports and accessories not prefinished, ready for finish painting. Refer to Division 01.

O. Establish invert elevations, slopes for drainage to 1/8inch per foot minimum unless otherwise noted on contract documents. Maintain gradients.

P. Install bell and spigot pipe with bell end upstream.

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

3.3 APPLICATION

A. Use grooved mechanical couplings and fasteners only in accessible locations.

B. Make all joints watertight and gas tight under pressure required for various services.

C. For threaded pipe joints, use only an approved pipe joint compound or teflon tape; apply only on male threads. Cut pipe nipples evenly; cut threads, clean, remove burrs, ream ends to full inside bore. Teflon tape shall be used in systems 150 degrees F and lower.

D. All changes in direction and intersections of all welding piping shall be made with welding fittings. Mitering of pipe to form elbows and notching straight runs to form tees will not be permitted. Provide full size tees when branch lines are same size as main or one pipe size smaller. On mains 2-1/2 inches and larger having branch connections at least 2 sizes smaller than main threadolets, weldolets, saddle tees or welding tees may be used. On mains 2 inches and smaller full size tees shall be used.

E. Install unions downstream of valves and at equipment or apparatus connections.

F. Provide unions, screwed or flanged, where indicated and in following locations even if not indicated.

3.4 DRAINAGE PIPING INSTALLATION

A. Where changes in pipe sizes occur, use only reducing fittings. For drainage piping changes in direction, use long sweep bends where possible, otherwise short sweep 1/4 bends or combination Y and 1/8 bends, also Y's or in combination with other bends, use sanitary T. branches only for horizontal branches discharging to stacks.

B. Where waste lines from fixtures are indicated on plans to be acid resistant, vents shall be also be acid resistant.

C. Soil, waste and storm water piping shall not pitch less than 1/8 inch per foot unless otherwise indicated.

3.5 EXHAUST AND RELIEF VENT PIPING INSTALLATION

A. Extend exhaust vents separately through the roof. Sanitary vents shall not connect to exhaust vents.

B. Provide relief vent piping for relief valves, receivers, etc., as indicated.

C. Pipe size shall be such that cross sectional area is equal to the sum of the areas of the discharge connections of relief valves.

D. Terminate vent piping so as to avoid injury to life or property.

3.6 INTERIOR WATER PIPING INSTALLATION

A. Each branch from a main line shall be valved with a gate valve and each individual fixture shall be so valved that it can be readily shut off without interrupting the service to any other fixture or apparatus, fixture shut-offs being required for this purpose.

B. All piping shall be installed to drain to low points where 2 inch male hose connections are to be installed.

C. Connect branch lines at bottom of main serving fixtures below and pitch down so that main may be drained through fixtures. Connect branch lines to top of main serving only fixtures. Connect branch lines to top of main serving only fixtures located on floor above.

D. Provide swing connections throughout system to allow adequate horizontal and vertical expansion and contraction.

3.7 PIPE JOINTS

A. Make all joints watertight and gastight under pressure required for various services.

B. For threaded pipe joints, use teflon (R) tape, oil or approved pipe joint compound: apply only on male threads. Cut pipe nipples evenly; cut threads, clean, remove burrs, ream ends to full inside bore.

C. For soldering or sweating joints on copper tubing, clean and polish outer surface of tube ends and inner surface of fittings, apply flux and solder as specified. The use of self-cleaning flux is prohibited. Copper tubing and fittings 2 inches and larger shall be tinned prior to making solder joint. A circular torch shall be used for soldering joints 2 inches and larger.

3.8 MECHANICAL PIPE COUPLINGS

A. Couplings for steel pipe shall be self-centering and shall engage and lock in place the grooved or shouldered pipe and pipe fitting ends in a positive watertight couple.

B. Coupling housing clamps shall be fabricated in two or more parts of malleable iron castings. Housing clamps shall hold in place a composition water-sealing gasket designed so that internal water pressure serves to increase the seal's watertightness. Coupling assembly shall be securely held together by two or more track-head, square or oval neck steel bolts.

C. Pipe fittings used in connection with pipe couplings shall have grooved or shouldered ends and shall be fabricated of malleable iron castings.

D. Pipe fittings used in accordance with pipe coupling manufacturer's recommendations. Piping may be cut-grooved or rolled-grooved, except that pipe wall thickness, less than the minimum recommended by manufacturer, for cut-grooving shall be rolled-grooved without removal of any metal.

3.9 ELECTROLYSIS CONTROL

A. The installation of copper tubing shall be accomplished in such a way as to not touch or come in contact in any way with ferrous metals.

B. Where copper tubing or fittings are anchored, supported or may come in contact with metal construction, an insulation non-conductor spacer, similar to rubber, fiber or an approved equal, shall be installed to assure prevention of electrolysis.

C. Hangers supporting copper tubing shall be copper coated and large enough to accommodate the insulating pipe covering. Copper tubing lines shall not be (even temporarily) supported or secured to ferrous metals.

D. When copper piping or tubing is connected to ferrous piping or equipment, it shall be done with the use of a dielectric union or fitting.

E. For connection of copper tubing to ferrous metal pipe, install dielectric union type fittings with non-conducting material in contact with both pipe materials, screwed or flanged, as manufactured by EPCO Sales, Inc., or approved equal.

F. Samples of fittings shall be submitted to the Engineer for approval.

3.10 PIPES OVER ELECTRICAL EQUIPMENT

A. Where pipe joints or valves in water lines occur within two feet in horizontal directions from electrical panels, equipment, provide drip pans of size which will afford protection as approved.

B. Pans shall be 20 oz. sheet copper, edges turned up 2-1/2 inches all sides, reinforced with brass angles or by rolling edges over 1/4 inch diameter brass wire.

C. Provide drain with 3/4 inch brass flange and copper tube to drain to nearest floor drain.

D. Support the brass or angles, brace to prevent sagging or swaying as directed.

E. No piping carrying water shall be installed in Electric Room.

F. No piping shall be run in the dedicated equipment space as defined in the N.E.C. (NFPA 70). The dedicated equipment space is the space equal to the width and depth of the equipment and extending from the floor to a height of 6ft. Refer to the National Electrical Code section 110.26 (E) for further information. No piping, ducts, sprinklers, leak protection apparatus, or other equipment foreign to the electrical installation shall be located in this zone. It is this contractor's responsibility to coordinate with the electrical contractor for all phases of this project.

3.11 HANGERS AND SUPPORTS

A. Supports shall secure pipes in place, shall prevent pipe vibration, maintain required grading by proper adjustment, provide expansion and contraction and shall make a neat appearance.

B. Supports shall be of strength and rigidity to suit loading, service and installed in manner which will not stress unduly the building construction.

C. Where support is from concrete construction, take care not to weaken concrete or penetrate waterproofing.

D. Fasten supports, hangers, to building steel framing wherever practicable. Where required, add supplementary steel members to support piping.

E. Use inserts for suspended hangers from concrete slab.

F. Hangers shall be capable of vertical adjustment after piping is erected.

G. Hanger rods shall not pierce ducts.

H. Horizontal piping hanger spacing shall conform to the applicable plumbing code for this project. Where required, provide supplementary steel members for hanger attachment at the required intervals.

I. Vertical piping supports:

1. Cast iron and steel: Support at each floor with a maximum spacing as listed in the applicable plumbing code, and not exceeding eight feet from ends of risers, unless otherwise required by expansion conditions.
2. Support vertical lines which rise from lowest story with base fitting set on concrete or brick pier, or by hangers located on horizontal connections to riser.
3. Bolt pipe riser clamps securely to pipe; rest clamp and extension on building structure. In special cases where directed weld clamp to pipe and to building steel. Where required, provide supplementary steel members for clamp rest.
4. Vertical piping support spacing shall conform to the applicable plumbing code for this project.

J. Concrete Inserts:

1. Where concrete inserts are required for pipe, ducts, hanging radiation supports, perform as follows:

a. Furnish and set inserts in concrete forms in ample time to permit pouring of concrete as scheduled; provide reinforcing rods for pipe sizes over 3 inches and for duct sizes as directed.
b. In areas where concrete slab forms finished ceiling, take care to have inserts finish flush with concrete slab surface; make appearance neat.

K. Pipe Covering Protection

1. Hangers and supports for piping testing on toilets shall not injure or pierce insulation.
2. Hangers and supports shall be placed on the outside of the insulation.

3.12 EXPANSION REQUIREMENTS

A. All piping shall be installed throughout the project with due regard for expansion to prevent damage to the building, equipment and piping. Provide anchors, loops or approved type expansion joints where indicated or required for the accurate control of movement.

B. Bullhead connections in any piping service are prohibited.

C. Provide adequate expansion allowance for service temperatures and piping materials.

D. When installing piping with loop or bend expansion, submit piping to cold spring, which will take care of about half of total expansion between hot and cold conditions. Radiation branch connections shall have strain on when cold, off when hot. Make riser offsets in manner to avoid pocket forming due to expansion.

3.13 ANCHORS AND ALIGNMENT GUIDES

A. Steel pipe anchors shall be made of minimum 1/4 inch "T" shape steel members. Anchors shall be welded to the pipe along the long axis. The top point of the "T" shall be welded to building steel. Submit detail drawings for approval before installation.

B. Anchor pipe couplings shall be used on steel piping system for pipe 3 inch and smaller.

C. Provide pipe alignment guides to guide the expanding pipe to move freely from anchor points in expansion joints, loops or bends. Submit detail drawings for approval before installation.

3.14 INTERIOR AND EXTERIOR GAS PIPING

A. Install gas piping with plugged drip pockets at low points. Entire gas piping installation shall be in accordance with the utility having jurisdiction.

B. Where gas piping is installed on building roofs, and run parallel to the roof slope, provide all fittings such as double elbow swing joints (welded and/or threaded), mitered joints for welded connections to accommodate the angle change at the high points and low points in the roof slope.

C. Where gas piping is installed on building roofs, and run dead-level horizontal, provide pre-engineered piping support system with height ranges to accommodate the deepest low point relative to the high point B.O.P. (bottom of pipe).

D. Pressure regulators shall be of type approved by utility. Furnish valve with automatic vent extended to exterior of building.

E. All gas piping (exposed and concealed) shall be painted. Refer to Division 09 Section "Painting" for paint materials, surface preparation and application of paint. Paint all gas piping with "Yellow" semi-gloss, acrylic-enamel paint. Coat piping with two (2) coats finish over two (2) coats of rust inhibitive metal primer.

3.15 UNION AND FLANGES

A. Provide unions, screwed or flanged, where indicated and in following locations even if not indicated.

1. In bypass around equipment.
2. In connections to pumps, traps and other equipment requiring disconnections for repairs, replacement, locate between shutoff and equipment. Do not conceal unions in walls, partitions or ceilings.

3.16 WALL SEALS

A. Contractor shall determine the required inside diameter of each individual wall opening or sleeve before ordering, fabricating or installing. The inside diameter of each wall opening shall be sized as recommended by the manufacturer to fit the pipe and Link-Seal to assure a watertight joint. If pipe O.D. is nonstandard due to coating, insulation, etc., consult factory for assistance and recommendation before proceeding with all opening detail.

B. In lieu of providing fire stopping materials between sleeves and pipes in fire partitions and floors, the contractor may use the wall seals having a fire rating.

3.17 GAS COCKS

A. For shutoffs, use all bronze gas cocks with flat heads.

B. Gas cocks shall be service pattern straight way, flat head, i.p.s. as manufactured by Muller Brass Company or Hays Corporation.

END OF SECTION 22 10 00

SECTION 22 30 00 - PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 WORK INCLUDED

A. Water Softener

1.3 RELATED WORK

A. Division 22 – Supports and Anchors

1.4 REFERENCES

A. ANSI/ASME Section 8D – Pressure Vessels

B. ANSI/NFPA 30 – Flammable and Combustible Liquids Code

C. ANSI/NFPA 54 – National Fuel Gas Code

D. ANSI/NFPA 58 – Storage and Handling of Liquefied Petroleum Gases

E. ANSI/NFPA 70 – National Electrical Code

1.5 QUALITY ASSURANCE

A. Provide pumps with manufacturer's name, model number, and rating/capacity identified.

B. Ensure products and installations of specified products are in conformance with recommendations and requirements of the following organizations.

1. American Gas Association (AGA)
2. National Sanitation Foundation (NSF)
3. American Society of Mechanical Engineers (ASME)
4. National Board of Boiler and Pressure Vessel Inspectors (NBBPVI)
5. National Electrical Manufacturers' Association (NEMA).
6. Underwriters Laboratories (UL)

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

1.6 REGULATORY REQUIREMENTS

A. Conform to AGA, NSF, ANSI/NFPA 54, ANSI/NFPA 70, UL 174, requirements for water heaters.

B. Conform to ANSI/ASME Section 8D for manufacture of pressure vessels for heat exchangers.

C. Conform to ANSI/ASME Section 8 D, ANSI/NFPA 30 and ANSI/NFPA 31 for tanks.

1.7 SUBMITTALS

A. Submit shop drawings and product data under provisions of Division 22 – Common Work Results for Plumbing.

B. Include dimension drawings of water heaters indicating components and connections to other equipment and piping.

PART 2 - PRODUCTS

2.1 WATER SOFTENER

A. Furnish and install ATS Model NXT300-3" triple water softener to provide a zero soft water effluent as determined by an ASTM standard soap test method, when operated in accordance with operating instructions. Each unit softener to have a dedicated 2" S/S/ pulse meter and shall be designed to provide 300K grains per tank maximum capacity of hardness reduction between regenerations at a maximum salt dosage of 225 lbs. salt. Each unit shall be capable of a continuous flow rate of 120 GPM with a pressure drop of 15 psi and a peak flow rate of 170 GPM with a pressure drop of 25 psi.

B. The softener vessel(s) shall be designed for a working pressure of 150 psi and a temperature of 120°F. A minimum freeboard volume of 50% shall be provided to assure adequate bed expansion during backwash. Vessel(s) shall be manufactured of fiberglass reinforced polyester (FRP). The exterior side shall be reinforced by a continuous roving glass filament overwrap of the same color as the vessel(s) shell. The vessel(s) shall be supported by a molded polypropylene structural base. Each vessel(s) shall have the dimensions of 24" diameter x 72" height plus the height of the base.

C. The backwash distributor and soft water collector shall be of the hub-radial. The radials shall be designed with a higher density of slots at the outer ends to provide adequate distribution and collection of water away from the center of the tank. Internal piping material shall be constructed of PVC and/or ABS plastic. A washed gravel under bedding shall be provided as a support bed for the exchange media and an aid in backwashing. Systems under 90,000 grains and smaller shall have single point distributors.

D. The softener shall be provided with 10 cubic feet of high capacity, non-phenolic resin per vessel(s) having a minimum exchange of capacity of 30,000 grains per cubic foot when regenerated with 15 lbs. of salt per cubic foot. The media shall be solid, of the proper particle size (not more than 4% through 40 mesh U.S. standard screen, wet screening) and shall contain no plates, shells, agglomerates or other shapes which might interfere with the normal function of the water softener.

E. The combination salt storage and brine measuring tank with cover shall be sized to hold 1000 lbs. of salt and have the dimensions of 30" diameter x 50" tall. The tank shall be of rotationally molded rigid polyethylene. The brine valve assembly shall include an automatic air eliminator and safety float shut-off valve. It shall open automatically, to educt brine, close to prevent the entrance of air after the brine has been drawn, and permit refill of the tank with the correct amount of water. Brine dosage shall be controlled by the softener control valve through an adjustment on the clock timer. The system shall be designed to allow proper refiling regardless of the salt level in the tank.

F. The control valve shall have 3" inlet and outlet connections and be constructed of lead-free brass. It shall be of the mechanically actuated, four position type to accomplish the regeneration steps of backwash, brine draw / slow rinse, fast rinse and brine tank refill. The valve shall contain a fixed orifice eductor nozzle and self-adjusting backwash flow control. For simplex systems, the control valve shall allow for the bypass of hard water to service during the regeneration cycle.

G. The control system shall have an integral timer for adjustable duration of the various steps in the regeneration cycle and shall allow for the manual initiation of the regeneration cycle. The regeneration cycle shall also be capable of automatic initiation by one (1) of the following methods:

1. Electronic Meter – The standard electronic operated water meter shall be NXT Model 3200 electronic microprocessor-based water timer. The NXT timer shall have a digital display for volume batch size, volume batch remaining, continuous flow rate, and volume totalization.
2. Programmable Controller – A solid state programmable microprocessor controller shall be furnished and be capable of operating up to four (4) softener vessels in either a parallel, alternating, or additive flow configuration. Softener regeneration shall be initiated by a paddle wheel electronic meter that is to installed remotely in the soft water effluent line of each softener unit. The controller shall have a digital display for the volume batch, volume remaining, continuous flow rate, peak flow rate, and totalization for up to four (4) softener units.

H. A complete hardness test kit shall be furnished (ASTM soap test method).

I. The water softening equipment shall be warranted against failure due to faulty materials, and workmanship for a period of one (1) year. In addition, the fiberglass reinforced pressure vessel(s) shall be warranted for a period of five (5) years. William Kolstad R.C. Kolstad Water Corp 73 Lake Rd Ontario, NY 14519. Phone: 585-216-2230, Fax: 585-216-2233

END OF SECTION 22 30 00

SECTION 22 40 00 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 WORK INCLUDED

A. Water Closets

B. Urinals

C. Lavatories

D. Showers

1.3 RELATED WORK

A. Division 22 – Custom Casework: Preparation of counters for sinks.

B. Division 22 – Joint Sealers: Seal Fixtures to walls and floors.

C. Division 22 – Toilet and Bath Accessories: Lavatory tops.

D. Division 22 – Anchors and Supports

E. Division 22 – Common Work Results for Plumbing

F. Division 22 – Plumbing General

G. Division 22 – Plumbing Piping

H. Division 22 – Plumbing Specialties

I. Division 22 – Plumbing Equipment

1.4 REFERENCES

A. ANSI A112.6.1 – Supports for Off-the-Floor Plumbing Fixtures for Public Use.

B. ANSI A112.18.1 – Finished and Rough Brass Plumbing Fixture Fittings.

C. ANSI A112.19.2 – Vitreous China Plumbing Fixtures

D. ANSI A112.19.5 – Trim for Water-Closet Bowls, Tanks, and Urinals.

E. ANSI Z124.2 – Gel-Coated Glass-Fiber Reinforced Polyester Resin Shower Receptor and Shower Stall Units.

F. ARI 1010 – Drinking Foundations and Self-Contained Mechanically Refrigerated Drinking Water Coolers.

1.5 QUALITY ASSURANCE

A. Fixtures: By same manufacturer for each product specified throughout.

B. Trim: By same manufacturer for each product specified throughout.

1.6 SUBMITTALS

A. Submit product data under provisions of Division 01 and 22 – Common Work Results for Plumbing.

B. Include fixtures, sizes, rough-in dimensions, utility sizes, trim, and finishes.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Division 22 – Common Work Results for Plumbing.

B. Include fixture trim exploded view and replacement parts lists.

1.8 WARRANTY

A. Provide three-year manufacturer's warranty under provisions of Division 22 – Common Work Results for Plumbing.

B. Warranty: Include coverage of electric water cooler compressor.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS – FIXTURE

A. Zurn

B. Sloan

C. Toto

2.2 ACCEPTABLE MANUFACTURERS - FIXTURE TRIM

A. Zurn

B. Sloan

C. Toto

D. Substitutions: Under provisions of Division 22 – Basic Mechanical Requirements.

2.3 ACCEPTABLE MANUFACTURERS - FLUSH VALVES

A. Zurn

B. Sloan

C. Toto

2.4 ACCEPTABLE MANUFACTURERS - WATER CLOSET SEATS

A. Bemis

B. Olsonite

C. Beneke

D. Substitutions: Under provisions of Division 22 – Basic Mechanical Requirements.

2.5 ACCEPTABLE MANUFACTURERS - FIXTURE CARRIERS

A. Zurn

B. J.R. Smith

C. Wade

D. Substitutions: Under provisions of Division 22 – Basic Mechanical Requirements.

2.6 WATER CLOSET TAG HA ADA COMPLIANT

A. Bowl: ANSI A112.19.2 / CSA B45.1; vitreous China, 1.28gpf [4.8lpf] or greater, high efficiency floor mounted back outlet toilet, siphon jet flushing action, Zurn SHIELD, ceramic glaze, elongated front rim, ADA compliant rim height, 1-1/2" top spud inlet connection and 4-

1/8" back outlet rough-in height. This bowl is designed to perform to industry standards with as little as 1.28 gallons per flush, engineered to provide optimal performance. Model Z5645-BWL vitreous china bowl, with elongated rim, 1 1/2 inch top-spud, china bolt caps, 1.28 GPF; Model Z5665-BWL1 manufactured by Zurn Elkay Water Solutions.

B. Carrier(s) Horizontal (Left, Right), Vertical:

1. EZCarry: **Horizontal** siphon jet water closet carrier system with high performance waterway and 4" no-hub connections. Floor mount back outlet connection optimized for installation. System includes Dura-Coated cast iron main fitting with hydro-mechanically optimized sweep and extended 2" vent, adjustable faceplate, QuickFit faceplate gasket, floor mounted, back outlet fixture support, trim, bonded "Neo-Seal" gasket, and 3" dia x 12" EZ-Set Coupling designed to increase flow velocity and line carry; Model Z1201-NL4-FMBO 4" No-Hub left hand inlet with flow to right or Model Z1201-NR4-FMBO 4" No-Hub right hand inlet with flow to left.
2. EZCarry: **Vertical** siphon jet water closet carrier system with high performance waterway and 4" no-hub connections. Floor mount back outlet connection optimized for installation. System includes Dura-Coated cast iron main fitting with hydro-mechanically optimized sweep and extended 2" vent, adjustable faceplate, QuickFit faceplate gasket, floor mounted, back outlet fixture support, trim, bonded "Neo-Seal" gasket, and 3" dia x 12" EZ-Set Coupling designed to increase flow velocity and line carry; Model Z1202-N4-FMBO.

C. Flush Valve: ANSI A112.18.1; exposed chrome plated, hydropowered sensor gear operated, triple filtered diaphragm type, integral screwdriver stop and high-pressure vacuum breaker, internal siphon-guard protection, 1.28 GPF; Model Zurn Hydro-X ZER6000AV-HYD as manufactured by Zurn.

D. Seat: Solid white plastic, open front, large molded-in bumpers, external check hinges to feature stainless steel posts; Model 1955SSC manufactured by Bemis.

2.7 WATER CLOSET TAG HA-1 ADA COMPLIANT

A. Bowl: ANSI A112.19.2; floor mounted bottom outlet toilet, siphon jet, vitreous china bowl, with elongated rim, 1 1/2 inch top-spud, china bolt caps, 1.28 GPF; Model Z5665-BWL1 manufactured by Zurn.

B. Flush Valve: ANSI A112.18.1; exposed chrome plated, hydropowered sensor gear operated, triple filtered diaphragm type, integral screwdriver stop and high-pressure vacuum breaker, internal siphon-guard protection, 1.28 GPF; Model Zurn Hydro-X ZER6000AV-HYD as manufactured by Zurn.

C. Seat: Solid white plastic, open front, large molded-in bumpers, external check hinges to feature stainless steel posts; Model 1955SSC manufactured by Bemis.

2.8 URINAL TAG HB

A. Urinal: ANSI A112.19.2; wall hung, vitreous china ADA compliant, asymmetric backwall for reduced splashing, 0.50 GPF, urinal shall have integral trap, ¾" inch top spud, with wall hanger, Model Z5755-U manufactured by Zurn.

B. Flush Valve: ANSI A112.18.1; exposed chrome plated, hydro-powered gear-operated sensor operated, triple filtered diaphragm type, escutcheon, integral screwdriver stop and high-pressure vacuum breaker, internal siphon-guard protection, 0.50 GPF; Model Zurn Hydro-X ZER6003AV-HYD as manufactured by Zurn.

C. Wall Mounted Carrier: Wall urinal support system complete with Dura-Coated carbon structural steel rectangular tubing uprights, conforming to ASTM A500 Grade C, with welded base feet having slotted floor anchor holes. Lower bearing plate is vertically adjustable with slot to accommodate bearing jack placement. Upper universal hanger plate is pre-notched for back spud inlet and is designed for various hardware positions and fixtures. Includes mounting fasteners and hardware. Carrier system exceeds load and deflection requirements as outlined in ASME Standard A112.6.1M. Model No. Z1222 manufactured by Zurn.

2.9 LAVATORY TAG HC

A. Lavatory: ANSI A112.19.2; vitreous china wall mounted lavatory, 20" x 18" with hanger plate and holes for concealed arm carrier systems, front overflow, Model Z5340 manufactured by Zurn.

B. Trim: ANSI A112.18.1; Zurn Hydro-X Model No. Z6950-XL-S Sensor Activated handwashing faucet, 0.5 gpm flow rate for pre-tempered or hot/cold water supplies. Product to have adjustable timeout feature. Motor gear-driven ceramic cartridge and self-sustaining hydropowered faucet. Thermostatic mixer ordered separately to comply with ASSE 1070 requirements. The product shall be tested and certified to industry standards: ASME A112.18.1M, CSA B125.1, California Health and Safety Code 116875 (AB1953-2006), and Vermont Bill S.152. This product meets ADA ANSI/ICC A117.1 requirements.

C. Support:

1. Universal Carrier System designed to reduce installation time and provide job site flexibility. Zurn's Concealed Arm Carrier comes standard with Dura-Coated, ductile iron universal arms, including leveling screws, and soft-set elastomeric locking devices pre-installed. Reversible header plates with slots and integral welded arm sleeves that provide 2" of horizontal adjustment per plate, allowing for horizontal post anchoring adjustment from 13"-21". Uprights, rigid spacing plates, and header plates are factory assembled for easy installation. Carrier system comes complete with Dura-Coated uprights constructed of carbon-steel tubing that meet ASTM A500 Grade C standards. Uprights also include welded steel plate mounting feet that feature separate bolt patterns for use with either (2) 3/8" or 1/2" anchors per leg. Carrier includes lower and upper rigid spacing plates for a spacing of 17". Upper spacing plate includes horizontal slots for securing water supply and vent piping. Zurn's Universal carrier systems exceeds load and deflection requirements when tested in accordance to ASME Standard A112.6.1M up to a 250 lb static load rating

at all rough-in positions, and meets OSHPD spacing requirements for two anchor per upright installation. Model No. Z1231EZ with universal concealed arm carrier system for wall hung lavatory with waste line sleeve -WL manufactured by Zurn.

2. Wall supported exposed arm system. Dura-Coated wall plate securing assembly with acid resistant epoxy coated cast iron exposed arms, complete with mounting fasteners. Model No. Z1257 manufactured by Zurn.

D. Trap: Adjustable cast brass "P" trap.

E. Supplies: 3/8" supply pipe with loose key stop for wheelchair lavatory, escutcheon, 1/4" reducer coupling.

F. Drain: Handicapped offset drain as manufactured by Zurn.

G. Insulation: Suppliers and drain shall be insulated with Handi Lav-Guard Lavatory Insulation Kit as manufactured by Zurn.

2.10 LAVATORY TAG HC-1

A. Lavatory: ANSI A112.19.2; vitreous china undermount lavatory, 19" X 16" front overflow, Rimless oval design Model Z5220 manufactured by Zurn.

B. Trim: ANSI A112.18.1; Zurn Hydro-X Model No. ZURN Z6950-XL-S Sensor Activated handwashing Faucet, 0.5 gpm flow rate for pre-tempered or hot/cold water supplies. Product to have adjustable timeout feature. Self-sustaining hydropower with battery backup. Thermostatic mixer ordered separately to comply with ASSE 1070 requirements. The product shall be tested and certified to industry standards: ASME A112.18.1M, CSA B125.1, California Health and Safety Code 116875 (AB1953-2006), and Vermont Bill S.152. This product meets ADA ANSI/ICC A117.1 requirements.

C. Trap: Adjustable cast brass "P" trap.

D. Supplies: 3/8" supply pipe with loose key stop for wheelchair lavatory, escutcheon, 1/4" reducer coupling.

E. Drain: Handicapped offset drain as manufactured by Zurn.

F. Insulation: Suppliers and drain shall be insulated with Handi Lav-Guard Lavatory Insulation Kit as manufactured by Zurn.

2.11 SHOWER TAG HG (ADA COMPLIANT)

A. Transfer Shower Stall - The shower enclosure shall be aqua bath Model C4136TD-FUS 3/4” acrylic and be molded from a single sheet so as not to have any joints or seams, shall meet ANSI Z124.2. Shall meet ADA guidelines and other standards for accessibility. Unit shall have a backside flame spread of less than 30 (class b). Shall be designed to be ADA compliant and NAHB listed. The enclosure shall have inside dimensions of 36”d x 78”h and outside dimensions of 41”w x 37”d x 82 3/4"h. The approximate weight of the unit shall be 230lbs. The unit shall

be formed with a patented recessed trench system so as to direct water to the front drain. To be ADA compliant, top of threshold cannot exceed 1/2" above finished floor material.

1. Included Accessories:

   a. One 31 3/4" x 15 3/4" x 1 1/2" diameter two wall horizontal wrap grab bar and one 18" vertical grab bar, fabricated from 18-gauge stainless steel with 1 1/2" safety statute clearance, mounted with stainless steel bolts and secured from the rear with 3" x 3" x 11" gauge metal mounting plates.
   b. 34" "l" shaped phenolic fold-up seat.
   c. 1" diameter, 18-gauge stainless steel curtain rod.
   d. One wall bracket installed at 40" above floor in center of back wall for handheld shower set. After grab bars, fold-up seat, curtain rod and wall bracket have been factory installed, they will be sealed from the backside making the unit completely waterproof.
   e. Ribbed bottom for slip resistance (standard).
   f. Handheld shower set (includes 60" flex hose, swivel connector, brass nipple, lock nut, wall outlet and vacuum breaker).
   g. 24" slide bar, 30" slide bar or two (2) wall brackets installed on valve wall for use with handheld shower set.

   NOTE: The determination of the use of the slide bar or wall brackets to be installed in the unit is based upon the valve package chosen by the specifier for use in the unit. Aqua bath recommends the use of a slide bar as an accessory in the unit rather than the use of a glide bar / glide rail.

   h. Pressure balance or thermostatic control valve.
   i. Shower curtain - antibacterial, with hooks.
   j. Weighted shower curtain (patented), antibacterial, with hooks.
   k. Seat belt.
   l. Dome light, (factory drilled only, must be field installed and light shipped separately from unit).

2.12 SHOWER TAG HG-1 (3-STATION, RINSE)

A. Model: WS-3W, 6'-0" showerhead height, soap dish by Bradley

B. Materials:

1. Shower panel is type 304 stainless steel polished to a #4 finish. All other exposed parts are stainless steel or chrome-plated brass. Valve bodies are brass casting. Supply inlets are copper tubing.

C. Standard Equipment:

1. Shower Panel

   a. Shower panel with top and bottom covers constructed of 18-gauge stainless steel polished to a #4 finish. Stainless steel soap tray for each station mounted to panel.

D. Valve Type:

1. Thermostatic Mixing

E. Showerhead Type:

1. Deluxe Showerhead w/ Ball Joint

F. Flow Control:

1. A 1.5 GPM (5.7 LPM) flow control is standard. Actual flow may vary, but will not exceed 2.0 GPM (7.6 LPM) max.

G. Supply Inlets:

1. Constructed of 3/4" type “L” copper tubing. Inlets are accessible through the back of the shower or through knockouts in the top cover.

2.13 SHOWER TAG HG-2 (3-STATION BATHING)

A. Model: WS-3W, 6’-0” showerhead height by Bradley

B. Materials:

1. Shower panel is type 304 stainless steel polished to a #4 finish. All other exposed parts are stainless steel or chrome-plated brass. Valve bodies are brass casting. Supply inlets are copper tubing.

C. Standard Equipment:

1. Shower Panel

a. Shower panel with top and bottom covers constructed of 18-gauge stainless steel polished to a #4 finish. Stainless steel soap tray for each station mounted to panel.

D. Valve Type:

1. Thermostatic Mixing

E. Showerhead Type:

1. Deluxe Showerhead w/ Ball Joint

F. Flow Control:

1. A 1.5 GPM (5.7 LPM) flow control is standard. Actual flow may vary, but will not exceed 2.0 GPM (7.6 LPM) max.

G. Supply Inlets:

1. Constructed of 3/4" type “L” copper tubing. Inlets are accessible through the back of the

H. Optional Privacy Compartments:

1. Partitions

a. Fabricated of 20-gauge 300 series stainless steel sheets polished to a #4 finish. Sandwich type construction with waterproof cores securely bonded between sheets. Partitions are secured to posts with 14-gauge type 300 stainless steel stirrups and stainless-steel screws.

I. Posts:

1. Fabricated 18 gauge 1-1/4" square x 80" stainless steel tubing. Post is secured to floor with an expansion anchor and a concealed foot angle which allows plus or minus 1/2" vertical adjustment.

J. Curtains:

1. Curtain rails fabricated of 300 series #4 finish stainless steel cylindrical tubing. Curtain hooks are steel wire with a zinc chromate finish. Curtains are 60" W x 74" H and fabricated of heavy gauge translucent vinyl with hemmed edges and aluminum grommet reinforced eyelets.

K. Hardware:

1. All exposed fasteners are vandal-proof stainless steel. Post shoes are anodized aluminum and finished to match stainless steel.

PART 3 - EXECUTION

3.1 INSPECTION

A. Review millwork shop drawings. Confirm location and size of fixtures and openings before rough-in and installation.

B. Verify adjacent construction is ready to receive rough-in work of this Section.

3.2 INSTALLATION

A. Install each fixture with trap, easily removable for servicing and cleaning.

B. Provide chrome plated rigid or flexible supplies to fixtures with screwdriver stops reducers, and escutcheons.

C. Install components level and plumb.

D. Install and secure fixtures in place with chair, carriers and bolts as required.

E. Seal fixtures to wall and floor surfaces with sealant as specified in Division 1, color to match fixture.

F. Mount fixtures to the following heights above finished floor:

Water Closet:		
Standard	15	inches to top of bowl rim
*Handicapped	18	inches to top of seat

*Flush valve for handicapped must have operator set on the wide side of the stall, not more than 44 inches above finish floor.

Urinal:		
Standard	22	inches to top of bowl rim
*Handicapped	17	inches to top of bowl rim

*Flush valve for handicapped shall have the operator set no more than 44 inches above finish floor.

Lavatory:		
Standard	31	inches to top of basin rim
Handicapped	34	inches to top of basin rim and 29 inches to bottom of the apron

Drinking Fountain:		
Standard	40	inches to top of basin rim
Handicapped	36	inches to spout

Water Closet Flush Valves:		
*Standard	11	inches minimum above bowl rim
*Recessed	10	inches minimum above bowl rim
*Not more than	44	inches above finish floor for handicapped use.

Shower Heads:		
Adult	69.5	inches to bottom of head
Handicapped		Shower spray unit with 60 inches of hose and handheld shower.
Controls	38	inches to 48 inches above finish floor

3.3 ADJUSTING AND CLEANING

A. Adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.

B. At completion clean plumbing fixtures and equipment.

C. Solidly attach water closets to floor with lag screws. Lead flashing is not intended to hold fixture in place.

3.4 FIXTURE ROUGH-IN SCHEDULE

A. Rough-in fixture piping connections in accordance with following table of minimum sizes for particular fixtures.

	Hot Water	Cold Water	Waste	Vent
Lavatory	1/2"	1/2"	1-1/2"	1-1/2"
Service Sink	1/2"	1/2"	3"	2"
Sink	1/2"	1/2"	1-1/2"	1-1/2"
Drinking Fountain	--	1/2"	1-1/2"	1-1/2"
Water Closet (Flush Valve)	--	1-1/2"	4"	2"
Water Closet (Tank Type)	--	1/2"	4"	2"
Urinal (Flush Valve)	--	3/4"	2"	1-1/2"

END OF SECTION 22 40 00

SECTION 23 00 00 - HVAC SCOPE OF WORK

PART 1 - GENERAL

1.1 STIPULATIONS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Sections, apply to this Section.

1.2 REQUIREMENTS

A. The conditions as defined in Division 23 – Common Work Results for HVAC, shall apply to all Division 23 specifications.

B. This contractor shall carefully read the above-mentioned documents and study the drawings of all trades. He shall be responsible for neglect to read or attend to any paragraph or items contained herein.

1.3 INTENT

A. It is the intent of this specification and accompanying drawings to provide HVAC system, as specified herein and as shown on the contract drawings. The drawings show the general arrangement and extent of the work to be done. Exact location and arrangement of all components shall be determined as the work progresses. Plans are subject to such modification as may be necessary at the time of installation in order to meet construction conditions. Any adjustments shall be made by the HVAC Contractor, without extra charge.

B. The project is to be completed during normal working hours.

1.4 WORK INCLUDED

A. These specifications and accompanying drawings are intended to cover the furnishing by this Contractor of all labor, material and equipment of every kind necessary for the complete installation of the various systems and such other material and equipment as hereinafter specified and shall not be limited to the following:

1. Provide packaged rooftop water source heat pump units with roof curbs, accessories for mounting on steel dunnage, VFD driven fans, energy recovery wheels, gas fired heating sections, hydronic heating sections, filters in all units providing outside air, hot gas reheat coils, condenser barrels and both single point and dual point power connections.
2. Provide packaged rooftop air conditioning units with roof curbs.
3. Provide roof-mounted modular air conditioning units with roof curbs with curb sound attenuation.
4. Provide indoor mounted modular air handling units.

5. Provide packaged terminal air conditioning units.
6. Provide outdoor, air-cooled packaged chillers.
7. Provide centrifugal chillers.
8. Provide rotary screw chillers.
9. Provide cooling towers.
10. Provide cast iron hot water heating boilers.
11. Provide cast iron steam boilers.
12. Provide fire tube steam boilers.
13. Provide water tube steam boilers.
14. Provide fire tube hot water boilers.
15. Provide water tube hot water boilers.
16. Provide unit heaters and cabinet heaters.
17. Provide cooling condensate pumps and receivers and pumps.
18. Provide deaerator systems including but not limited to pumps, controls and steam specialties.
19. Provide flash tanks.
20. Provide steam to hot water heat exchangers.
21. Provide plate and frame heat exchangers.
22. Provide refrigerant piping systems with fittings, hangers and specialties.
23. Provide pipe fittings, valves and specialties for chilled water, hot water heating, geothermal water, process water, steam and steam condensate piping.
24. Provide hot water reheat coils.
25. Provide steam reheat coils.
26. Provide electric reheat coils.
27. Provide grilles, registers and diffusers.
28. Provide dampers, turning vanes, louvers and other ductwork accessories for all airside systems.
29. Provide ventilating equipment consisting of power roof ventilators, inline and thru wall exhaust fans and other fans as needed for all airside systems.
30. Provide raised floor Computer Room units.
31. Provide steam pressure reducing station, steam traps and all steam and steam condensate specialties.
32. Provide fan coil units with sound attenuators.
33. Provide balancing fittings, air vents, unions, strainers, thermometers, pressure gauges and other hydronic accessories for all waterside piping systems.
34. Provide insulation for piping, ductwork and equipment.
35. Provide sound attenuators for rooftop units, fan coil and other similar motor driven equipment serving occupied spaces.
36. Provide exhaust piping and ductwork from emergency generator.
37. Provide direct digital control system including all controls, components and control wiring. Provide thermostats, CO2 sensors and occupancy sensors.
38. Provide complete balancing and testing of all air and water systems.
39. Provide HVAC commissioning.
40. Provide painting of ductwork flat black in auditorium.
41. Provide displacement ventilation diffusers.
42. Provide indoor water to water heat pump units.
43. Provide condensing hot water heating boilers.
44. Provide flue condensate neutralizers for boilers.
45. Provide breeching and intake ductwork for boilers.

46. Provide condensate drain piping and concrete splash blocks.
47. Provide hot water, process water, chilled water, geothermal water and condenser water pumps.
48. Provide hot water, chilled water, process water, geothermal water, condenser water, steam and condensate piping systems.
49. Provide expansion tanks, dirt/air separators, air vents and hydronic accessories.
50. Provide pressure independent control valves for all equipment and terminal units connected to waterside systems
51. Provide condensate drain piping.
52. Provide electric heat tracing with thermostats. Include field grooving of insulation for proper installation.
53. Provide panel radiators, fin radiation and other wall/floor mounted terminal heating units.
54. Provide double wall insulated FRP underground ductwork, plenums, fittings and concrete encasement of system.
55. Provide PEX radiant heating systems with manifolds, pumps and rail mounting system.
56. Provide gas fired humidifiers, RO system with water softener and low absorption distance steam grids in ductwork Provide non-freeze thermodynamic trap and stainless-steel steam piping with supports to account for pipe and roof pitch.
57. Provide supply, return, exhaust and outside air ductwork.
58. Provide galvanealed ductwork for ductwork to be painted. Painting by G.C.
59. Provide sheet metal that is within the tolerance of the gauges for airside systems.
60. Provide ductwork leakage testing.
61. Provide piping pressure testing.
62. Provide process water filters.
63. Provide strainers at the inlet of control valves, at pump suction and wherever needed.
64. Provide staff break area range hood system.
65. Provide 20% inhibited propylene glycol solution for geothermal system and 30% for snowmelt system.
66. Provide custom fabric ductwork with hangers and supports.
67. Provide variable frequency drives for pumps and fans.
68. Provide air vents, unions, strainers, thermometers and gauges for all piping systems.
69. Provide coil hookup packages for hydronic terminals.
70. Provide coil hookup packages with pressure independent control valves for hydronic terminals.
71. Provide all steel supports, vibration isolators, hangers and inertia bases for all equipment, ductwork and piping.
72. Provide sound attenuators for rooftop units, motor driven equipment, airside terminal units and fan coil units serving occupied spaces.
73. Provide chemical treatment for piping systems.
74. Provide expansion loops, anchors and guides for hot water, steam, steam condensate and pumped condensate piping.
75. Provide piping expansion devices at building expansion joints.
76. Provide relief valves and piping for pressure vessels such as water source heat pumps, boilers, chillers, heat exchangers, expansion tanks, etc.
77. Provide piping from refrigerant relief valves on mechanical room installed heat pumps and chillers to discharge above roof. Furnish curbs for this work to General Contractor for installation.
78. Provide refrigerant detection system and ventilation system for the mechanical room containing water source heat pumps and chillers.

79. Provide CO and NG detection system and ventilation system for the mechanical room containing boilers.
80. Provide CO and N detection system and ventilation system including ductwork, ductwork accessories, louvers and DWDI and SWSI utility exhaust fans for the parking garage.
81. Provide O2 depravation system and ventilation system for the MRI areas.
82. Concrete housekeeping pads for mechanical equipment shall be provided by the Mechanical Contractor.
83. Provide constant air volume boxes and variable air volume boxes with sound attenuators.
84. Provide laboratory controls including terminal units with sound attenuators.
85. Provide fume hood controls.
86. Provide fire, smoke and fire/smoke dampers where indicated or needed.
87. Provide all fire-stopping for your work.
88. Setting of sleeves. Provide link seals. Core drilling floors and walls.
89. Proved framed openings in walls for ductwork penetrations and for framing of fire, smoke and fire/smoke dampers.
90. Provide all excavation and backfilling required for mechanical work.
91. Provide installation of direct digital control system utilizing owner furnished equipment and all additional components, control wiring and other required control equipment necessary for a complete code and operable system compliant with the design intent.
92. Provide refrigeration machinery room appurtenances
93. Provide startup on all equipment by factory authorized personnel.
94. Provide alignment and startup on all pumps by factory authorized personnel.
95. Provide all software and integration cards on all equipment with factory controls and VFD's.
96. Provide radon mitigation system.
97. Provide airflow and waterflow measurement stations

B. The following items of work related to HVAC will be performed by others as follows:

1. The General Contractor shall provide all foundations and pads for equipment, paint all piping in finished areas, provide all base flashing on roof, build in all sleeves, unless otherwise noted.
2. The General Contractor shall furnish and install all access panels and doors of sizes required.
3. The General Contractor shall install all access panels furnished by the HVAC Contractor.
4. The Plumbing Contractor shall provide valved make up water outlets and gas outlets for heating and air conditioning equipment for final connection to equipment by the HVAC Contractor.
5. The Plumbing Contractor shall provide floor drains for HVAC equipment. Drainage piping from equipment to drains shall be by the HVAC Contractor.
6. The Plumbing Contractor shall furnish the steam temperature regulator to the HVAC Contractor for installation in the steam line to the hot water generator.
7. The Electrical Contractor shall do all power wiring for HVAC equipment.
8. The Kitchen Equipment Contractor shall provide all kitchen equipment and hoods. The HVAC Contractor shall rough-in piping and ductwork and make final connections.
9. All metal casework and laboratory hoods will be provided by the General Contractor. The HVAC Contractor will rough-in and make final piping and ductwork connections to equipment and hoods.

1.5 ADDITIONAL MATERIALS AND INSTALLATION INCLUDED

A. This contractor shall, as part of his base bid, provide the following materials and installations for the complete systems installation.

1. The contractor shall provide one offset for each 20'-0" of run for each piped service in the building.
2. The contractor shall provide twenty-five (25) additional 3/4" ball valves for installation at locations to be determined during the construction.
3. The contractor shall provide twenty-five (25) additional 1-1/2" ball valves for installation at locations to be determined during the construction.
4. The contractor shall provide twenty-five (25) additional 3/4" check valves for installation at locations to be determined during the construction.
5. The contractor shall provide twenty-five (25) additional 1-1/2" check valves for installation at locations to be determined during the construction.
6. The contractor shall provide twenty-five (25) additional 3/4" unions for installation at locations to be determined during the construction.
7. The contractor shall provide twenty-five (25) additional 1-1/2" unions for installation at locations to be determined during the construction.
8. The contractor shall provide twenty-five (25) additional 3/4" dielectric unions for installation at locations to be determined during the construction.
9. The contractor shall provide twenty-five (25) additional 1-1/2" dielectric unions for installation at locations to be determined during the construction.
10. The contractor shall provide ten (10) additional 1/2" balancing valve assemblies (consisting of a balancing valve, a check valve and a ball valve) for installation at locations to be determined during the construction.
11. The contractor shall provide one offset for each 20'-0" of run for each ducted service in the building.

B. The contractor shall provide a cost breakdown for each of the items listed in paragraph A, above. The cost shall be broken down to indicate material, accessories and labor required for the installation of the items listed above. Upon projected completion, contractor shall submit credit for additional material and installation which is unused.

1.6 WORK AS A SUBCONTRACTOR

A. When the HVAC work is subcontracted, the exact scope of work may be limited or added to at the discretion of the General Contractor/Construction Manager. A subcontractor shall, therefore, verify the extent of his work with the General Contractor/Construction Manager.

1.7 RELATED WORK SPECIFIED ELSEWHERE

The following related work items are included in separate divisions and Sections as follows:

A. General Requirements, Division 01.

B. Site Work – Division 31.

C. Concrete – Division 03.

D. Roof – Division 07.

E. Painting – Division 09.

F. Basic Plumbing Requirements – Division 22.

G. Fire Protection General Requirements – Division 21.

H. Electrical – Division 26.

PART 2 - PRODUCTS

A. As specified in the following related sections.

PART 3 - EXECUTION

A. All HVAC systems shall be complete and fully operational.

B. It is the intent of the Drawings and Specifications, and the contractor's responsibility is to provide a complete code compliant workable system ready for the Owner's operation. Any item not specifically shown on the Drawings or called for in the Specifications, but normally required to conform with the intent, is to be considered a part of the Contract.

END OF SECTION 23 00 00

SECTION 23 05 00 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 STIPULATIONS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Sections, apply to this Section.

1.2 EXECUTION OF THE WORK

A. These specifications call out certain duties of the HVAC Contractor and any Subcontractors. They are not intended as a material list of items required by the Contract. Any reference in these specifications and on the accompanying drawings to the Contractor, Mechanical Contractor, ATC Contractor, Mechanical HVAC Subcontractor, Subcontractor or abbreviation "M.C.", shall be construed to mean the Contractor responsible for all mechanical construction (Division 23) work for this project.

B. This division of the specifications covers the HVAC systems of the project. It includes work performed by the mechanical trades as well as trades not normally considered as mechanical trades.

C. Provide all items and work indicated on the Drawings and all items and work called for in this division of the specifications in accordance with the conditions of Contract (Division 01 General Requirements Documents). This includes all incidentals, equipment, appliances services, hoisting, scaffolding, supports, tools supervision, labor consumable items, fees licenses, etc., necessary to provide complete systems. Perform start-up and checkout on each item and system to provide fully operable systems.

D. Comply with all provisions of the Contract Documents including the General Conditions, and Division 01 General Requirements of the specifications.

E. Certain terms such as "shall, provide, install, complete, start-up" are not used in some parts of these specifications. This does not indicate that the items shall be less than completely installed or that systems shall be less than complete.

F. Examine and compare the HVAC Drawings with these specifications, and report any discrepancies between them to the Architect/Engineer and obtain from him written instructions for changes necessary in the work. At time of bid the most stringent requirements must be included in said bid.

G. Examine and compare the HVAC Drawings and Specifications with the Drawings and Specifications of other trades, and report any discrepancies between them to the Architect/Engineer and obtain from him written instructions for changes necessary in the work. At time of bid, the most stringent requirements must be included in said bid.

H. Install and coordinate the HVAC work in cooperation with other trades installing interrelated work. Before installation, make proper provisions to avoid interferences in a manner approved by the Architect/Engineer. All changes required in the work of the Contractor, caused by his neglect to do so, shall be made by him at his own expense.

I. It is the intent of the Drawings and Specifications to provide a complete code compliant workable system ready for the Owner's operation. Any item not specifically shown on the Drawings or called for in the Specifications, but normally required to conform to the intent, are to be considered a part of the Contract.

J. These specifications are basically equipment, installation, and performance Specifications. Some installation details are indicated on the Drawings. Where these differ from the Specifications, apply the more stringent at time of bid. Upon award of bid, contact Architect/Engineer for definite instructions.

K. All materials furnished by the Contractor shall be new and unused (temporary services are excluded) and free from defects.

L. All products and materials shall be new, clean, free of defects and free of damage and corrosion.

M. The exclusion from, or limitation in, the symbolism used on the Drawings or the language used in the Specifications for HVAC work shall not be interpreted as a reason for omitting the accessories necessary to complete any required system or item of equipment.

N. The use of words in the singular shall not be considered as limiting where other indications denote that more than one item is referred to.

O. All items of equipment or material shall be the product of one manufacturer throughout. Multiple manufacturers will not be permitted.

P. Receive, inspect, store and install Owner-furnished equipment where Owner furnished equipment is supplied.

1.3 COORDINATION OF THE WORK

A. Certain materials will be provided by other trades. Examine the Contract Documents to ascertain these requirements.

B. Carefully check space requirements with other trades and the physical confines of the area to insure that all material can be installed in the spaces allotted thereto including finished suspended ceilings and the spaces within the existing building. Make modifications thereto as required and approved.

C. No items foreign to the electrical system shall be run in the dedicated space of the electrical equipment. Dedicated space shall be defined as the width and depth of the equipment from the floor to the bottom of the structural ceiling. Foreign systems include but are not limited to ductwork, piping, sprinklers, drip trays, etc. Contractor shall be responsible to coordinate the locations of the dedicated spaces with electrical and other trades as required.

D. Transmit to other trades all information required for work to be provided under their respective Sections in ample time for installation.

E. Wherever work interconnects with work of other trades, coordinate with other trades to insure that all trades have the information necessary so that they may properly install all the necessary connections and equipment. Identify all items of work that require access so that the ceiling trade will know where to install access doors and panels.

F. Due to the type of installation, a fixed sequence of operation is required to properly install the complete systems. Coordinate, project and schedule work with other trades in accordance with the construction sequence.

G. The locations of piping, control panels, diffusers and other equipment indicated on the Drawings are approximately correct, but they are understood to be subject to such revision as may be found necessary or desirable at the time the work is installed in consequence of increase or reduction of the number of outlets, or in order to meet field conditions or to coordinate with modular requirements of ceilings, or to simplify the work, or for other legitimate causes.

H. Exercise particular caution with reference to the location of panels, diffuser, grilles, sensors, thermostat, switches, etc., and have precise and definite locations approved by the Architect/Engineer before proceeding with the installation.

I. The Drawings show only the general run of duct/piping and approximate location of outlets/termination. Any significant changes in location of routing, necessary in order to meet field conditions shall be brought to the immediate attention of the Architect/Engineer and receive his approval before such alterations are made. All such modifications shall be made without additional cost to the Owner.

J. Obtain from the Architect/Engineer in the field, the location of such outlets or equipment not definitively located on the Drawings.

K. Wherever the work is of sufficient complexity, prepare additional Detail Drawings to scale similar to that of the bidding Drawings, prepared on tracing medium of the same size as Contract Drawings. With these layouts, coordinate the work with the work of other trades. Such detailed work shall be clearly identified on the Drawings as to the area to which it applies. Submit for review Drawings clearly showing the work and its relation to the work of other trades before commencing shop fabrication or erection in the field.

L. Contractor shall furnish services of an experienced Superintendent, who shall be in constant charge of all work, and who shall coordinate his work with the work of other trades. No work shall be installed before coordinating with other trades.

M. Coordinate with contractors for work under other Divisions of this specification for all work necessary to accomplish this contractor’s work.

N. Where service connections are required, to equipment provided by the Owner or by other trades, this Contractor shall verify the exact requirements for these connections prior to ordering any materials or laying out any work. Where there is a discrepancy between the equipment being furnished and that shown on the Contract Drawings, the Contractor shall notify the Architect/Engineer for direction. Failure to comply with this coordination shall not constitute a

reason for extra monies for equipment ordered or installed. Restocking charges will not be paid.

O. Structural steel fabricator and installer shall be responsible for the coordination of all framed openings in roof with approved equipment manufacturers. (Openings such as, but not limited to mechanical units, exhaust fans, curb mounted equipment, roof drains, skylights, stair openings, roof hatches, smoke hatches, duct thru roof penetrations, expansion joints, etc.

P. Exact sizes and exact locations of all openings are to be verified with the approved shop drawings issued for installation. The exact sizes shall be coordinated prior to any fabrication and installation by any/all trades. (Sizes and locations indicated on contract drawings are diagrammatic and for information only.)

Q. Any fabrication and/or installation which has not been properly coordinated with approved equipment manufacture and must be repaired, relocated, altered, replaced, re-installed or modified in any manner will be done to the satisfaction of the owner with no additional cost to the owner or design professional.

1.4 RELATED DOCUMENTS

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

1.5 SUMMARY

A. This section includes the general requirements that apply to the Mechanical and HVAC Contractor. Fire Protection and the Controls Contractor or Sub-Contractor.

B. The following work is specified under other Divisions, unless otherwise noted or specified hereinafter:

1. Painting except as herein specified shall be by the General Contractor under Division 09 and Section 01 81 13.13 requirements.
2. Site Work, Divisions 31, 32 and 33.
3. Concrete, Division 03.
4. Roof, Division 07.
5. Plumbing, Division 22.
6. Electrical, Division 26.
7. Installation of starters, contactors, thermal overload switches and remote push buttons, and connection of power wiring to motors, Division 26.

1.6 INTENT

A. Requirements specified herein shall govern applicable portions of Heating, Ventilation and Air Conditioning.

B. It is the intent of this specification and accompanying drawings to describe and indicate the general manufacture, erection and installation of the equipment and connection to same specified herein and shown on the drawings. It is not intended that the specifications and drawings describe and indicate each piece of equipment required for installation, for where items are intended or required for satisfactory installation and are considered to be the accepted practice of the trade, they shall be considered to be both specified and indicated. Drawings are diagrammatic in nature; for piping systems; water piping is tapped off the bottom of the pipe and steam and steam condensate piping is tapped off the top of the pipe; provide all tees, elbows and swing joints as required for hookup to coils or branch piping as required for this work whether they are indicated on the drawings or not. For ductwork systems, provide offsets at interference locations and/or where changes in ceiling heights require such offsets; offsets shall be smooth as possible and without the need for hard elbows; offsets shall minimize the elbow angle required which shall result in minimal static pressure gradients into the system.

C. It shall be understood that the Contractor as hereinafter mentioned shall be the Mechanical Contractor unless specifically noted otherwise.

D. The Contractor shall furnish all plant, labor and material necessary for the complete and satisfactory installation of all Mechanical work for this contract.

E. The Contractor shall assume the entire responsibility for the materials, workmanship and satisfactory operation of the various mechanical systems, and other work as specified herein and/or as shown on the drawings.

F. The Contractor shall schedule and coordinate all work in close cooperation with all trades working on this project.

1.7 DEFINITIONS

A. Following definition of terms and expressions used in this section are in addition to listing given in Supplementary Conditions:

1. "Provide" shall mean "furnish and install" unless otherwise indicated.
2. "Herein" shall mean the contents of a particular section where this term appears.
3. "Indicated" shall mean "Indicated on contract drawings".
4. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawl spaces, and tunnels.
5. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
6. Exposed, Exterior Installations: Exposed to view outdoors, or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
7. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
8. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants, but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

9. The following are industry abbreviations for plastic materials:

   a. ABS: Acrylonitrile-butadiene-styrene plastic
   b. CPVC: Chlorinated polyvinyl chloride plastic
   c. NP: Nylon plastic
   d. PE: Polyethylene plastic
   e. PVC: Polyvinyl chloride plastic

10. The following are industry abbreviations for rubber materials:

   a. CR: Chlorosulfonated polyethylene synthetic rubber
   b. EPDM: Ethylene propylene dieneterpolymer rubber

11. For additional abbreviations see the Abbreviations and Symbols Drawings.

1.8 CONTRACTOR'S RESPONSIBILITY

A. The Contractor shall be responsible for establishing grades and elevations, and checking of all interferences, and shall verify all dimensions and locations in the field.

B. Contract drawings for mechanical work are in part diagrammatic, intended to convey the scope of work and indicate general arrangement of equipment, ducts, piping and approximate sizes and locations of equipment outlets. Mechanical trades shall follow these drawings in layout of their work, consult general construction, structural and electrical drawings to familiarize themselves with all conditions affecting their work, and shall verify spaces in which their work will be installed.

C. The Contractor shall verify with the A/E before bidding any item of piping or piping arrangement which may be incomplete, incorrect or indefinite. After contract is let, the A/E's decision shall be final.

D. All trades shall cooperate and confer with each other as to locations of their materials and equipment before erecting work, so as to avoid interference as much as possible, and in such a manner that will in no way retard progress of construction. In instances where interferences develop, the contractor shall relocate the work as required by the A/E regardless of which work was installed first.

E. Where job conditions require reasonable changes to indicate locations and arrangement, make such changes without extra cost to Owner. This is not to be construed to permit redesigning of the various systems.

F. Additional and supplementary drawings may, from time to time, be furnished, and the same, when made, are to constitute a part of the original contract. These drawings will be made to clarify the contract drawings and will not depart materially therefrom.

G. The A/E specifically reserves the right, up to the time of roughing-in, to exactly define the position of the equipment to be installed and connected to and arrangement of these connections.

H. Special attention is called to the contract drawings and specifications involving general construction, electrical work and details thereon. Bidders are notified to carefully scrutinize these documents for the details affecting the performance of the mechanical trades.

1.9 SCHEDULE OF WORK

A. The Contractor shall schedule all of his work to conform to the Job Progress Schedule as submitted by the General Contractor or Construction Manager, and approved by the A/E.

1.10 PREMIUM TIME WORK

A. The following work shall be performed at night or weekends other than holiday weekends, as directed and coordinated with the Owner:

1. Tie connections to all existing systems.
2. All work in the existing building finished space.

1.11 PROGRESS OF WORK

A. The Contractor shall order the progress of his work so as to conform to the progress of the work of other trades and shall complete the entire installation as soon as the conditions of the building will permit. Any cost resulting from the defective or ill-timed work performed under this section shall be borne by the Contractor.

1.12 DELIVERY, STORAGE, PROTECTION AND HANDLING

A. Deliver, store, protect and handle all products and materials in a manner which will protect them from damage, weather and entry of debris. If items are damaged, do not install, but take immediate steps to obtain replacement or repair. Any such repairs shall be subject to review and acceptance of the Architect/Engineer.

B. Delivery of Materials: Delivery materials in manufacturer's unopened container fully identified with manufacturer's name, trade name, type, class, grade, size and color.

C. Storage of Materials, Equipment and Fixtures: Store materials suitably sheltered from the elements, but readily accessibly for inspection by the Architect/Engineer until installed. Store all items, susceptible to moisture damage, in dry, heated spaces.

D. Protect materials and equipment according to the manufacturer’s instruction. Protection shall include damage due to fire, water, rust, oxidation, sunlight (for UV sensitive materials), breakage of UV lights, etc.

E. Following is in addition to Protection of Work and Property, General Requirements:

1. Responsibility for care and protection of mechanical work rests with the Contractor until it has been tested and accepted.

2. After delivery, before, during and after installation, protect equipment and materials against theft, injury and damage from all causes.
3. Protective covers, skids, plugs, caps and coating shall be provided to protect equipment materials from damage during construction.
4. All equipment and material shall be stored under cover and off the ground.
5. For outdoor storage, protective covers of sheet plastic shall be provided. Covers shall be of gauge required for the area involved and shall be reinforced to withstand wind, rain, sleet and snow. Equipment and material shall be set on skids or platforms of sufficient height to avoid deterioration from spattering and ground water.
6. Plug open ends of pipes when work is stopped to prevent debris from entering the pipes.
7. Open ends of duct work shall be closed when work is stopped with temporary closures of sheet plastic taped in place on horizontal ducts and sheet metal caps with drip overhangs for ducts opening upward.
8. Air handling system shall not be operated during the construction period.
9. Coat polished or plated metal parts with Vaseline immediately after installation.

F. The Contractor shall receive, properly house, handle, hoist, and deliver to proper location, equipment and other materials required for the contract.

G. In the event of damage, immediately make all repairs and replacements necessary to the approval of the Architect/Engineer and at no additional cost to the Owner.

1.13 INTERFERENCE WITH THE OWNER'S NORMAL OPERATION

A. All work shall be performed in such a manner as not to interfere with the normal work operations in adjacent spaces or buildings.

B. In no way shall the Contractor:

1. Block or restrict the means of egress for adjacent spaces.
2. Decrease the fire rating of walls, partitions, ceilings, doors or combination thereof of adjacent spaces or of means of egress.
3. Interrupt safety systems or in any way adversely affect the safety of people or materials in adjacent spaces.

C. The Contractor shall provide acoustical isolation of the work area via temporary doors, partitions, etc., adequate to allow normal work functions.

D. The Contractor shall provide exhaust fans, dust proof temporary partitions and any containment measure required to prevent dirt, dust, or fumes from reaching adjacent work spaces.

E. All personal traffic and material delivery shall be routed so as to absolutely minimize travel through adjacent work area.

1.14 VISIT TO SITE

A. The Contractor shall visit the site and thoroughly acquaint himself with all existing conditions relative to type and source of service available. He shall verify location and extent of these

services and consider routing, interferences and excavation required by the contract and any and all other difficulties that may be encountered.

B. Submission of a proposal shall be construed as evidence that such an examination has been made.

C. Failure to visit the site shall not constitute sufficient reason to warrant claims for extra monies for difficulties not apparent in the contract documents.

1.15 MANNING THE PROJECT

A. The Contractor shall, upon initiation of construction, keep a suitable force of men on the site at all times in order to lace all sleeves, inserts, outlet boxes, fixtures and provide all other openings as are required for the satisfactory installation of equipment.

1.16 FEES AND PERMITS

A. The Contractor shall secure all permits and pay all fees, required by local and state governing bodies, necessary to complete his phase of the construction. Failure to investigate all applicable payments before the bid submission shall not constitute grounds for additional monies from the Owner. The Owner shall be furnished with all certificates of approval.

B. The Contractor shall provide insurance and bonding as required by the Building Owner or as stated in the General Conditions.

1.17 CODES AND STANDARDS

A. The design, construction and installation of all materials and equipment shall be in compliance with the latest edition of all national, state and local codes or standards.

B. The codes and standards referred to are minimum standards. Where the requirements of these specifications and the accompanying drawings exceed those of the codes and standards, the drawings and specifications shall be followed.

1.18 BASIS OF DESIGN

A. The layout is based upon the use of particular items of equipment, identified by manufacturer's make and model number. Dimensions, arrangements and service connections required for these particular items have been considered in making the layout. The contractor may use the equipment of any manufacturer whose name is approved for substitution on that item of equipment after he had ascertained that all provisions of MATERIAL SUBSTITUTIONS will be complied with and that all required service connections will be made at no additional cost to the Owner.

B. Manufacturers are listed for a quality assurance level only. Although a manufacturer is listed does not constitute compliance with the specification size, weight, functionality, capacity, noise, or performance levels. It is this contractor's responsibility to assure the proposed manufacturer has complete compliance with the Contract Documents, **prior to bidding**.

C. Except where dimensions are shown, the drawings are diagrammatic and shall not be scaled. Exact location of fixtures, apparatus, duct work and piping shall be determined by dimensions on the site. Contractor shall refer to architectural plans and details for exact dimensions.

D. The drawings indicate the locations of apparatus, fixtures, ductwork, and piping shall be followed as closely as possible. If before the installation it is found necessary to change the location to accommodate conditions at the building, such changes shall be made at no additional cost to the Owner, and as approved by the Architect/Engineer.

E. Equipment requiring operation, service or maintenance during the life of the system shall be made easily accessible.

F. Ductwork or piping shall not be run within 48" of switchboards, panelboards or motor control centers.

G. No piping, ductwork to other HVAC items shall be run in the dedicated equipment space as defined in the N.E.C. (NFPA 70). The dedicated equipment space is the space equal to the width and depth of the equipment and extending from the floor to a height of 6ft. Refer to the National Electrical Code section 110.26 (E) for further information. No piping, ducts, leak protection apparatus, or other equipment foreign to the electrical installation shall be located in this zone. It is this contractor’s responsibility to coordinate with the electrical contractor for all phases of this project.

H. Use of open-flame devices in work shall be accompanied by fire extinguishing apparatus within 25 feet of work location. All work shall be done in accordance with the general construction requirements and fire watch procedures.

1.19 QUALITY OF MATERIALS

A. Where a specific model and manufacturer of equipment is specified, the Contractor shall provide what is specified without substitution. Where specified as "or approved equal", the Contractor may substitute equipment except that the burden is upon the Bidder to prove such equality. If the Bidder elects to prove such equality, he must request the Architect's approval in writing to substitute such item for the specified item, stating the cost difference involved with supporting data, and samples, if required, to permit a fair evaluation of the proposed substitute with respect to quality, serviceability, warranty and cost.

B. Where a specific model of equipment is specified along with an approval equal manufacturer, no substitution will be allowed. The Contractor shall submit one of the manufacturers listed.

C. Final approval of competitive equipment is reserved by the Engineer when, in the Engineer's opinion, the equipment does not correspond to that specified.

1.20 MATERIAL SUBSTITUTIONS

A. Material substitutions shall be allowed only where "or equivalent" is stated.

B. Material substitution submittals shall, include complete description of the proposed substitute, the name of the material or equipment for which it is to be substituted, drawings, cuts, performance, test data and evidence that the proposed manufacturer or his established representative maintains a qualified service organization including spare parts and is available for competent service on short notice.

C. Each bidder by submitting his bid represents that the proposal of such article, device, product, material, fixture, form or type of construction by name, make, catalog number of manufacturer which varies with the equipment specified shall be incorporated into the project without claims against the Owner for additional cost. The bidder shall be responsible for all additional costs incurred by others due to the substitutions.

D. The Architect/Engineer shall have the final approval of all submitted substitutions.

E. Manufacturers are listed for a quality assurance level only. Although a manufacturer is listed does not constitute compliance with the specification size, weight, functionality, capacity, noise, or performance levels. It is this contractor's responsibility to assure the proposed manufacturer has complete compliance with the Contract Documents, **prior to bidding**.

1.21 SUBMITTALS

A. Product Data, Shop Drawings: Submit for approval by the authority having jurisdiction and the Owner's insurance underwriter.

B. Product Shop Drawing Submittal List:

1. Within thirty (30) days after date of execution of the Owner/Contractor Agreement, submit for review and acceptance, a list of all material and equipment manufacturers whose products are proposed, as well as names of all subcontractors whom this trade proposes to employ.
2. Any requests for substitutions of equipment or materials must be submitted and returned prior to submitting the Submittal List. Only specified or accepted manufacturers or suppliers shall appear on the Submittal List.
3. The complete Submittal List must be reviewed and accepted by the Architect/Engineer prior to submittal of Shop Drawings. No Shop Drawings will be processed without an accepted Submittal List.
4. The Submittal List shall include all material, systems, and equipment specified herein.

C. Approval shall be obtained for all equipment and material before delivery to the job site. Delivery, storage or installation of equipment or material which has not had prior approval will not be permitted at the job site.

D. All submittals shall bear a stamp or notation indicating that the Contractor has reviewed and approved the submittals.

E. All submittals shall include adequate descriptive literature, catalog cuts, shop drawings and other data necessary to ascertain that the proposed equipment and materials comply with specification requirements. Catalog cuts submitted for approval shall be legible and shall clearly identify equipment being submitted.

F. Submittals shall be marked to show specification reference including the section and paragraph numbers.

G. Submit each section separately and include the following:

1. Information which confirms compliance with contract requirements. Include the manufacturer's name, model or catalog numbers, catalog information, technical data sheets, shop drawings, pictures, nameplate data and test reports as required.
2. Submittals on all pumps and fans shall be complete with performance curves marked with the design points.
3. Submittals on electrical equipment shall be complete with all power and control wiring diagrams.
4. Vibration isolators shall include operating weight and load distribution at each mounting point.

H. The Contractor agrees that failure of manufacturer's submittal to conform to the above will result in a manufacturer's disqualification on this project.

I. Submit samples as directed of items called for in the specifications; samples of the materials which the manufacturer will actually ship shall be submitted for approval after award of contract and properly labeled on this project.

1.22 COORDINATION DRAWINGS

A. Detailed layout shop drawings on all systems as required in Division 01 – Project Coordination, Division 21, 22, 23, and 26, must be coordinated with field erection drawings for Architectural, HVAC, Plumbing, Fire Protection, and Electrical Systems by the respective contractors.

B. Prepare coordination drawings for all areas by building, floor area and/or phase, of the project. Close attention should be implemented where limited space availability necessitates maximum utilization of space for efficient installation of different components.

C. Mechanical, Electrical and Plumbing Prime Contractors are responsible to prepare coordination drawings to a Scale of ¼” = 1’-0” or larger; detailing major elements, components, and systems of mechanical and electrical 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 limited to the following:

1. Proposed locations of ductwork, piping, conduit, equipment, and materials.
2. Clearances for installing and maintaining insulation.
3. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.

4. Equipment connection and support details.
5. Exterior wall and foundation penetrations.
6. Fire rated wall, floor, ceiling, and roof penetrations.
7. Sizes and location of required concrete pads and bases.
8. Valve stem movement.
9. Sleeves.

D. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations. Clearly define relationships between sleeves, piping, ductwork, conduit, ceiling grid, lighting, fire sprinkler, HVAC equipment and other mechanical, plumbing, and electrical equipment with other components of the building such as beams, columns, ceilings, and walls.

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

F. Resolve conflicts between trades, prepare composite coordination drawings and obtain signatures from all affected Prime Contractors on original composite drawings. Submit coordination drawings to the Architect/Engineer and Construction Manager for approval.

G. Mechanical, Electrical and Plumbing Prime Contractors are to first submit their respective shop drawings for approval, to the Architect/Engineer, in order to make any necessary changes prior to going through the coordination process.

H. Coordination drawings to be signed off by affected Contractors within 45 days of Notice to Proceed. A Coordination drawing timeline schedule shall be developed and tracked.

I. The coordination drawings shall be coordinated with the construction and phasing schedule.

J. The routing process will begin with the HVAC Contractor who shall take the lead in the coordination of their work with all affected trades.

K. The HVAC Contractor shall prepare CAD drawings to be used as the basis for coordination drawings in all areas or as determined by the Construction Manager (Scale: ¼" = 1'-0" or larger). These drawings shall be completed in digital format. All architectural features shall be accounted for in preparation of this drawing; i.e., permanent, casework, interior columns, partitions, finish ceiling and height, lighting and roof elevations, etc. The HVAC Contractor will provide CAD files and drawings showing all of the approved ductwork. HVAC Contractor is to locate all piping with orange lines. Forward drawings to the Plumbing Contractor.

L. The Plumbing Contractor is to locate the plumbing lines with blue lines and sprinkler lines and head locations with red lines, and resolve all conflicts and determine locations and elevations, and forward drawing to the Electrical Contractor.

M. The Electrical Contractor to indicate all lighting fixtures, panels with associated clearances, duct banks, bus duct, conduit racks and all individual conduits 1 ½" and larger in with green lines, and resolve all conflicts and determine locations and elevations and forward to the General Construction Contractor.

N. The General Construction Contractor will have the last coordination review. Provide overlaid coordination drawings for all General Construction work and resolve all conflicts. All architectural features shall be detailed clearly, i.e. permanent casework, interior columns, partitions, finish ceiling and roof elevations, etc. Provide a ceiling layout detailed coordination drawing showing ceilings, lights, diffusers, etc.

O. Contractors to provide underground coordination drawings for all underground utilities; show exact location of piping stub ups, floor drains, etc. as required.

P. Prime Contractors shall be responsible for all costs associated with creating CAD files.

Q. All coordination meetings will be held in the Construction Manager's field office or as required by the Architect/Engineer. As each coordination drawing is completed, Contractors are to meet with the Construction Manager to review and resolve all conflicts on the coordination drawings. Contractors are required to distribute shop drawings, cut sheets and submittals to other Prime Contractors where appropriate. Approved coordination drawings will also be available for reviewing at the Construction Managers field office.

R. All Contractors shall provide a hard copy of the coordination drawings for review by the Architect/Engineer.

S. Once complete and signed off, the HVAC, Plumbing and Electrical Contractors will submit dimensioned wall and slab penetration drawings and housekeeping pad drawings to the appropriate parties.

T. If the coordination drawing process is not complete, Mechanical, Electrical and Plumbing Contractors will provide wall penetration drawings to the General Construction Contractor no later than five (5) days prior to wall erection.

U. All Prime Contractors must install the work in accordance with the coordinated drawings at no additional cost to the Owner. No additional compensation will be made for extra ductwork offsets, piping and/or conduit or retrofit work due to improper component location, or lack of Contractor(s) coordination.

V. All Prime Contractors shall take special care in verifying with the Electrical Contractor that the equipment matches the characteristics of the power being supplied. The Electrical Contractor is similarly bound.

W. The Mechanical, Electrical and Plumbing Drawings are schematic in nature and are not intended to show every offset and detail. The Mechanical, Electrical and Plumbing Contractors will make adequate provisions in their bid to accommodate the actual conditions, provide all required ductwork, piping and conduit offsets per the coordination drawings, without additional cost to the Owner.

X. The Mechanical, Electrical and Plumbing Contractors shall hang streamers from all above ceiling equipment that will require access. This is in addition to any specification requirements for tags, labels, etc. Shop drawings should also highlight these areas for Architect/Engineer's review. In addition, the Contractors shall notify the Construction Manager and Architect/Engineer of all areas where equipment maintenance access is difficult. Coordinate

architecturally placed access doors with points of mechanical/electrical systems requiring that access.

Y. Specific Requirements – Required Information to be provided on Coordination Drawings:

1. General Construction/Structural Work Information including but not limited to:

   a. Openings and sleeve locations required in slabs, walls, beams, and other structural elements, including required openings not indicated on the Contract Documents.
   b. Slab edge locations
   c. Embed locations, as described above. Note embedded steel angles at edges of sump and sewage ejector pits, to accept basin covers.
   d. Wall and chase spaces for housing HVAC, Plumbing, or Electrical items.
   e. Access doors in coordination with the respective contractor systems.
   f. Other specific/critical conditions unique to this Project, not noted above but necessary to assure proper coordination.

2. HVAC Work Information including but not limited to:

   a. Sizes and bottom elevations of rectangular ductwork, including angle bracing, flanges, and support systems.
   b. Sizes and centerline elevations of round ductwork, piping and conduit runs
   c. Acoustical lining in ductwork.
   d. Identification of ductwork pressure class.
   e. Dimensions of major components, such as dampers, valves, diffusers, registers, cleanouts, coils, VAV boxes, HVAC equipment, and electrical distribution equipment.
   f. Fire-rated enclosures around ductwork.
   g. Access panels required.
   h. Other specific/critical conditions unique to this Project, not noted above but necessary to assure proper coordination.

3. Plumbing and Fire Protection Information including, but not limited to:

   a. Sizes and centerline elevations of piping runs.
   b. Locations of plumbing valves, equipment, and fixtures.
   c. Locations of standpipes, floor control assemblies, fire hose valves, mains, piping, branch lines, pipe drops, sprinkler heads, fire pumps/controllers, and jockey pumps.
   d. Other specific/critical conditions unique to this Project, not noted above but necessary to assure proper coordination.

4. Electrical Work Information including, but not limited to:

   a. Runs of vertical and horizontal conduit, 1 ¼” diameter and larger
   b. Light fixture locations
   c. Exit light locations
   d. Smoke detector and other fire alarm locations

e. Panelboards, switchboards, switchgear, transformers, busways, generators and motor control center, exit signs, and emergency battery pack locations.
f. Locations of pull boxes and junction boxes, dimensioned from column centerlines
g. Access panels required.
h. Other specific/critical conditions unique to this Project, not noted above but necessary to assure proper coordination.

5. Ceiling Systems and Plenum Space Information including, but not limited to:

a. For HVAC, Plumbing, Fire Protection, Fire Alarm, Electrical, Controls and Telecommunications Work penetrating acoustical ceilings, show locations of each item (including sprinkler heads, diffusers, grilles, access doors, light fixtures, smoke detectors exit signs, speakers, and other visible ceiling mounted devices) relative to the acoustical ceiling grid.
b. Locate components within ceiling plenums to accommodate layout of light fixtures indicated on Drawings. Clearly indicate areas of conflict between light fixtures and other components on Coordination drawings.
c. Other specific/critical conditions unique to this Project, not noted above but necessary to assure proper coordination.
d. Materials within plenums shall be non-combustible or shall be listed and labeled as having a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested in accordance with ASTM E 84 or UL 723. All materials located in plenums shall conform to International Mechanical Code.

Z. The Sheet Metal Contractor shall prepare his work on reproducibles and submit 1/4" scale CAD drawings of the sheet metal duct field erection shop drawings for the coordination procedures, and each Contractor will supply the necessary qualified personnel for these procedures which will be conducted by the General Contractor. The HVAC, Plumbing and Fire Suppression work to the drawings where conflicts are noted and achieve solutions to any conflicts that may exist.

AA. The General Contractor will be required to signify his acceptance of the results of the coordination procedures by signing and dating the master coordination print.

BB. Each Contractor will be required to correct his field erection drawing(s) used as a basis for the coordination procedures to complement the results of the procedures prior to submitting same for approval. No field erection shop drawings will be accepted for approval without having been coordinated.

CC. As part of the coordination procedures, applicable "Approval" or "Approved as Noted" copies of other trades' shop drawings will be transmitted to the Contractor. It will be each Contractor's responsibility to check these shop drawings to ascertain what effect, if any, these shop drawings have on that portion of the work under his direct responsibility. Each contractor will advise the General Contractor within forty-eight (48) hours of receipt of the shop drawings, in writing, indicating receipt of same and whether or not they have any effect on the work of his contract.

1.23 ELECTRICAL

A. Power Wiring

1. For the purpose of this specification, power wiring shall be defined as follows:

    a. All wiring from the power source panelboards (or switchboard) to the disconnect switch to the equipment, and final connection to the equipment.
    b. All power wiring to transformers serving VAV/CV boxes.
    c. All wiring to control panels as indicated in the Electrical and Mechanical Contract Documents. (All control panels not indicated on the Electrical Contract Documents as receiving power shall do so by jumpers from other control panels, this wiring shall be considered control wiring as defined below).

2. All power wiring from the power source to the above noted switches and wiring from these switches to the equipment, including final connection to same, shall be provided under Division 26, Electrical.

B. Control Wiring

1. All other wiring required, whether line voltage or low voltage, internal or external to provide for the operation of the equipment shall be considered as control wiring. This shall include power wiring from transformers serving VAV/CV boxes and dampers at exhaust fans; wire to damper and fan end switch to starter.
2. All control wiring throughout the building, including wiring installed at piping, in ductwork, or as specified shall be provided under this Division.

C. The Contractor shall furnish all motors, mounts, motor starters and remote mounted push-button controls for all electrically operated equipment furnished as part of the contract. The Contractor shall furnish all safety disconnects where described hereinafter. The Contractor shall furnish all speed control switches for all multi-speed motors. All motors shall have copper windings. (Aluminum windings will not be acceptable).

D. This Contractor is completely responsible for the coordination with all other trades as to the correct voltage for all equipment requiring power. Equipment and or changes required to meet the project voltages will be the responsibility of this contractor.

E. All push-button switches and starters shall be mounted under Division 26, Electrical.

F. The Contractor shall provide all controls and control devices, all mounting for controls and all other electrical devices as specified and necessary for the complete installation and satisfactory operation of all electrically operated controls furnished under this Division.

G. All locally mounted starters shall be furnished under Division 23, except as noted below. Where indicated hereinafter, starters shall be furnished as an integral part of equipment. Starters furnished in motor control centers shall be provided in Division 26, Electrical (refer to Electrical Drawings). Control of starters in motor control centers feeding mechanical equipment shall be provided under Division 23.

H. Starting equipment of each motor shall be of the proper voltage and HP rated for the motor it is to serve. All starters shall be of the enclosed type; NEMA Type 1, for general-purpose enclosures; NEMA Type 4 for watertight enclosures, and NEMA Type 12 for the dust-tight enclosures. Location of motor shall determine type of enclosure to be used.

I. Manual motor starters for single-phase motors shall be one or two poles as required, consisting of a snap switch combined with a thermal overload device. It shall be impossible for the switch to be held in a closed position under a sustained motor overload. For resetting the overload mechanism, the switch lever shall be of a design where it has to be moved to the "off" position. Starter shall be enclosed in type of enclosure for area in which it is to be used.

J. Magnetic starters for 3-phase motors shall be furnished with 110 volt holding coils, 120 volt fused transformers, normally open and normally closed auxiliary contact and overload relay heater elements in all three phases. Provide hand/off/auto selector switch along with running status lights and external reset button.

K. Locate starters and associated starter controls in accessible locations wherever possible. Location of starters for roof mounted exhaust fans and mechanical equipment above ceilings shall be located at accessible locations above ceiling. Locations shall be coordinated with furniture and equipment layouts for the optimum accessible location for installation and maintenance means.

L. The Contractor shall be completely responsible for the coordination of automatic temperature control system with control interlocks between various items of mechanical equipment.

1.24 SCAFFOLDING

A. The Contractor shall furnish and install scaffolding, ladders and runways required in connection with his work.

1.25 TEMPORARY OPENINGS

A. Temporary openings not indicated, which may be required for purpose of bringing equipment into building, shall be as approved. General Contractor will perform work of providing and maintaining openings, and of restoring structure; but Contractor for whom temporary openings are provided shall bear costs thereof, and for restoring structure. Ample notice shall be given of size and location of such openings by Contractor requiring same.

B. Holes provided in General Construction work to permit installation of lines for temporary mechanical services will, after removal of such lines, be patched as specified under Division 01.

1.26 TEMPORARY SERVICE

A. Temporary services are specified under Division 01, “General Requirements”.

1.27 EXCAVATION, TRENCHING AND BACKFILLING

A. All excavation is unclassified. The Contractor shall inspect the site and make allowance in his bid for soil to be excavated since no compensation will be given where rock is encountered.

B. Refer and comply with pertinent specifications of Divisions 31, 32 and 33.

C. The Contractor, unless otherwise noted on the drawings, shall do all excavations for trenches, foundations, and pits of whatever kind necessary for the installation of this work. Bottom of trenches shall have the proper uniform grade wherever possible, or unless otherwise directed.

D. Trenches are to be excavated to the widths, lines and grades indicated on the drawings and/or specified in the appropriate sections of these specifications. Trenches for piping are to be excavated to a minimum width of one (1) foot plus the outside diameter of the pipe. The trench shall be excavated in a manner such that the pipe will be located in the center of the trench with the trench bottom having the proper uniform grade in the direction of flow. Trenches shall be deep enough to provide a minimum of four (4) feet fill over the piping except as may be otherwise indicated on the drawings.

E. In each excavation, trenches shall be carried to six inches below invert of pipe. Pipe whall be surrounded in all directions by a six inch layer of selected crushed stone or gravel. If rock is encountered, carry trench to a point six inches below pipe invert. No pipe shall be bedded directly upon rock but shall be cushioned by a six inch layer of selected crushed stone or gravel.

F. The Contractor shall do any shoring, bracing, etc., necessary to maintain the banks of his excavation, shall make good and damage done to property of adjoining premises or work of other contractors due to his failure to properly shore his excavation. The Contractor shall do all pumping required to keep his excavations free of water including rental of pumps, temporary power and labor.

G. All excavations shall be left open until work has been inspected and approved by the Architect. Sufficient time shall be allowed after notice is given that work is ready for inspection for making all examinations and tests. Under no circumstances shall excavated material be left even temporarily, where it will interfere with the building or other Contractor’s operations.

H. Excavations which pass under or within eighteen (18) inches of columns or wall foundations shall be backfilled up to the level of columns or wall foundations with concrete mixed in proportions to one part cement, three parts sand and five parts coarse aggregate. Excavations shall not undermine foundations at a slope of 1:1 or greater.

I. All earth backfilling shall be made in layers not to exceed eight (8) inches and each layer shall be thoroughly tamped into place before the next layer is placed. Backfilling shall be clean earth, free of stone, pieces of concrete, rubbish and other foreign materials. Material frozen in lumps or material softer than the adjoining soil shall not be used in backfilling. The Contractor shall distribute on the premises as directed, all earth remaining after the backfilling.

J. Any necessary blasting shall be performed by experienced and competent personnel in the most careful manner. All local ordinances and laws relating to blasting and storing of explosives must be strictly observed. No explosives shall be stored in the project properly. All contractors shall be notified prior to any blasting.

K. Explosives used shall be subject to approval of the Architect. The blasting shall be properly covered with blasting mats.

L. Any rock encountered within five (5) feet of pipes of building walls shall be removed without blasting. Any blasting required shall be performed at such times as to meet reasonable request of the Architect.

M. The Contractor will do all patching of bituminous surfaces, concrete walks, driveways, streets, etc., necessary to complete his work. All patching shall match the existing surfaces. Painting shall be done by personnel skilled in their trades.

N. Provide adequate temporary crossovers of pedestrian and vehicular traffic including guard rails, lamps, flags, as directed; remove same when necessity for such protection ceases.

1.28 CUTTING AND PATCHING

A. The Contractor shall provide all floor and wall cuts as required for ductwork and piping penetrations of existing construction.

B. No cutting of bearing walls, beams, etc., shall be done without the approval of the Architect. All patching and finishing, etc., shall match the surroundings. All cutting and patching shall be done by workmen skilled in the trades and in the employ of the General Contractor for the project. All cutting shall be done with saw type edges to give a neat and workmanlike appearance. All pipe holes shall be core drilled unless specified otherwise.

C. Should it be necessary to do any cutting and patching due to the failure of this Contractor to give proper information to the General Contractor, it shall be done at the expense of the Mechanical Contractor.

1.29 PAINTING AND FINISHING

A. Except as specified herein, the finished painting of Mechanical Work within the building and on the roof shall be as specified under Division 09.

B. All mechanical equipment shall have a factory-applied prime and finish coat of paint. Galvanized surfaces shall be considered as finished surfaces for equipment rooms and items concealed from view. Plastic products shall be acceptable without a finish coat of paint. All items of equipment marred or rusted, even though factory finished, shall be repainted; steel angles and steel supports for ductwork, piping or miscellaneous equipment shall have a prime coat of paint before installation.

C. General Contractor to paint all exposed piping, ductwork, equipment, and trim that does not have a factory applied finish. Refer to Division 09 "Painting" for paint materials, surface preparation and application of paint. Paint shall be semi-gloss, acrylic-enamel paint. Coat components with two (2) coats of finish paint over two (2) coats of rust inhibitive metal primer or approved equivalent based on component type.

1.30 CONCRETE WORK

A. Concrete work shall be in accordance with Division 03.

1.31 SUSPENSION SUPPORT FOR DUCTS, PIPES, EQUIPMENT

A. All pipes, ducts, and equipment that are suspended shall be connected directly to the building steel. Where hangers are required between building steel points, supplementary steel members shall be added by the Contractor as required to adequately support the load.

B. Pipes and ducts shall not be supported from other pipes, ducts, or equipment.

C. Hangers from joists shall be attached at the panel points. Pipes and ducts with weights of 50 pound per foot (total for single or multiple runs) routed parallel with bar joists shall be supported from a minimum of 3 joists at each hanger point (channel members between joists).

1.32 ACCESS PANELS – BUILDING

A. Duct access panels, access plates, damper operators, fan cleanouts and valves located concealed in walls or above ceilings, and are otherwise inaccessible shall be furnished with an access panel for each location. A hinged inconspicuous type access panel complete with frame, of such size and so located as to provide proper access for service and maintenance.

B. The minimum size of each access panel shall be 18” x 18” unless physical restraints require a smaller door.

C. Where such equipment is located above removable concealed spline push up type acoustical tile or metal pan ceilings, it shall be considered as accessible if the acoustical material is arranged for access to the space above the ceilings.

D. Access panels shall be Milcor “DW”, or equal, for drywall locations and Milcor “K”, or equal, elsewhere.

E. Panels and frames shall be prime painted in complete compliance with all maximum VOC requirements found in Section 01 81 13.13.

F. Panels shall be furnished under this Division and installed under another Division of the Specification.

G. Panel material shall be steel except that construction shall be all aluminum in bathroom applications.

H. Access panels and doors in ductwork are specified in Division 23 – HVAC Ducts and Casings.

I. When access panels or doors are installed in fire rated construction, they shall be fire rated to match the construction.

1.33 FIRESTOP PENETRATION PROTECTION SEALING SYSTEM

A. Where pipes pass through fire partitions, firewalls, floors or ceilings, install a firestop that provides an effective barrier against the spread of fire, smoke, gases and water. Fire-stop material shall be packed tight, and completely fill clearances between pipe, sleeves and

structure. All crack voids or holes (up to 4" diameter) shall be sealed using 3M brand Fire Barrier Caulk CP25 or putty 303 or an approved equal. Larger diameter or square holes, 3M system 7902, 7904, 7902R or 7904R or approved equal shall be in accordance with manufacturer's instructions.

B. Fire-stopping material shall maintain its integrity while preventing the passage of flame, smoke, gases or water. Fire-stopping material shall be a one-part, intumescent elastomer noncombustible, noncorrosive and compatible with synthetic cable jackets as defined by ASTM E814 (UL 1479); and in addition for insulation materials, melting points shall be a minimum of 1700 degrees F for one-hour protection and 1850 degrees F for 2-hour protection.

1.34 RECORD DRAWINGS

A. The Contractor shall furnish record as-built drawings to the Architect at completion and acceptance of the job. Transparencies of the original drawings with corrections shall be submitted as specified in the General Requirements.

B. Record all changes from installation originally indicated. Record final location of underground lines by depth from finished grade and by offset distances in feel and tenths to surface improvement such as buildings, curb, or edges of walks. Where work appears on two or more drawings, Contractor shall mark changes on all drawings. Contractor shall mark changes on all drawings. At completion, furnish the above required transparencies to the A/E for approval and record. Drawings shall be certified to be record of work installed and signed by the Contractor. Work shall not be accepted until such drawings have been delivered to the A/E.

1.35 GUARANTEE

A. In addition to the requirements stated in the specifications, the Contractor must guarantee all equipment, materials, and appurtenances installed by him to be free from all defects for a period of one year from date of final acceptance.

B. Upon written notice from the A/E, the Contractor shall promptly correct all defects without additional cost to the Owner. This Contractor shall adjust each part of the entire installation for proper working order. Reports are to be submitted to the A/E and adjustments repeated until the entire system is satisfactory. This Contractor must make good, at his own expense, any defects in materials or workmanship that may appear.

1.36 CLEAN UP

A. The Contractor shall be held responsible for the general clean up of all areas affected by the work in the Contract. All rubbish and accumulative material shall be removed from the premises and the premises left "broom clean" upon completion.

B. All stickers, rust, stains, labels and temporary covers shall be removed before final acceptance.

C. Foreign matter shall be blown, vacuumed or flushed out of piping, pumps, fans, motors, devices, switches, panels, duct work and equipment.

D. Identification plates on equipment shall be free of excess paint and shall be polished.

1.37 OPERATION AND MAINTENANCE MANUALS

A. Submit to the Engineer for approval three manuals covering details of operation maintenance for all apparatus requiring service. The Contractor shall arrange formal instruction sessions by competent representatives of the manufacturer for the Owner's operating personnel to cover the following:

1. Service telephone number, fax number, websites, email addresses, business and service addresses and mobile telephone numbers of the installing contractor, and manufacturer and supplier and parts counters of pumps, fans, air handling units, condensate return units, chillers, CV boxes, fan coil units and other components comprising the systems.
2. Manufacturer's operating and maintenance manuals, including detailed parts lists with numbers, power and control wiring diagrams for each piece of equipment and accessory requiring services or maintenance, the guarantee period and the name, address and phone number of the nearest sales and service organization for each item. Both on print and CD’s (min 3 copies) form (PDF/MS Word).
3. Cross out options that are not used on equipment sheets, highlight options selected.
4. Step-by-step procedure for starting, stopping, setpoint adjustment, monitoring and alarm enunciation for each system.
5. Copies of inspection certificates provided by the City, County, State and insurance companies.
6. Provide separate Operation and Maintenance Manuals covering the FMCS and in compliance with this section.
7. Routine maintenance procedures and scheduling for all mechanical equipment.

B. Obtain written statements from the Owner's representative acknowledging satisfactory completion of each item of the manuals.

1.38 INSTRUCTION TO OPERATIONAL PERSONNEL

A. Furnish the services of competent instructors to give full instruction to the designated Facilities personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system on the Contract Documents. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work.

B. Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Owner for regular operation. Provide 4 man-hours of instruction for each: chemical treatment/glycol systems, pumps, exhaust and intake fans, heat exchangers, CV boxes, fan coil units, condensate return units; 8 man-hours for the AH-1 air handling unit and components including the UV system, 24 man hours for the CH-1 chiller; and 40 man hours instruction for the FMCS (operational, maintenance, programming instruction for

trend logging and charting, setpoint adjustment schemes, alarm functionality and other routine operational commands/functions) required by the Owner's personnel..

C. Instruction shall cover routine maintenance, control and power wiring diagrams and component analysis, preventative maintenance and scheduling, starting and stopping, alarm resets, trend-logging, setpoint adjustment, emergency and normal shutdown/startup, alarm date stamping and all else required by the Owner for complete usage/maintenance/adjustment of equipment in their intended systems.

D. Obtain written statements from the Owner's representative acknowledging satisfactory completion of each item of instructions.

PART 2 - PRODUCTS

2.1 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Acceptable Manufacturers:

   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Metraflex Co.
   d. Accepted substitute in accordance with Section 01600.

2. Sealing Elements: EPDM interlocking inks, shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.2 SLEEVES

A. Galvanized-Steel Sheet: 0.0239 inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set screws.

2.3 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.

1. Finish: Polished chrome-plated.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

1. Finish: Polished chrome-plated.

E. One-Piece, Stamped-Steel Type: With and chrome-plated finish.

F. Split-Plate, Stamped-Steel Type: With hinge and chrome-plated finish.

G. One-Piece, Floor-Plate Type: Cast-iron floor plate.

H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.4 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000 psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SITE INSPECTION

A. Before starting work under this section, carefully inspect the site and installed work of other trades and verify that such work is complete to the point where installation of materials and accessories under this section can begin.

B. Verify that all materials and accessories can be installed in accordance with project drawings and specifications and material manufacturers' recommendations.

C. Verify, by inspecting product labeling, submittal data, and/or certifications which may accompany the shipments, that all materials and accessories to be installed on the project

comply with applicable specifications and standards and meet specified thermal and physical properties.

3.2 PROJECT MANAGEMENT AND COORDINATION

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

1. Schedule construction operations in sequence required to obtain the best results where installation of one part of the work depends on installation of other components, before or after its own installation.
2. Coordinate installation of different components with other contractors to ensure maximum accessibility for required maintenance, service, and repair.
3. Make adequate provisions to accommodate items scheduled for later installation.
4. Where availability of space is limited, coordinate installation of different components to ensure maximum performance and accessibility for required maintenance, service, and repair of all components, including mechanical and electrical.

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

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

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

1. Preparation of Contractor's Construction Schedule
2. Preparation of the Schedule of Values
3. Installation and removal of temporary facilities and controls
4. Delivery and processing of submittals
5. Progress meetings
6. Pre-installation conferences
7. Project closeout activities
8. Startup and adjustment of systems
9. Project closeout activities

D. Conservation: Coordinate construction activities to ensure that operations are carried out with consideration given to conservation of energy, water, and materials.

1. Salvage materials and equipment involved in performance of, but not actually incorporated into the work. Refer to other Sections for disposition of salvaged materials that are designated as Owner's property.

3.3 SUBMITTALS

A. Coordination Drawings: Prepare Coordination Drawings if limited space availability necessitates maximum utilization of space for efficient installation of different components or if coordination is required for installation of products and materials fabricated by separate entities.

1. Content: Project-specific information, drawn accurately to scale. Do not base Coordination Drawings on reproductions of the Contract Documents or standard printed data. Include the following information, as applicable:

   a. Indicate functional and spatial relationships of components of architectural, structural, civil, mechanical, and electrical systems.
   b. Indicate required installation sequenced.
   c. Indicate dimensions shown on the Contract Drawings and make specific note of dimensions that appear to be in conflict with submitted equipment and minimum clearance requirements. Provide alternate sketches to Architect for resolution of such conflicts. Minor dimension changes and difficult installations will not be considered changes to the Contract.

2. Number of Copies: Submit three opaque copies of each submittal. Architect, through Construction Manager, will return one copy.

   a. Submit five copies where Coordination Drawings are required for operation and maintenance manuals. Architect and Construction Manager will retain two copies; remainder will be returned. Markup and retain one returned copy as a Project Record Drawing.

3. Refer to individual Sections for Coordination Drawing requirements for work in those Sections.

B. Key Personnel Names: Within 15 days of starting construction operations, submit a list of key personnel assignments, including superintendent and other personnel in attendance at Project Site. Identify individuals and their duties and responsibilities; list addresses and telephone numbers, including home and office telephone numbers. Provide names, addresses, and telephone numbers of individuals assigned as standbys in the absence of individuals assigned to Project.

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

3.4 ADMINISTRATIVE AND SUPERVISORY PERSONNEL

A. General: In addition to Project Superintendent, provide other administrative and supervisory personnel as required for proper performance of the work.

3.5 PROJECT MEETINGS

A. General: Schedule and attend meetings and conferences at Project Site, unless otherwise indicated.

1. Attendees: Inform participants and others involved, and individuals whose presence is required, of date and time of each meeting. Notify Owner and Architect of scheduled meeting dates and times.
2. Agenda: Be prepared for the meeting agenda. Distribute the agenda to all invited attendees.
3. Minutes: Record significant discussions and agreements achieved. Distribute the meeting minutes to everyone concerned, including Owner and Architect, within three days of the meeting.

B. Preconstruction Conference: Attend a preconstruction conference before starting construction, at a time convenient to Owner, Construction Manager, and Architect, but no later than 15 days after execution of the Agreement. Hold the conference at Project site or another convenient location. Conduct the meeting to review responsibilities and personnel assignments.

1. Attendees: Authorized representatives of Owner, Construction Manager, Architect, and their consultants; Contractor and its superintendent; major subcontractors; suppliers; and other concerned parties shall attend the conference. All participants at the conference shall be familiar with Project and authorized to conclude matters relating to the work.
2. Agenda: Discuss items of significance that could affect progress, including the following:

a. Tentative construction schedule
b. Phasing
c. Critical work sequencing and long-lead items
d. Procedures for processing field decisions and Change Orders
e. Procedures for requests for interpretations (RFIs)
f. Procedures for testing and inspecting
g. Procedures for processing Applications for Payment
h. Submittal procedures
i. LEED requirements
j. Preparation of Record Documents
k. Use of the premises and existing building
l. Work restrictions
m. Owner's occupancy requirements
n. Responsibility for temporary facilities and controls
o. Construction waste management and recycling
p. Parking availability
q. Office, work, and storage areas
r. Equipment deliveries and priorities
s. First aid
t. Security
u. Progress cleaning
v. Working hours

3. Minutes: Record and distribute meeting minutes.

C. Pre-installation Conferences: Attend a pre-installation conference at Project Site before each construction activity that requires coordination with other construction.

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

    a. The Contract Documents
    b. Deliveries
    c. Review of mockups
    d. Possible conflicts
    e. Time schedules
    f. Manufacturer's written recommendations
    g. Acceptability of substrates
    h. Temporary facilities and controls
    i. Coordination with other work
    j. Protection of construction and personnel

3. Record significant conference discussions, agreements, and disagreements, including required corrective measures and actions.
4. Reporting: Distribute minutes of the meeting to each party present and to parties who should have been present.
5. Do not proceed with installation if the conference cannot be successfully concluded. Initiate whatever actions are necessary to resolve impediments to performance of the work and reconvene the conference at earliest feasible date.

D. Progress Meetings: Attend progress meetings at biweekly intervals. Coordinate dates of meetings with preparation of payment requests.

1. Attendees: In addition to representatives of Owner, Construction Manager, and Architect, each contractor, subcontractor, supplier, and other entity concerned with current progress or involved in planning, coordination, or performance of future activities shall be represented at these meetings. All participants at the conference shall be familiar with Project and authorized to conclude matters relating to the work.
2. Agenda: Review and correct or approve minutes of previous progress meeting. Review other items of significance that could affect progress. Include topics for discussion as appropriate to status of Project.

    a. Contractor's Construction Schedule: Review progress since the last meeting. Determine whether each activity is on time, ahead of schedule, or behind schedule, in relation to Contractor's Construction Schedule. Determine how construction behind schedule will be expedited; secure commitments from parties involved to do so. Discuss whether schedule revisions are required to ensure that current and subsequent activities will be completed within the Contract Time.

1) Review schedule for next period.

b. Review present and future needs of each entity present, including the following:

1) Interface requirements
2) Status of submittals
3) Off-site fabrication
4) Site utilization
5) Hazards and risks
6) Progress cleaning
7) Status of correction of deficient items
8) Requests for interpretations (RFIs)
9) Status of proposal requests
10) Pending changes
11) Status of Change Orders
12) Pending claims and disputes
13) Documentation of information for payment requests

3. Minutes: Record the meeting minutes.
4. Reporting: Distribute minutes of the meeting to each party present and to parties who should have been present.

a. Schedule Updating: Revise Contractor's Construction Schedule after each progress meeting where revisions to the schedule have been made or recognized. Issue revised schedule concurrently with the report of each meeting.

3.6 EQUIPMENT LOCATIONS

A. Equipment locations: All mechanical equipment shall be located to provide for manufacturer's recommended clearances, clearance for routine maintenance, clearance per code requirements and locations/clearances required for removal/replacement in the future.

1. Manufacturer's recommended clearances shall include space for proper airflow and non-short circuiting airflow pathway (condensing units, air cooled chillers, cooling towers, etc), clearance for pumps (18" minimum around pumps), 30" clearance or complete access door swings (air handling units), clearances for tube pulls (heat exchangers, chillers, coil pulls, etc); locate piping to be clear of these locations.
2. Provide minimum 36" clearance around boilers, chillers, heat exchangers and other pressure vessels; note this is a minimum requirement, provide excess wherever possible. Provide minimum 42" clearance from power panels per the latest edition NEC having jurisdiction; include requirements for piping and ductwork at such locations.
3. Locate equipment in mechanical rooms to allow for future removal and replacement. Include heights to overhead piping where applicable. Wherever possible, clearances shall include removal/replacement as a whole entity without knock-down.
4. Access platforms with metal grating shall be provided for equipment located outdoors such for power and control panels for air cooled chillers, air handling equipment located on dunnage. This access system shall provide for maintenance and requirements per

codes having jurisdiction. Platforms shall include stairs and handrails per OSHA regulations.

5. Locate roof mounted equipment minimum 10’ away from edges of roof. Where equipment is located closer, provide handrail system at roof edge as required per codes having jurisdiction. Maintain clearances from handrail system to power panels.
6. Locate air intakes 25’ away from exhaust outlets and plumbing vents for healthcare facilities. Locate air intakes minimum 10’ away from exhaust outlets and plumbing vents for all other applications.
7. Locate air intakes for kitchen air intakes min 10’ away from exhaust outlets from kitchen exhaust fans.

3.7 ACCEPTANCE TESTING

A. An acceptance test of the HVAC system shall be performed by the Contractor in the presence of the Owner's representative and the Local Fire Marshal. Upon completion of the successful test, the Contractor shall so certify in writing to the Owner and General Contractor.

B. The Contractor shall also utilize all sub-contractors such as sheetmetal, balancing, piping, controls and commissioning agent, and other contractors such as electrical, plumbing, fire alarm and communications as required to perform this acceptance test.

C. The acceptance test shall be performed to determine that the protective measures required as outlined in NFPA 90A and shall function when needed in order to restrict the spread of fire and smoke.

D. The acceptance test shall include testing the HVAC system to determine its full functionability and in compliance with NFPA 90A and the sequence of operation. All controls and equipment shall be modulated throughout their entire ranges and adjustments shall be made for optimum performance.

1. Portions of control or alarm systems are permitted to have standby power or other emergency modes of operation.
2. The tests shall be performed to determine that the system operates under the standby power or emergency operation mode as well as under normal conditions.

E. All fire, smoke, combination fire/smoke dampers and ceiling dampers shall be operated and tested by the Contractor prior to occupancy of a building to determine that they function in accordance with NFPA 90A. A compliance report shall be forwarded to Engineer and Owner.

3.8 CONNECTION TO EXISTING UTILITIES

A. If connecting to an existing piping system (water, gas, oil, sewer, steam, condensate, etc.). It shall be the responsibility of this contractor to verify the integrity of the existing piping system being connected. All applicable testing and acceptance will apply.

B. If connecting to an existing duct system (supply, return, exhaust, etc.). It shall be the responsibility of this contractor to verify the integrity of the existing ducted system being connected. All applicable testing and acceptance will apply.

C. Existing Pipe Testing: The contractor shall remove a section of piping at the point of connection between new and existing. The contractor shall determine the integrity of the existing piping after analysis of the piping section for tube wall thickness, scaling and corrosion. The analysis shall determine the ability for tie-in, pressure testing ability and remaining useful life. The contractor shall guarantee the piping integrity at the point of tie-in and subsequent acceptance. For existing piping not currently being used; the contractor shall pressure test in order to determine integrity and subsequent acceptance. Report all results in writing to the Architect/Engineer.

D. Existing Ductwork Testing: The contractor shall examine the existing ductwork at the point of tie-in pertaining to gauge, reinforcement and joint methods in order to determine the successful tie in and operation of new systems. The contractor shall determine that the existing systems have adequate construction for new system pressure characteristics. The contractor shall guarantee the ductwork integrity at the point of tie in and subsequent acceptance. Report all results in writing to the Architect/Engineer.

3.9 PIPING SYSTEMS – COMMON REQUIREMENTS

A. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern type.
   b. Chrome Plated Piping: One piece, cast brass type with polished chrome plated finish.
   c. Insulated Piping: One piece, stamped steel type with spring clips.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass type with polished chrome plated finish.
   e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, stamped steel type.
   f. Bare Piping at Ceiling Penetrations in Finished Spaces: Cast brass type with polished chrome plated finish.
   g. Bare Piping at Ceiling Penetrations in Finished Spaces: Set screw.
   h. Bare Piping in Unfinished Service Spaces: One piece, cast brass type with finish.
   i. Bare Piping in Unfinished Service Spaces: One piece, stamped steel type with hinge.
   j. Bare Piping in Equipment Rooms: One piece, cast brass type.
   k. Bare Piping in Equipment Rooms: One-piece, stamped steel type.
   l. Bare Piping at Floor Penetrations in Equipment Rooms: One piece, floor plate type.

2. Existing Piping: Use the following:

   a. Chrome Plated Piping: Split casting, cast brass type with chrome plated finish.
   b. Insulated Piping: Split plate, stamped steel type with hinge and spring clips.
   c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast brass type with chrome plated finish.

d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split plate, stamped steel type with concealed hinge and spring clips.
e. Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass type with chrome plated finish.
f. Bare Piping at Ceiling Penetrations in Finished Spaces: Split plate, stamped steel type with concealed hinge and set screw.
g. Bare Piping in Unfinished Service Spaces: Split casting, cast brass type with finish.
h. Bare Piping in Unfinished Service Spaces: Split plate, stamped steel type with hinge and set screw or spring clips.
i. Bare Piping in Equipment Rooms: Split casting, cast brass type.
j. Bare Piping in Equipment Rooms: Split plate, stamped steel type with set screw or spring clips.
k. Bare Piping at Floor Penetrations in Equipment Rooms: Split casting, floor plate type.

B. Sleeves are not required for core drilled holes, ***except in mechanical and electrical rooms or other wet areas where sleeves shall extend 2 inches above finished floor and shall be made watertight.***

C. Permanent sleeves are not required for holes formed by removable PE sleeves.

D. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical and electrical equipment areas or other wet areas 2 inches above finished floor level. Extended cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide ¼ inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
4. Steel Pipe Sleeves: For pipes smaller than 6 inches.

a. Steel Pipe Sleeves: For pipes 6 inches and larger, penetrating gypsum-board partitions.
b. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast iron soil pipe to extend sleeve to 2 inches below finished floor level. Refer to Section 07620 – Sheet Metal Flashing and Trim for flashing.

5. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Section 07920 – Joint Seals for materials and installation.

E. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeves size to allow for 1 inch annular clear space between pipe and sleeves for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast iron “wall pipes” for sleeves 6 inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

F. Underground, Exterior Wall Pipe Penetrations: Install cast iron “wall pipes” for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1 inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

G. Fire Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Section 07840 – Firestopping Systems for materials.

H. Verify final equipment locations for roughing-in.

I. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

END OF SECTION 23 05 00

SECTION 23 05 10 - HVAC DEMOLITION

PART 1 - GENERAL

1.1 STIPULATIONS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Sections, apply to this Section.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 23 Specification Sections, apply to this Section.

1.3 SUMMARY

A. This Section includes the following:

1. Demolition and removal of selected portions of Division 23 systems.

B. Related Sections include the following:

1. Division 23 Sections for demolishing, cutting, patching, or relocating mechanical items.

1.4 DEFINITIONS

A. Remove: Detach items from existing construction and legally dispose of them off-site, unless indicated to be removed and salvaged or removed and reinstalled.

B. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.5 MATERIALS OWNERSHIP

A. Except for items or materials indicated to be reused, salvaged, reinstalled, or otherwise indicated to remain Owner's property, demolished materials shall become Contractor's property and shall be removed from Project site.

1. Coordinate with Owner's Maintenance Supervisor, who will establish special procedures for removal.

1.6 SUBMITTALS

A. Proposed Dust-Control and Noise-Control Measures: Submit statement or drawing that indicates the measures proposed for use, proposed locations, and proposed time frame for their operation. Identify options if proposed measures are later determined to be inadequate.

B. Schedule of Selective Demolition Activities: Indicate the following:

1. Detailed sequence of selective demolition and removal work, with starting and ending dates for each activity. Ensure Owner's building managers and other tenants' on-site operations are uninterrupted.
2. Interruption of utility services. Indicate how long utility services will be interrupted.
3. Coordination for shutoff, capping, and continuation of utility services.
4. Use of elevator and stairs.
5. Locations of proposed dust- and noise-control temporary partitions and means of egress, including for other tenants affected by selective demolition operations.
6. Coordination of Owner's continuing occupancy of portions of existing building and of Owner's partial occupancy of completed Work.

C. Inventory: After selective demolition is complete, submit a list of items that have been removed and salvaged.

D. Predemolition Photographs or Videotapes: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by selective demolition operations. Comply with Division 01 Section "Photographic Documentation." Submit before Work begins.

E. Landfill Records: Indicate receipt and acceptance of hazardous wastes by a landfill facility licensed to accept hazardous wastes.

1.7 QUALITY ASSURANCE

A. Demolition Firm Qualifications: An experienced firm that has specialized in demolition work similar in material and extent to that indicated for this Project.

B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning selective demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.

C. Standards: Comply with ANSI A10.6 and NFPA 241.

D. Predemolition Conference: Conduct conference at Project site to comply with requirements herein. Review methods and procedures related to selective demolition including, but not limited to, the following:

1. Inspect and discuss condition of construction to be selectively demolished.
2. Review structural load limitations of existing structure.

3. Review and finalize selective demolition schedule and verify availability of materials, demolition personnel, equipment, and facilities needed to make progress and avoid delays.
4. Review requirements of work performed by other trades that rely on substrates exposed by selective demolition operations.
5. Requirements of system downtime and scheduling with site personnel.

1.8 PROJECT CONDITIONS

A. Owner will occupy portions of building immediately adjacent to selective demolition area. Conduct selective demolition so Owner's operations will not be disrupted. Provide not less than 72 hours' notice to Owner of activities that will affect Owner's operations.

B. Maintain access to existing walkways, corridors, and other adjacent occupied or used facilities.

1. Do not close or obstruct walkways, corridors, or other occupied or used facilities without written permission from authorities having jurisdiction.

C. Owner assumes no responsibility for condition of areas to be selectively demolished.

1. Conditions existing at time of inspection for bidding purpose will be maintained by Owner as far as practical.

D. Hazardous Materials: It is not expected that hazardous materials will be encountered in the Work.

1. If materials suspected of containing hazardous materials are encountered, do not disturb; immediately notify Architect and Owner. Owner will remove hazardous materials under a separate contract.

E. Hazardous Materials: Hazardous materials are present in building to be selectively demolished. A report on the presence of hazardous materials is on file for review and use. Examine report to become aware of locations where hazardous materials are present.

1. Hazardous material remediation is specified elsewhere in the Contract Documents.
2. Do not disturb hazardous materials or items suspected of containing hazardous materials except under procedures specified elsewhere in the Contract Documents.

F. Storage or sale of removed items or materials on-site is not permitted.

G. Utility Service: Maintain existing utilities indicated to remain in service and protect them against damage during selective demolition operations.

1. Maintain fire-protection facilities in service during selective demolition operations.

1.9 WARRANTY

A. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during selective demolition, by methods and with materials so as not to void existing warranties.

1. If possible, retain original Installer or fabricator to patch the exposed Work listed below that is damaged during selective demolition. If it is impossible to engage original Installer or fabricator, engage another recognized experienced and specialized firm.

a. Processed concrete finishes.
b. Stonework and stone masonry.
c. Ornamental metal.
d. Matched-veneer woodwork.
e. Preformed metal panels.
f. Roofing.
g. Firestopping.
h. Window wall system.
i. Stucco and ornamental plaster.
j. Terrazzo.
k. Finished wood flooring.
l. Fluid-applied flooring
m. Aggregate wall coating.
n. Wall covering.
o. Swimming pool finishes.
p. HVAC enclosures, cabinets, or covers.

PART 2 - PRODUCTS

2.1 REPAIR MATERIALS

A. Use repair materials identical to existing materials.

1. If identical materials are unavailable or cannot be used for exposed surfaces, use materials that visually match existing adjacent surfaces to the fullest extent possible.
2. Use materials whose installed performance equals or surpasses that of existing materials.

B. Comply with material and installations requirements specified in individual Specification Sections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that utilities have been disconnected and capped.

B. Survey existing conditions and correlate with requirements indicated to determine extent of selective demolition required.

C. Inventory and record the condition of items to be removed and reinstalled and items to be removed and salvaged.

D. When unanticipated mechanical, electrical, or structural elements that conflict with intended function or design are encountered, investigate and measure the nature and extent of conflict. Promptly submit a written report to Architect/Engineer.

E. Engage a professional engineer to survey condition of building to determine whether removing any element might result in structural deficiency or unplanned collapse of any portion of structure or adjacent structures during selective demolition operations.

F. Perform surveys as the Work progresses to detect hazards resulting from selective demolition activities.

3.2 UTILITY SERVICES

A. Existing Utilities: Maintain services indicated to remain and protect them against damage during selective demolition operations.

B. Do not interrupt existing utilities serving occupied or operating facilities unless authorized in writing by Owner and authorities having jurisdiction. Provide temporary services during interruptions to existing utilities, as acceptable to Owner and to authorities having jurisdiction.

1. Provide at least 72 hours' notice to Owner if shutdown of service is required during changeover.
2. Perform work during unoccupied night or weekend hours as required by Owner during disruption of utilities.

C. Utility Requirements: Locate, identify, disconnect, and seal or cap off indicated utility services and mechanical/electrical systems serving areas to be selectively demolished.

1. Building Owner or Representative will arrange to shut off indicated services/systems when requested by Contractor.
2. Arrange to shut off indicated utilities with utility companies.
3. If services/systems are required to be removed, relocated, or abandoned, before proceeding with selective demolition provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.
4. Cut off pipe or conduit in walls or partitions to be removed. Cap, valve, or plug and seal remaining portion of pipe or conduit after bypassing.

D. Utility Requirements: Refer to Division 23 and 26 Sections for shutting off, disconnecting, removing, and sealing or capping utilities. Do not start selective demolition work until utility disconnecting and sealing have been completed and verified in writing.

3.3 PREPARATION

A. Site Access and Temporary Controls: Conduct selective demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.

1. Comply with requirements for access and protection specified in Division 01 Section "Temporary Facilities and Controls."

B. Temporary Facilities: Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.

1. Provide protection to ensure safe passage of people around selective demolition area and to and from occupied portions of building.
2. Provide temporary weather protection, during interval between selective demolition of existing construction on exterior surfaces and new construction, to prevent water leakage and damage to structure and interior areas.
3. Protect walls, ceilings, floors, and other existing finish work that are to remain or that are exposed during selective demolition operations.
4. Cover and protect furniture, furnishings, and equipment that have not been removed.
5. Comply with requirements for temporary enclosures, dust control, heating, and cooling specified in Division 01 Section "Temporary Facilities and Controls."

C. Temporary Shoring: Provide and maintain shoring, bracing, and structural supports as required to preserve stability and prevent movement, settlement, or collapse of construction and finishes to remain, and to prevent unexpected or uncontrolled movement or collapse of construction being demolished.

1. Strengthen or add new supports when required during progress of selective demolition.

3.4 SELECTIVE DEMOLITION, GENERAL

A. General: Demolish and remove existing construction only to the extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations and as follows:

1. Proceed with selective demolition systematically, from higher to lower level. Complete selective demolition operations above each floor or tier before disturbing supporting members on the next lower level.
2. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction. Use hand tools or small power tools designed for sawing or grinding, not hammering and chopping, to minimize disturbance of adjacent surfaces. Temporarily cover openings to remain.
3. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.
4. Do not use cutting torches until work area is cleared of flammable materials. At concealed spaces, such as duct and pipe interiors, verify condition and contents of hidden

space before starting flame-cutting operations. Maintain fire watch and portable fire-suppression devices during flame-cutting operations.

5. Maintain adequate ventilation when using cutting torches.
6. Remove decayed, vermin-infested, or otherwise dangerous or unsuitable materials and promptly dispose of off-site.
7. Remove structural framing members and lower to ground by method suitable to avoid free fall and to prevent ground impact or dust generation.
8. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.
9. Dispose of demolished items and materials promptly.Comply with requirements in Division 01 Section "Construction Waste Management."
10. Return elements of construction and surfaces that are to remain to condition existing before selective demolition operations begun.
11. Provide demolition on an on-going basis, schedule permitting. Demolition of existing systems or portions there to shall be performed without interruption of the operation of the central heating plant.
12. Remove demolition debris on a continuous and daily basis as work proceeds. Do not leave debris in the room.
13. Schedule and locate dumpster space as required by the project and coordinate location with facility personnel.
14. Remove from site boilers and other large pieces of equipment immediately upon movement. Coordinate schedule of removal trains and cranes with facility personnel so that removal minimizes impact on-site traffic movement.
15. Maintain the operation of the central heating plant due to requirements of site steam while demolition is in progress. Where conditions cannot be met, coordinate and schedule with **[hospital or facility]** personnel and other requirements to minimize down-time.

B. Reuse of Building Elements: Project has been designed to result in end-of-Project rates for reuse of building elements as follows. Do not demolish building elements beyond what is indicated on Drawings without Architect's approval.

1. Non-shell Elements: 50 percent.

C. Removed and Salvaged Items:

1. Clean salvaged items.
2. Pack or crate items after cleaning. Identify contents of containers.
3. Store items in a secure area until delivery to Owner.
4. Transport items to Owner's storage area off-site, designated by Owner.
5. Protect items from damage during transport and storage.

D. Removed and Reinstalled Items:

1. Clean and repair items to functional condition adequate for intended reuse. Paint equipment to match new equipment.
2. Pack or crate items after cleaning and repairing. Identify contents of containers.
3. Protect items from damage during transport and storage.

4. Reinstall items in locations indicated. Comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make item functional for use indicated.

E. Concrete: Demolish in small sections. Cut concrete to a depth of at least 3/4 inch at junctures with construction to remain, using power-driven saw. Dislodge concrete from reinforcement at perimeter of areas being demolished, cut reinforcement, and then remove remainder of concrete indicated for selective demolition. Neatly trim openings to dimensions indicated.

F. Concrete: Demolish in sections. Cut concrete full depth at junctures with construction to remain and at regular intervals, using power-driven saw, then remove concrete between saw cuts.

G. Masonry: Demolish in small sections. Cut masonry at junctures with construction to remain and at regular intervals, using power-driven saw, then remove concrete between saw cuts.

H. Concrete Slabs-on-Grade: Saw cut perimeter of area to be demolished, then break up and remove.

I. Resilient Floor Coverings: Remove floor coverings and adhesive according to recommendations in RFCI-WP and its Addendum.

1. Remove residual adhesive and prepare substrate for new floor coverings by one of the methods recommended by RFCI.

J. Roofing: Remove no more existing roofing than can be covered in one day by new roofing. Refer to applicable Division 07 Section for new roofing requirements.

K. Air-Conditioning Equipment: Remove equipment without releasing refrigerants.

3.5 DISPOSAL OF DEMOLISHED MATERIALS

A. Burning: Do not burn demolished materials.

B. Disposal: Transport demolished materials off Owner's property and legally dispose of them.

3.6 CLEANING

A. Clean adjacent structures and improvements of dust, dirt, and debris caused by selective demolition operations. Return adjacent areas to condition existing before selective demolition operations began.

END OF SECTION 23 05 10

SECTION 23 05 13 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 STIPULATIONS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Sections, apply to this Section.

1.2 RELATED DOCUMENTS

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

1.3 SUMMARY

A. This Section includes basic requirements for factory-and field installed motors.

1.4 DEFINITIONS

A. Factory-Installed Motor: A motor installed by motorized-equipment manufacturer as a component of equipment.

B. Field-Installed Motor: A motor installed at Project site and not factory installed as an integral component of motorized equipment.

1.5 SUBMITTALS

A. Product Data for Field-Installed Motors: For each type and size of motor, provide nameplate data and ratings; shipping, installed, and operating weights; enclosure type and mounting arrangements; size, type, and location of winding terminations; conduit entry and ground lug locations; and information on coatings or finishes.

B. Shop Drawings for Field-Installed Motors: Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:

1. Each installed unit's type and details.
2. Nameplate legends.
3. Diagrams of power, signal, and control wiring. Provide schematic wiring diagram for each type of motor and for each control scheme.

C. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around field-installed motors. Show motor layout, mechanical power transfer link, driven load, and relationship between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Manufacturer Seismic Qualification Certification: Submit certification that motors, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls". Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Qualification Data: For testing agency.

F. Source quality-control test reports.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For field-installed motors to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

B. Source Limitations: Obtain field-installed motors through one source from a single manufacturer.

C. Product Options for Field-Installed Motors: Drawings indicate size, profiles, and dimensional requirements of motors and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with NFPA 70.

1.7 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices and features that comply with the following:

1. Compatible with the following:

a. Magnetic controllers.
b. Multispeed controllers.
c. Reduced-voltage controllers.

2. Designed and labeled for use with variable frequency controllers, and suitable for use throughout speed range without overheating.
3. Matched to torque and horsepower requirements of the load.
4. Matched to ratings and characteristics of supply circuit and required control sequence.

B. Coordinate motor support with requirements for driven load; access for maintenance and motor replacement; installation of accessories, belts, belt guards; and adjustment of sliding rails for belt tensioning.

C. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 MOTOR REQUIREMENTS

A. Motor requirements apply to factory-and field-installed motors except as follows:

1. Different ratings, performance, or characteristics for motor are specified in another Section.
2. Motorized-equipment manufacturers require ratings, performance, or characteristics, other than those specified in this Section, to meet performance specified.

2.2 MOTOR CHARACTERISTICS

A. Motors 1/2 HP and Larger: Three phase. Unless otherwise specified.

B. Motors smaller than 1/2 HP: Single phase. Unless otherwise specified.

C. Frequency Rating: 60 Hz.

D. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.

E. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.

F. Duty: Continuous duty at ambient temperature of 105 deg F and at altitude of 3300 feet above sea level.

G. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

H. Enclosure: Open dripproof.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium] as defined in NEMA MG 1.

C. Stator: Copper windings, unless otherwise indicated.

1. Multispeed motors shall have separate winding for each speed.

D. Rotor: Squirrel cage, unless otherwise indicated.

E. Bearings: Double-shielded, pre-lubricated ball bearings suitable for radial and thrust loading.

F. Temperature Rise: Match insulation rating, unless otherwise indicated.

G. Insulation: Class F, unless otherwise indicated.

H. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

I. Enclosure: Cast iron for motors 7.5 hp and larger; rolled steel for motors smaller than 7.5 hp.

1. Finish: Gray enamel or as approved by Engineer.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Inrush Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Designed with critical vibration frequencies outside operating range of controller output.
2. Temperature Rise: Matched to rating for Class B insulation.
3. Insulation: Class H.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
5. Ground motor shafts.

C. Rugged-Duty Motors: Totally enclosed, with 1.25 minimum service factor, greased bearings, integral condensate drains, and capped relief vents. Windings insulated with non-hygroscopic material.

1. Finish: Chemical-resistant paint over corrosion-resistant primer.

D. Source Quality Control for Field-Installed Motors: Perform the following tests on each motor according to NEMA MG 1:

1. Measure winding resistance.
2. Read no-load current and speed at rated voltage and frequency.
3. Measure locked rotor current at rated frequency.
4. Perform high-potential test.

2.5 SINGLE-PHASE MOTORS

A. Type: One of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split-phase start, capacitor run.
3. Capacitor start, capacitor run.

B. Shaded-Pole Motors: For motors 1/20 hp and smaller only.

C. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

D. Bearings: Ball type for belt-connected motors and other motors with high radial forces on motor shaft; sealed, pre-lubricated-sleeve type for other single-phase motors.

E. Source Quality Control for Field-Installed Motors: Perform the following tests on each motor according to NEMA MG 1:

1. Measure winding resistance.
2. Read no-load current and speed at rated voltage and frequency.
3. Measure locked rotor current at rated frequency.
4. Perform high-potential test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive field-installed motors for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before motor installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FIELD-INSTALLED MOTOR INSTALLATION

A. Anchor each motor assembly to base, adjustable rails, or other support, arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and align with load transfer link.

B. Install motors on concrete bases complying with Division 03.

C. Comply with mounting and anchoring requirements specified in Division 23 Section "Vibration and Seismic Controls."

3.3 FIELD QUALITY CONTROL FOR FIELD-INSTALLED MOTORS

A. Prepare for acceptance tests.

1. Align motors, bases, shafts, pulleys, and belts. Tension belts according to manufacturer's written instructions.
2. Verify bearing lubrication.
3. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.
4. Test interlocks and control and safety features for proper operation.
5. Verify that current and voltage for each phase comply with nameplate rating and NEMA MG 1 tolerances.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

C. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

D. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

E. Perform the following field tests and inspections and prepare test reports:

1. Perform electrical tests and visual and mechanical inspections including optional tests and inspections stated in NETA ATS on factory-and field-installed motors. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.4 FIELD-INSTALLED MOTOR DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain field-installed motors. Refer to Division 01 Section "Closeout Procedures and Demonstration and Training."

END OF SECTION 23 05 13

SECTION 23 05 16 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 STIPULATIONS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Sections, apply to this Section.

1.2 WORK INCLUDED

A. Flexible pipe connections.

B. Expansion joints and compensators.

C. Pipe loops, offsets and swing joints.

D. Pump specialties.

E. Pipe guides.

F. Pipe anchors.

1.3 RELATED WORK

A. Division 23 – Scope or Work

B. Division 23 – Common Work Results for HVAC

C. Division 23 – Hangers, Supports and Anchors

1.4 REFERENCES

A. Conform to Standards of Expansion Joint Manufacturer's Association.

1.5 DESIGN CRITERIA

A. Base expansion calculations on 40° F installation temperature to 210° F for hot water heating, plus 30 percent safety factory; resulting pipe stress shall be 1/3 of maximum allowable.

1.6 SUBMITTALS

A. Submit shop drawings under provisions of Section 01 or 23.

B. Flexible pipe connector shop drawing data to include maximum allowable temperature and pressure rating, overall 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.

C. Expansion joint shop drawings to include maximum allowable pipe stress per 1.4 A. above.

1.7 QUALITY ASSURANCE

A. Engineering Responsibility: Design and preparation of Shop Drawings and calculations for expansion fittings and loops by a qualified professional engineer.

1. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of expansion fittings and loops that are similar to those indicated for this Project in material, design, and extent.

B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Flexonics

B. Metraflex (Basis of Design)

C. Keflex

D. Grinnell

2.2 FLEXIBLE PIPE CONNECTIONS – AT PUMPS

A. For steel piping construct with stainless steel inner hose and braided exterior sleeve.

B. For copper piping construct with bronze inner hose and braided exterior sleeve.

C. Construct spool pieces to extract size for insertion of flexible connection.

D. Install flexible connectors at all suction and discharge pump connections to relieve pump and piping stresses. Flexible hose section to be 304 stainless steel, close pitch, annular corrugated hose with type 304 braided outer covering. End connections to be ANSI class 150 carbon steel plate flanges. Overall length to allow for intermittent flexing or per manufacturer's recommendations for additional motion.

E. Connectors mounted at the suction side of pumps shall be located upstream of the inlet elbow and incorporate specially designed stationary vanes that impart a rotational motion as the fluid enters the elbow. Vanes to be capable of counteracting elbow induced turbulence, enabling the fluid to negotiate the turn uniformly, and exit with a flat velocity profile. Suction side flexible connectors shall be Metraflex model CRV Flex or reviewed equivalent.

F. Connectors at the discharge side of pumps shall incorporate internal flow straightening vanes to reduce turbulence prior to the balancing valve. Vanes to be capable of reducing discharge turbulence equal to 5-10 pipe diameters of straight pipe, while allowing full rated movement of the connector. Discharge side flexible connectors shall be Metraflex model Vane Flex or reviewed equivalent.

2.3 EXPANSION JOINTS

A. Expansion joints shall be pack-less, externally pressurized type where line pressure is external to the bellows. Factory provided with drain plug and lifting lug. Double joints shall have anchor base to act as intermediate anchor. Construction, pressure ratings and end fittings shall be appropriate for the application. Performance rated for 150 psi @ 700F or 300 psi @ 700F as required. Movement at 4”, 6” or 8” axial movement, as required. All welded construction with stainless steel bellows, steel shroud, integral guide rings and internal liner. Bellows shall be low corrugation style manufactured from Type 304 stainless steel with number of corrugations and overall length to be determined by the thermal expansion requirement, system design engineer and manufacturer’s recommendations based upon EJMA standards. Guiding and anchoring per EJMA recommendations and guidelines. Metraflex MetraGator as Basis of Design or reviewed equivalent.

2.4 PIPE GUIDES

A. Style IV – Pipe Alignment Guide (Spider Type)

1. Primary and intermediate guides shall be of the radial type employing a heavy wall guide cylinder with weld down anchor base. A two section guide spider, having 1/8" maximum diametrical clearance with guide cylinder inside diameter, bolted or welded tight to the carrier pipe which slides through the guide cylinder I.D. Cylinder shall be of sufficient size to clear pipe insulation and long enough to prevent over travel of the spider. Pipe alignment guides shall be Metraflex style PGIV or reviewed equivalent. Guides may be insulated type.

B. Style RG – Riser Pipe Alignment Guide (Glide Type)

1. Primary guides shall be of the vertical sliding type. Guides to be used in all building riser, piping systems in conjunction with the Metraflex HPL series compensators. Glide

systems in conjunction with the Metraflex HPL series compensators. Glide series floor and ceiling pipe guides to be installed in pairs, at the floor and ceiling penetrations, and require no additional intermediate guides. Two-piece construction employing a sliding member to be welded to the carrier pipe and a bolt down anchor base. Sliding member shall be of sufficient height to clear pipe insulation and long enough to prevent over travel of the slide. Stationary member shall consist of a steel mounting bracket, containing an isolating slide bearing to prevent the transmission of vibration and mechanically transmitted sound to the building structure. Riser pipe alignment guides shall be Metraflex style RG or reviewed equivalent.

2.5 FACTORY FABRICATED EXPANSION LOOPS

A. Non-Seismic Flexible Expansion Loops

1. Provide flexible expansion loops of size and type noted on drawings. Flexible loops shall consist of two flexible sections of hose and braid, two 90° elbows, and a 180° return assembled in such a way that the piping does not change direction but maintains its course along a single axis. Flexible loops shall have a factory supplied, center support nut located at the bottom of the 180° return, and a drain/air release plug. Flexible loops shall impart no thrust loads to system support anchors or building structure. Loops shall be installed in a neutral, pre-compressed or pre-extended condition as required for the application. Install and guide per manufacturer's recommendations. Materials of construction and end fitting type shall be consistent with pipe material and equipment / pipe connection fittings. Flexible expansion loops to be Metraflex model Metraloop or reviewed equivalent.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install flexible pipe connectors on pipes connected to equipment supported by vibration isolation.

B. Provide pipe guides at expansion locations so that movement takes place along axis of pipe only. Support guide from minimum two joists or beams.

C. Install connections between piping mains and terminal units at least four (4) pipe fittings including tee in the main.

D. Pipe guides adjacent to expansion joint shall be in accordance to EJMA guidelines based on design pressure and line sizes.

E. When installed in vertical pipe runs, expansion joint shall be installed with the traveling end on top.

F. Expansion joint drain shall be installed so the drain connection is on the low end of the joint.

G. Install expansion fittings according to manufacturer's written instructions. Install expansion fittings in sizes matching pipe size in which they are installed. Align expansion fittings to avoid end-loading and torsional stress.

H. Install pipe bends and loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

I. Attach pipe bends and loops to anchors:

1. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.

3.2 ANCHOR INSTALLATION

A. Install anchors at locations to prevent stress from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.

C. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.

D. Install pipe anchors according to expansion fitting manufacturer's written instructions.

E. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

END OF SECTION 23 05 16

SECTION 23 05 29 - HANGERS & SUPPORTS FOR HVAC PIPING & EQUIPMENT

PART 1 - GENERAL

1.1 STIPULATIONS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Sections, apply to this Section.

1.2 WORK INCLUDED

A. This Section includes hangers, supports, anchors, sleeves, seals, flashing and sealing for mechanical system piping and equipment.

1.3 RELATED WORK

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

B. Related Sections include:

1. Division 05 Section "Metal Fabrications" for materials for attaching hangers and supports to building structure.
2. Division 21 Sections on fire-suppression piping for fire-suppression pipe hangers.

1.4 REFERENCES

A. ASTM A 36/A 36M-00a: Specification for Carbon Structural Steel

B. ASTM A 780-00: Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

C. ASTM C 533-95: Specification for Calcium Silicate Block and Pipe Thermal Insulation

D. ASTM C 552-00 (Revised 2001): Specification for Cellular Glass Thermal Insulation

E. ASTM C 1107-99: Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)

F. ASME B31.9-96: Building Services Piping

G. 2001 ASME Boiler and Pressure Vessel Code: Section II, "Materials"; Section IX, "Welding and Brazing Qualifications"

H. AWS D1.1-00: Structural Welding Code – Steel

I. MSS SP-58-93: Pipe Hangers and Supports – Materials, Design and Manufacture

J. MSS SP-69-96: Pipe Hangers and Supports – Selection and Application

K. MSS SP-89-98: Pipe Hangers and Supports – Fabrication and Installation Practices

L. MSS SP-90-00: (Reaffirmed 1991): Guidelines on Terminology for Pipe Hangers and Supports

M. MFMA-3-99: Metal Framing Standards Publication

N. MFMA-102-99: Guidelines for the Use of Metal Framing

O. SSPC-PA 1-2000: Paint Application Specification No. 1: Shop, Field and Maintenance Painting

P. IAPMO PS 42-96: Pipe Alignment and Secondary Support Systems

1.5 DEFINITIONS

A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.6 PERFORMANCE REQUIREMENTS

A. Design channel support systems for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

B. Design heavy-duty steel trapezes for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

C. Design seismic restraint hangers and supports for piping and equipment.

1.7 SUBMITTALS

A. Product Data: For each type of pipe hanger, channel support system component, and thermal-hanger shield insert indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer for multiple piping supports and trapeze hangers. Include design calculations and indicate size and characteristics of components and fabrication details.

C. Welding Certificates: Copies of certificates for welding procedures and operators.

1.8 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Engineering Responsibility: Design and preparation of Shop Drawings and calculations for each multiple pipe support, trapeze, and seismic restraint by a qualified professional engineer.

1. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of hangers and supports that are similar to those indicated for this Project in material, design, and extent.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Pipe Hangers:

a. B-Line Systems, Inc.
b. Carpenter & Patterson, Inc.
c. Grinnell Corp.

2. Channel Support Systems:

a. B-Line Systems, Inc.
b. Grinnell Corp.; Power-Strut Unit.
c. Unistrut Corp.

3. Thermal-Hanger Shield Inserts:

a. Carpenter & Patterson, Inc.
b. Michigan Hanger Co., Inc.
c. Pipe Shields, Inc.

4. Powder-Actuated Fastener Systems:

a. Gunnebo Fastening Corp.
b. Hilti, Inc.
c. ITW Ramset/Red Head.
d. Masterset Fastening Systems, Inc.

5. Piping supports systems for Roofs:

    a. Miro Industries, Inc.
    b. Curbs-Plus, Inc.
    c. PHP Systems/Design
    d. Reviewed Equivalent

2.2 MANUFACTURED UNITS

A. Pipe Hangers, Supports, and Components: MSS SP-58, factory-fabricated components. Refer to "Hanger and Support Applications" Article in Part 3 for where to use specific hanger and support types.

1. Galvanized, Metallic Coatings: For piping and equipment that will not have field-applied finish.
2. Corrosion resistant for piping located outdoors such as including but not limited to steam piping.
3. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with non-insulated copper tubing.

B. Channel Support Systems: MFMA-2, factory-fabricated components for field assembly.

1. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

C. Thermal-Hanger Shield Inserts: 100-psi minimum compressive-strength insulation, encased in sheet metal shield.

1. Material for Cold Piping: ASTM C 552, Type I cellular glass with vapor barrier.
1. Material for Hot Piping: ASTM C 552, Type I cellular glass for water and calcium silicate for steam and other high temperature pipes.
2. For Trapeze or Clamped System: Insert and shield cover entire circumference of pipe.
3. For Clevis or Band Hanger: Insert and shield cover lower 180 degrees of pipe.
4. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

D. Roof Support Systems:

1. Provide an engineered piping support system by Miro or reviewed equivalent for all piping to be supported directly on the rubber roof. System shall be designed to spread the load of each support over a wide area to minimize point loading and provide a stable base as not to crush the polysio roof insulation. Pipe supports shall be provided with a means to protect the rubber roof from any punctures or abrasions that could result in leaks.
2. All pipes shall be supported from adjustable height pipe rollers to allow longitudinal pipe movement from thermal expansion. Pipe roller system shall be designed to accommodate insulted piping. thermal expansion. Pipe roller system shall be designed to accommodate insulted piping. Pipe support system to account for roof pitch and piping pitch for secure support of piping systems.

2.3 MISCELLANEOUS MATERIALS

A. Powder-Actuated Drive-Pin Fasteners: Powder-actuated-type, drive-pin attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

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

D. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged, nonshrink and nonmetallic, dry, hydraulic-cement grout.

1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.
2. Properties: Nonstaining, noncorrosive, and nongaseous.
3. Design Mix: 5000-psi, 28-day compressive strength.

2.4 HANGER RODS

A. Steel Hanger Rods: Threaded both ends, threaded one end, or continuous threaded.

2.5 INSERTS

A. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustable, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit hanger rods. Inserts not allowed on piping 2 inches and larger.

2.6 FLASHING

A. Metal Flashing: 26 gauge galvanized steel.

B. Lead Flashing: 5 lb./sq. ft. sheet lead for waterproofing; one lb./sq. ft. sheet lead for soundproofing.

C. Flexible Flashing: Thick sheet butyl; compatible with roofing.

D. Caps: Steel, 22 gauge minimum; 16 gauge at fire resistant elements.

2.7 SLEEVES

A. Sleeves for Pipes: Schedule 10, black steel.

B. Sleeves for Ductwork: 18 gauge, black steel.

C. Fire Stopping Insulation: Glass fiber type, non-combustible.

D. Caulk: Acrylic sealant.

2.8 FABRICATION

A. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.

B. Design hangers without disengagement of supported pipe.

C. Provide copper plated hangers and supports for copper piping.

2.9 SEALS

A. Mechanical Type; Interlocking synthetic rubber links; pressure plates and compression bolts. Include sleeve from same manufacturer.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger requirements are specified in Sections specifying equipment and systems.

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

C. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Adjustable Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
7. Adjustable Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.

9. Adjustable Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipe, NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

D. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

E. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

F. Building Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): 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. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where head room is limited.

G. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe, 360-degree insert of high-density, 100-psi minimum compressive-strength, water-repellent-treated calcium silicate or cellular-glass pipe insulation, same thickness as adjoining insulation with vapor barrier and encased in 360-degree sheet metal shield.

H. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): 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.

3.2 HANGER AND SUPPORT INSTALLATION

A. Pipe Hanger and Support 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. Channel Support System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled channel systems.

1. Field assemble and install according to manufacturer's written instructions.

C. Heavy-Duty Steel Trapeze Installation: Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated, heavy-duty trapezes.

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 D-1.1.

D. Install building attachments within concrete slabs or attach to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, and expansion joints, 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.

E. Install powder-actuated drive-pin fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.

F. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

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

J. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping," is not exceeded.

K. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping.

    a. All Insulated Piping: Clamp shall not project through insulation.
    b. All Insulated Piping: Use thermal-hanger shield and insert with clamp sized to match OD of insert. Pipe insulation and jacket shall be continuous, provide pipe accessories as required.
    c. Do not exceed pipe stress limits according to ASME B31.9.

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. 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 arc of 180 degrees.

    a. 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.

L. Supports shall secure pipes in place, shall prevent pipe vibration, maintain required grading by proper adjustment, provide for expansion and contraction and shall make a neat appearance. Supports shall be of strength and rigidity to suit loading, service and installed in a manner in which will not stress unduly the building construction. Hangers shall not be permitted from roof and floor slabs. Fasten hangers and supports to building framing wherever practicable. Where required, add supplementary steel members to support piping. Hangers shall be capable of vertical adjustment after piping is erected. Hanger rods shall not pierce ducts.

1. Support horizontal piping of steel as per following schedule:

    a. NPS 3/4: Maximum span, 8 feet; minimum rod size, 1/4 inch
    b. NPS 1: Maximum span, 8 feet; minimum rod size, 1/4 inch
    c. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch
    d. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch
    e. NPS 2-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch
    f. NPS 3: Maximum span, 8 feet; minimum rod size, 3/8 inch
    g. NPS 4: Maximum span, 8 feet; minimum rod size, 1/2 inch
    h. NPS 6: Maximum span, 8 feet; minimum rod size, 1/2 inch
    i. NPS 8: Maximum span, 8 feet; minimum rod size, 5/8 inch
    j. NPS 10: Maximum span, 8 feet; minimum rod size, 3/4 inch
    k. NPS 12: Maximum span, 8 feet; minimum rod size, 7/8 inch
    l. NPS 14: Maximum span, 8 feet; minimum rod size, 1 inch
    m. NPS 16: Maximum span, 8 feet; minimum rod size, 1 inch
    n. NPS 18: Maximum span, 8 feet; minimum rod size, 1-1/4 inches
    o. NPS 20: Maximum span, 8 feet; minimum rod size, 1-1/4 inches

2. Support horizontal copper tubing as per following schedule:

    a. NPS 1/2: Maximum span, 6 feet; minimum rod size, 1/4 inch
    b. NPS 3/4: Maximum span, 6 feet; minimum rod size, 1/4 inch
    c. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch
    d. NPS 1-1/2: Maximum span, 10 feet; minimum rod size, 3/8 inch
    e. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch
    f. NPS 2-1/2: Maximum span, 10 feet; minimum rod size, 3/8 inch
    g. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch

Rod diameter shall be the same as specified for steel pipe. Support plastic piping in accordance with manufacturer's published recommendations.

3. Vertical Piping Supports

a. Cast Iron and Steel: Support at each floor and intermediates by stays or bracing with a maximum spacing of 10 feet unless otherwise required by expansion conditions.
b. Copper Tubing: Support at each floor intermediates by stays or bracing with a maximum spacing of 10 feet to prevent rattling and vibration, unless otherwise required by expansion conditions.
c. Plastic and Glass: Support in accordance with published manufacturer's recommendations.
d. Support vertical lines which rise from lowest story with base fitting set on concrete or brick pier, or by hangers located on horizontal connections to riser.
e. Bolt pipe riser clamps securely to pipe; rest clamp and extension on building structure. In special cases where directed, weld clamp to pipe and to building steel. Where required, provide supplementary steel members for clamp rest.

3.3 FLASHING

A. Provide flexible flashing and metal counter flashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.

B. Flash vent and soil pipes projecting 3 inches minimum above finished roof surface with lead worked one-inch minimum into hub, 8 inches sheet clear on sides with 24 x 24 inches sheet size. For pipes through outside walls, turn flanges back into wall and caulk metal counter flash and seal.

C. Seal floor, shower and mop sink drains watertight to adjacent materials.

D. Provide curbs for mechanical roof installations 14 inches minimum high above roofing surface. Flexible sheet flash and counter flash with sheet metal; seal watertight.

3.4 SLEEVES

A. Provide sleeves at all pipe penetrations of floor and walls.

B. Extend sleeves through floors one inch above finished floor level. Grout sleeves in place. Staff joint with fire stop insulation and caulk seal airtight.

C. Duct penetrations of non-rated floors and walls shall have the edge joint stuffed with insulation and the caulk sealed, airtight. No sleeve is required.

D. Duct penetrations of rated partitions and floor shall be sleeved with 12 gauge galvanized steel as per UL fire damper detail. Caulk all floor penetrations watertight between the floor and sleeve with fireproof caulk, airtight.

E. Install chrome plated steel escutcheons at finished surface.

F. Use mechanical seals at exterior wall pipe penetrations below grade.

3.5 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure above or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

3.6 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes and equipment supports.

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

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.7 ADJUSTING

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

3.8 PAINTING

A. Touching Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

C. Ceiling Plates: Where hanging rods or piping leave unsightly holes in ceilings in finished areas, provide plastic ceiling plates, Grinnell Figure 127 or cast iron ceiling plates with setscrew, Grinnell Figure 395.

END OF SECTION 23 05 29

SECTION 23 05 33 - HEAT TRACING FOR HVAC PIPING

PART 1 - GENERAL

1.1 STIPULATIONS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes a UL Listed, CSA Certified and FM Approved heat tracing system for freeze protection of aboveground water lines consisting of self-regulating heating cable, connection kits and electronic controller.

1.3 RELATED SECTIONS

A. Section 23 05 00 – Common Work Results for HVAC

B. Section 23 07 19 – HVAC Piping Insulation

1.4 SYSTEMS DESCRIPTION

A. System for freeze protection of aboveground water, steam and condensate lines with Proportional Ambient Sensing Control (PASC), monitoring, integrated ground-fault circuit protection and Building Management System (BMS) communication capabilities.

1.5 SUBMITTALS

A. Product Data

1. Heating cable data sheet
2. UL, CSA, FM approval certificates for freeze protection for aboveground water lines
3. Pipe freeze protection design guide
4. System installation and operation manual
5. System installation details
6. Connection kits and accessories data sheet
7. Controller data sheet
8. Controller wiring diagram

1.6 QUALITY ASSURANCE

A. Manufacturers Qualifications

1. Manufacturer to show minimum of thirty (30) years experience in manufacturing electric self-regulating heating cables.
2. Manufacturer will be ISO-9001 registered.
3. Manufacturer to provide products consistent with UL 515, CSA 22.2 No 130-03 and IEEE 515.1 requirements.

B. Installer Qualifications

1. System installer shall have complete understanding of product and product literature from manufacturer or authorized representative prior to installation. Electrical connections shall be performed by a licensed electrician.

C. Regulatory Requirements and Approvals

1. The system (heating cable, connection kits, and controller) shall be UL Listed, CSA Certified and FM Approved for freeze protection of aboveground water lines.

D. Electrical Components, Devices, and Accessories: Listed and labelled as defined in NFPA 70, Article 100, by a Nationally Recognized Testing Laboratory (NRTL), and marked for intended use.

1.7 DELIVERY, STORAGE AND HANDLING

A. General Requirements: Deliver, store and handle products to prevent their deterioration or damage due to moisture, temperature changes, contaminates or other causes.

B. Delivery and Acceptance Requirements: Deliver products to site in original, unopened containers or packages with intact and legible manufacturers' labels identifying the following:

1. Product and Manufacturer
2. Length/Quantity
3. Lot Number
4. Installation and Operation Manual
5. MSDS (if applicable)

C. Storage and Handling Requirements

1. Store the heating cable in a clean, dry location with a temperature range 0°F (-18°C) to 140°F (60°C).
2. Protect the heating cable from mechanical damage.

1.8 WARRANTY

A. Extended Warranty

1. Manufacturer shall provide ten (10) year warranty for all heating cables and components. Provide one (1) year warranty for all heat trace controllers.
2. Contractor shall submit to owner results of installation tests required by the manufacturer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS AND PRODUCTS

A. Contract Documents are based on manufacturer and products named below to establish a standard of quality.

B. Basis of Design

1. Basis of Design Product Selections

a. Manufacturer

1) Manufacturers shall have more than thirty (30) years experience with manufacture & installation self-regulating heating cables.
2) Manufacturer shall provide UL, CSA, FM approval certificates for freeze protection of aboveground water lines.
3) Delta Therm

2.2 PRODUCTS

A. Heat Tracing

1. Furnish and install electric heating cable, complete with electronic thermostat controls and accessories. The following systems shall be individually controlled by pipe wall sensing controllers. If maximum circuit length of heater cable or load capacity of controller is exceeded provide an additional controller for that system.
2. Electric heating cable shall be parallel construction constant wattage type, with 12 AWG bus wires, FEP Teflon jacket and a stainless steel over braid and accessories, as manufactured by Delta-Therm Inc.,Represented by Gassew Associates, Inc.
3. Each heating cable circuit shall be individually controlled by a solid state, direct reading Single Circuit controller Nextron Cat# TM-1P. Controllers shall be set at 40F. Heat trace system shall be for use at 120 volts AC.
4. Heating cable shall be installed parallel along length of pipe. Polyglass tape shall be used circumferencely around pipe to hold heater in place. A 2" wide aluminum tape shall be installed parallel over heater cable to ensure maximum heat transfer to pipe and to ensure maximum energy efficiency.
5. Refer to the following schedule for selection of appropriate heat tape.Pipe heat loss is based on 2” Mineral Wool insulation maintaining a 40o F. temperature with a [-20o F]. minimum ambient temperature and a 20% safety factor.

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Pipe Size	208V Wattage Output
1/2" - 1 1/2"	3.0 w/ft.
2" - 5"	6.0 w/ft.
6" - 10"	10.0 w/ft.
12" -16"	12.0 w/ft.
18" -24"	20.0 w/ft.

6. Provide a Single Circuit electronic controller designed for indoor or outdoor use. Controller shall use a 100-ohm three-wire platinum RTD with a control temperature range of 0-500oF. A alarm light mounted on the front door to indicate all systems are good. The controller shall have a 30 Amp contact and a built in Ground Fault Protection Device (GFPD) eliminating the need for ground fault breakers.
7. The controller shall have the following alarm functions; Low- Temp, High Temp, Current Fail, Ground Fault Trip, RTD Fail, Loss of Power, and alarm output contacts that may be connected to a building alarm system. The controller shall exercise dormant systems every 24 hrs. for early warning for shutdown prevention.
8. Heating cable shall be installed per manufacturer's recommendations.All tee splices to be made in a junction box. Cable shall be meggered prior to installation to check for damage done during shipping. After cable is installed and wired, but before insulation is installed the following tests shall be made:

    a. Resistance and megger test.
    b. Measure the actual voltage and current load. Make a chart showing the voltage and load for each circuit also marking junction boxes with the resistance readings for each branch leg.

9. All above tests to be also performed when insulation installation is completed. There shall be no change in readings. Installing contractor must submit all records and tests to engineer for review.
10. Thermal Pipe Insulation

    a. Pipes must be thermally insulated in accordance with the Delta Therm design guide requirements.
    b. Thermal insulation must be a type that is flame retardant (closed-cell or fiberglass) with waterproof covering.

2.3 SYSTEM LISTING

A. The system (heating cable, connection kits, and controller) shall be UL Listed, CSA Certified and FM Approved for freeze protection of aboveground water lines.

B. The freeze protection system shall have a design, installation and operating manual specific to aboveground water lines.

PART 3 - EXECUTION

3.1 INSTALLERS

A. Acceptable Installers

1. Subject to compliance with requirements of Contract Documents, installer shall be familiar with installing heat-trace cable and equipment.

3.2 EXAMINATION

A. Examine surfaces and substrated to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance

1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.
2. Ensure surfaces and substrates are level and plumb.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 INSTALLATION

A. Comply with manufacturer’s recommendations in the Pentair Raychem System Installation and Operation Manual.

B. Apply the heating cable linearly on the pipe after piping has successfully completed any pressure tests. Secure the heating cable to piping with fiberglass tape.

C. Score Pittsburgh Corning insulation to allow for insulation to encapsulate pipe heat trace cable properly; seal joints and finish with aluminium jacket.

D. Install electric heating cable according to the drawings and the manufacturer’s instructions. The installer shall be responsible for providing a complete functional system, installed in accordance with applicable national and local requirements.

E. Grounding of controller shall be equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

F. Connection of all electrical wiring shall be according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Start-up of system shall be performed by factory technician or factory representative per the owner’s requirements.

B. Field Testing and Inspections

1. The system shall be commissioned in accordance to the Pentair Raychem Installation and Operation manual.
2. The heating cable circuit integrity shall be tested using a 2500 Vdc megohmmeter at the following intervals below. Minimum acceptable insulation resistance shall be 1000 megohms or greater.

    a. Before installing the heating cable
    b. After heating cable has been installed onto the pipe
    c. After installing connection kits
    d. After the thermal insulation is installed onto the pipe
    e. Prior to initial start-up (commissioning)
    f. As part of the regular system maintenance

3. The technician shall verify that the C910-485 or ACCS-30 control parameters are set to the application requirements.
4. The technician shall verify that the C910-485 or ACCS-30 alarm contacts are corrected connected to the BMS.
5. The technician shall verify that the C910-485 or ACCS-30 and ProtoNode-RER/-LER **[Select one]** are configured correctly with the BMS.
6. All commissioning results will be recorded and presented to the owner.

3.5 MAINTENANCE

A. Maintenance Service

1. Comply with manufacturer's recommendations in XL-Trace System Installation and Operation Manual.

END OF SECTION 23 05 33

SECTION 23 05 46 - VIBRATION ISOLATION FOR HVAC COMPONENTS

PART 1 - GENERAL

This section provides for vibration isolation for the "equipment" components as listed below. This specification is part of the general conditions for the HVAC.

1.1 STIPULATIONS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Sections, apply to this Section.

1.2 DESCRIPTION

A. Intent

1. The work associated with the facility shall include vibration isolation of components as listed below:

    a. Heating Piping
    b. Boilers
    c. Cabinet Unit Heaters
    d. Curbs
    e. Equipment Supports
    f. Fans
    g. Fan Coil Units
    h. Ductwork
    i. Pumps
    j. Risers
    k. Supports
    l. Tanks
    m. Unit Heaters
    n. Vibration Isolators
    o. Rooftop Units
    p. Air Conditioning Units
    q. Chillers
    r. Unit Ventilators

2. All equipment, piping, ductwork and conduit as noted on the drawings schedule or in the specification shall be vibration isolated. Vibration control shall apply as described herein.
3. Vibration isolation materials shall be of the same manufacturer and shall be certified by the manufacturer.

4. Any variance or non-compliance with this specification requirement shall be corrected by the contractor in an approved manner.

B. The work in this section includes, but is not limited to the following:

1. Vibration isolation for piping, ductwork, conduit and equipment.
2. Equipment isolation bases.
3. All mechanical, equipment and systems within or on the building. Equipment buried underground is included. Entry of services to building, up to but not including the utility connection point is part of this Specification.

C. Definitions *(all codes).*

1. Positive Attachment:

a. Positive attachment is defined as a cast-in anchor, a drill-in wedge anchor, a double-sided beam clamp loaded perpendicular to a beam, or a welded or bolted connection to structure. Single sided "C" type beam clamps for support rods of overhead piping, ductwork, fire protection or any other equipment are not acceptable of this project as bracing points.

2. Transverse Bracing:

a. Restraint(s) applied to limit motion perpendicular to the centerline of the pipe or duct.

3. Longitudinal Bracing:

a. Restraint(s) applied to limit motion parallel to the centerline of the pipe or duct.

4. Definitions, IBC *(in addition to the above)*

Anchor: A device, such as an expansion bolt, for connecting duct or pipe bracing members into the structure of a building.

Approved Agency: An established and recognized agency regularly engaged in conducting tests or furnishing inspection services, when such agency has been approved.

Attachment: See **Positive Attachment** below.

Bracing: Metal channels, cables or hanger angles that prevent ducts and pipes from breaking away from the structure. See also **Longitudinal Bracing** and **Transverse Bracing.** Together, they resist lateral loads from any direction.

Certificate of Compliance: A certificate stating that materials and products meet specified standards or that work was done in compliance with approved construction documents, provided by an approved agency.

Component: A part or element of an electrical or mechanical system.

Component, Equipment: A mechanical or electrical component or element that is part of a mechanical and/or electrical system within or without a building system.

Dynamic Properties of Piping: The tendency of pipe to change in weight and size because of the movement and temperature of fluids in them. This does not refer to movement due to seismic forces.

Equipment: Systems associated with ducts, pipes and conduit, also called components.

Gas pipes: For the purpose of this Specification Guide, gas pipe is any pipe that carries fuel gas, fuel oil, medical gas, or compressed air.

Hazardous Contents: A material that is highly toxic or potentially explosive and in sufficient quantity to pose a significant life-safety threat to the general public if an uncontrolled release was to occur.

Inspection Certificate: Identification applied on a product by an approved agency containing the name of the manufacturer, the function and performance characteristics, and the name and identification of an approved agency that indicates that the product or material has been inspected and evaluated by an approved agency *(see Section 1703.5 and "Label" and Manufacturer's Designation" and "Mark").*

Label: An identification applied on a product by the manufacturer that contains the name of the manufacturer, the function and performance characteristics of the product or material, and the name and identification of an approved agency and that indicates that the representative sample of the product or material has been tested and evaluated by an approved agency *(see Section 1703.5 and "Inspection Certificate" and "Manufacturer's Designation" and "Mark").*

Lateral Forces: A force acting on a duct or pipe in the horizontal plane. This force can be in any direction.

Load: Gravity Load *(W)*: The total dead load and applicable portions of other loads as *defined in Section 1613 through 1622.*

Longitudinal Bracing: Bracing that prevents a duct or pipe from moving in the direction of its run.

Longitudinal Force: A lateral force that happens to be in the same direction as the duct or pipe.

Manufacturer's Designation: Identification applied on a product by the manufacturer indicating that a product or material complies with a specified standard or set rules *(see also "Inspection Certificate" and "Label").*

Positive Attachment: A mechanical device, designed to resist forces that connects a non-structural element, such as a duct, a structural element, such as a beam. Bolts and screws are examples of positive attachments. Glue and friction due to gravity do not create positive attachments.

Special Inspection, Continuous: The full-time observation of work requiring special inspection by an approved special inspector who is present in the area where the work is being performed.

Special Inspection, Periodic: The part-time or intermittent observation of work requiring special inspection by an approved special inspector who is present in the area where the work has been or is being performed and at the completion of the work.

Special Inspection: Inspection as herein required of the materials, installation, fabrication, election or placement of components and connections requiring special documents and referenced standards *(see Section 1704).*

Story Drift Ratio: The story drift divided by the story height.

Transverse Bracing: Bracing that prevents a duct or pipe from moving from side to side.

1.3 QUALITY ASSURANCE

A. For both Non-IBC and IBC Projects substitution of internally or externally isolated equipment supplied by the equipment vendor, in lieu of the isolation specified in this section, is acceptable provided all conditions of this section are met.

Letters from field offices or representatives are unacceptable. All costs for converting to the specified vibration isolation shall be borne by the equipment vendor in the event of non-compliance with the proceeding. Internal isolation is not acceptable for:

1. Indoor or outdoor mounted equipment over or adjacent to:

    a. Patient or operating areas
    b. Theatre space
    c. Office locations
    d. Assembly areas

B. Letters from representatives are unacceptable.

1.4 SUBMITTAL DATA REQUIREMENTS

A. Refer to Part I General Requirements.

B. The manufacturer of vibration isolation shall provide submittals for products as follows:

1. Descriptive Data:

    a. Catalog cuts or data sheets on vibration isolators detailing compliance with the specification.
    b. Detailed schedules of flexible and rigidly mounted equipment, showing vibration isolators by referencing numbered descriptive drawings.

2. Shop Drawings:

   a. Submit fabrication details for equipment bases including dimensions, structural member sizes and support point locations.
   b. Provide all details or suspension and support for ceiling hung equipment.
   c. Where walls, floors, slabs or supplementary steel work are used for supports, details of acceptable attachment methods for duct and pipe must be included and approved before the condition is accepted for installation. Manufacturers' submittals must include spacing and static loads at all attachment and support points.
   d. Provide specific details of restraints and anchors; include number, size and locations for each piece of equipment.

1.5 RELATED WORK

A. Housekeeping pad design shall be by the project structural engineer or as shown on the contract drawings. Attachment shall be designed and certified according to this section by the isolation supplier. Material and labor required for attachment and construction shall be by the concrete section contractor, or by this contractor where specified. Housekeeping pads shall be sized to accommodate a minimum of 6" of clearance all around the equipment or 12 times the anchor bolt diameter, whichever is greater. Where exterior isolators are used this distance shall be as measured from the outboard holes in the isolator base plate and its mounting package.

B. Structural support and connections for all equipment, including roof-mounted equipment, specified in other sections shall comply with all IBC requirements indicating load path to the structure.

C. Roof steel supporting roof-mounted equipment shall be designed for all forces including, but not limited to, tension, compression and moment loads.

D. Chimneys, stacks and boiler breeching passing through floors are to be bolted at each floor level or secured above and below each floor with riser clamps.

1.6 CODE AND STANDARDS REQUIREMENTS

A. Typical Applicable Codes and Standards

1. All City, State and Local Codes (Code)
2. New York State Building Code
3. American Society for Testing and Materials (ASTM) (Standard)
4. ASHRAE (Standard)

B. In cases where requirements vary, the guideline for the most stringent shall be utilized.

1.7 MANUFACTURER'S RESPONSIBILITY

A. Manufacturer of vibration isolation equipment shall have the following responsibilities:

1. Determine vibration isolation sizes and locations.
2. Provide vibration isolation as scheduled or specified.
3. Provide calculations and materials if required for restraint of unisolated equipment.
4. Provide installation instructions, drawings and trained field supervision to insure proper installation and performance.
5. Certify correctness of installation upon completion.

B. All manufacturers, including Original Equipment Manufacturer (OEM), providing equipment of vibration control systems, must provide an Error and Omissions Insurance Certificate for their firm or their design consultant to certify their ability to provide engineering and design as required by this section.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. All vibration isolators described in this section shall be the product of a single manufacturer. The basis of this specification is Vibration Mountings & Controls. Products from other nationally recognized manufacturers are acceptable provided their systems strictly comply with these specifications and have the approval of the specifying engineer.

2.2 VIBRATION ISOLATION TYPES

A. Type A: Spring Isolator – Free Standing
VMC: ASC

1. Spring isolators shall be free standing and laterally stable without any housing and complete with a molded neoprene cup or 1/4" neoprene acoustical friction pad between the base plate and the support.
2. All mountings shall have leveling bolts that must be rigidly bolted to the equipment.
3. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load.
4. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection.
5. Submittals shall include spring diameters, deflection, compressed spring height and solid spring height.

B. Type B: Seismically Restrained Spring Isolator
VMC: AWRS, ASCM

1. Restrained spring mountings shall have a Type A spring isolator within a rigid housing that includes vertical limit stops to prevent spring extension when weight is removed. The housing shall serve as blocking during erection. A steel spacer shall be removed

after adjustment. Installed and operating heights are equal. A minimum clearance of 1/4" shall be maintained around restraining bolts and internal neoprene deceleration bushings so as not to interfere with the spring action. Limit stops shall be out of contact during normal operation. Since housings will be bolted or welded in position there must be an internal isolation pad. Housing shall be designed to resist all seismic forces.

C. Type C: Combination Spring/Elastomer Hanger Isolator (30° Type)
VMC: RSH30

1. Hangers shall consist of rigid steel frames containing minimum 1-1/4" thick neoprene elements at the top and a steel spring with general characteristics as in Type A. The neoprene element shall have neoprene bushings projecting through the steel box.
2. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hander rod to swing through a 30° arc from side to side before contacting the rod bushing and short circuiting the spring.
3. Submittals shall include a hanger-drawing showing the 30° capabilities.
4. Hanger locations requiring pre-compression for holding piping at fixed elevation shall be type pre-compressed for all manufacturers.

D. Type D: Elastomer Double Deflection Hanger Isolator
VMC: RHD

1. Molded (minimum 1-1/4" thick) neoprene element with projecting bushing lining the rod clearance hole. Static deflection at rated load shall be a minimum of 0.35".
2. Steel retainer box encasing neoprene mounting capable of supporting equipment to four times the rated capacity of the element.

E. Type E: Combination Spring/Elastomer Hanger Isolator
VMC: RSH

1. Spring and neoprene elements in a steel retainer box with the features as described by Type C and D isolators.
2. Hanger locations requiring pre-compression for holding piping at fixed elevation shall be type pre-compressed for all manufacturers.
3. 30° angularity feature is no required.

F. Type F: Seismically Restrained Elastomer Floor Isolator
VMC: RSM

1. Bridge-bearing neoprene mountings shall have a minimum static deflection of o.2" and all directional seismic capability. The mount shall consist of a ductile iron or aluminum casting containing two separated and opposing molded neoprene elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. The shock absorbing neoprene materials shall be compounded to bridge-bearing specifications.

G. Type G: Pad Type Elastomer Isolator (Standard)
VMC: Maxiflex

1. One layer of 3/4" thick neoprene pad consisting of 2" square modules for size required.
2. Load distribution plates shall be used as required.
3. Bolting required for seismic compliance. Neoprene and duck washers and bushings shall be provided to prevent short-circuiting.

H. Type H: Pad Type Elastomer Isolator (High Density)
VMC: Fabriflex

1. Laminated canvas duck and neoprene, maximum loading 1000 psi, minimum 1/2" thick.
2. Load distribution plate shall be used as required.
3. Bolting required for seismic compliance. Neoprene and duck washers and bushings shall be provided to prevent short-circuiting.

I. Type I: Thrust Restraints
VMC: RSHTR

1. A spring element similar to Type A isolator shall be combined with steel angles, backup plates, threaded rod, washers and nuts to produce a pair of devices capable of limiting movement of air handling equipment to 1/4".
2. Restraint shall be easily converted in the field from compression type to tension type.
3. Unit shall be factory pre-compressed.
4. Thrust restraints shall be installed on all cabinet fan heads, axial or centrifugal fans whose thrust exceeds 10% of unit weight.

J. Type J: Pipe Anchors
VMC: MDPA

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

K. Type K: Pipe Guides
VMC: PG

1. Pipe guides shall consist of a telescopic arrangement of two sizes of steel tubing separated by a minimum 1/2" thickness of 60-durometer neoprene.
2. The height of the guides shall be present with a shear pin to allow vertical motion due to pipe expansion or contraction. Shear pin shall be removable and reinsertable to allow for selection of pipe movement.
3. Guides shall be capable of +/- 5/8" motion, or to meet location requirements.

L. Type L: Isolated Pipe Hanger System
VMC: CIH, CIR, TIH, PIH

1. Pre-compressed spring and elastomer isolation hanger combined with pipe support into one assembly. Replaces standard clevis, single or double rod roller, or double rod fixed support.
2. Spring element (same as Type A) with steel lower spring retainer and an upper elastomer retainer cup with an integral bushing to insulate support rod from the isolation hanger.
3. The neoprene element under the loser steel spring retainer shall have an integral bushing to insulate the support rod from the steel spring retainer.
4. Hangers shall be designed and constructed to support loads over three times the rated load without failure.
5. System shall be pre-compressed to allow for rod insertion and standard leveling.

2.3 EQUIPMENT BASES

A. General

1. All curbs, isolation rails, and roof rails are to be bolted or welded to the building steel or anchored to the concrete deck (minimum thickness shall be 4") for resisting wind load forces in accordance with the project location. (Fastening to metal deck is unacceptable.)

B. Base Types

1. Type B-1: Integral Structural Steel Base
VMC: WFB

a. Rectangular bases are preferred for all equipment.
b. Centrifugal refrigeration machines and pump bases may be T or L shaped where space is a problem. Pump for split case pump shall include supports for suction and discharge elbows.
c. All perimeter members shall be steel beam with a minimum depth equal to 1/12 of the longest dimensions of the base.
d. Base depth need not exceed 12" provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer.
e. Height saving brackets shall be employed in all mounting locations to provide a minimum base clearance of 2".

2. Type B-2: Concrete Inertia Base
VMC: MPF

a. Vibration isolation manufacturer shall furnish rectangular steel concrete pouring forms for floating and inertia foundations.
b. Bases for split case pumps shall be large enough to provide for suction and discharge elbows.
c. Bases shall be a minimum of 1/12 of the longest dimension of the base but not less than 6".

d. The base depth need not exceed 12" unless specifically recommended by the base manufacturer for mass or rigidity.
e. Forms shall include minimum concrete reinforcing consisting of 1/2" bars welded in place on 6" centers running both ways in a layer 1-1/2" above the bottom.
f. Forms shall be furnished with steel templates to hold the anchor bolts sleeves and anchors while concrete is being poured.
g. Height saving brackets shall be employed in all mounting locations to maintain a 2" minimum clearance below the base.
h. Flush profile wooden formed basis having correct depth and reinforcing requirements are acceptable.

3. Type B-3: Isolation Curb or Isolation Rails
VMC: P62/P6300 Sound Package Type VMC type RPFMA/SRPEMA

a. Curb or steel dunnage mounted rooftop equipment shown on isolation schedule shall be mounted on structural spring isolation curbs or isolation rails. The upper frame must provide continuous support around the entire perimeter of the equipment and must be captive so as to resiliently resist wind forces. The lower frame must accept point support for both attachment and leveling. The upper frame must be designed with positive fastening provisions (welding or bolting), to anchor the roof top unit to the curb or isolation rail, which will not violate the National Roofing Contractors Association (NRCA) ratings of the membrane waterproofing. Sheetmetal screws are unacceptable. Contact points between the roof top unit, the curb and the building's structure shall show load path through those locations only. For rooftop units mounted on steel dunnage, the vibration isolation rail shall be secured to the steel support dunnage with positive fastening provisions (welding or bolting).
b. All directional neoprene snubber bushings shall be a minimum of 1/4" thick. Steel springs shall be laterally stable and rest on 1/4" thick neoprene acoustical pads.
c. Hardware must be plated and the springs provided with a rust resistant finish.
d. The curbs waterproofing shall be designed to meet all NRCA requirements.
e. All spring locations shall have access ports with removable waterproof covers and all isolators shall be adjustable, removable and interchangeable.
f. Curbs shall be the sound attenuating type utilizing standard 2" roof insulation supplied and installed by the roofing contractor to act thermally outside and acoustically inside. Curbs supplied within this feature shall be factory acoustically lined with 2" duct liner.

Option #1: Where sound barrier package is required, curb shall have full size lay-in attenuation panels having a minimum STC rating of 60 when combined with the roof deck's rating. Attenuation system shall add a full sound attenuation structural floor to the curb capable of spanning the curb's width and designed for live loads of 20 psf. Panels shall not weigh more than 6 psf. The 4" nominal galvanized panel shall be joined and allow for airtight construction and additionally shall have a support system where the panels are used below an outside condenser section. Panels shall be waterproof for both outdoor and indoor application. The space below the curb panels and the roof deck shall have 4" of insulation contractor furnished and installed.

Curb wall construction shall utilize the roofer's standard insulation where curbs use the TAS open thermal acoustical screening system. Solid wall curbs shall use 2" of factory ductliner installed by the curb manufacturer. The entire curb shall have a continuous neoprene air seal. Type RPFMA shall use an open return system with the roof return opening set as far as possible from the unit's return opening.

Option #2: When curb type SRPFMA (Supply Return Plenum Construction) is required, in addition to Option #1 the walls of the supply section will use 2" sound attenuating panels as well as a continuous inner neoprene air seal and isolated plenum divider. Both supply and return ducts shall seal directly to curb base floor attenuation panels.

4. Type B-4: Non-Isolated Curbs
   VMC: P6000
   Sound Package Type – VMC – RPFMA/SRPFMA System

   a. These curbs shall have all provisions as Type B-3 curbs with the exception of spring isolation.

5. Type B-5: Isolated Equipment Supports
   VMC: R7200/R7300

   a. Continuous structural equipment support rails that combine equipment support and isolation mounting into one utilized roof flashed assembly with all features as described for Type B-3.
   b. System shall be designed for positive anchorage or welding of equipment to supports and welding of supports to the building steel.

6. Type B-6: Non-Isolated Equipment Supports
   VMC: CRC

   a. This shall have the same provisions as Type B-5 without the spring isolation.

7. Type B-7: Computer Room Unit Base
   VMC: CRC

   a. Computer Room air conditioning units shall be welded or bolted to welded structural steel stands.
   b. Non-isolated stand shall have 1" of adjustment to accommodate floor irregularities.

2.4 FLEXIBLE CONNECTORS

A. Type FC-2: Flexible Stainless-Steel Hose
   VMC: BS

   1. Flexible stainless-steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3" and larger shall be flanged. Smaller sizes shall have male nipples.

B. Type FC-2 connector shall be braided bronze for Freon connections.

1. Minimum lengths shall be as tabulated:

FLANGED		MALE NIPPLES	
3 x 14	10 x 26	1/2 x 9	2 x 14
4 x 15	12 x 28	3/4 x 10	2 1/2 x 18
5 x 19	14 x 30	1 x 11	
6 x 20	16 x 32	1 1/4 x 12	
8 x 22		1 1/2 x 13	

2. Hoses shall be installed on the equipment side for the shut-off valves horizontally and parallel to the equipment shafts wherever possible.

PART 3 - EXECUTION

3.1 GENERAL

A. All vibration isolators systems must be installed in strict accordance with the manufacturer's written instructions and all certified submittal data.

B. Installation of vibration isolators must not cause any change of position of equipment, piping or ductwork resulting in stresses or misalignment.

C. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.

D. The contractor shall not install any isolated equipment, piping or duct, which makes rigid connections with the building unless isolation is not specified. "Building" includes, but is not limited to, slabs, beams, columns, studs and walls.

E. Coordinate work with other trades to avoid rigid contact with the building.

F. Overstressing of the building structure must not occur because of overhead support of equipment. Contractor must submit loads to the structural engineer of record for approval. General bracing may occur from flanges of structural beams, upper truss cords in bar joist construction and cast in place inserts or wedge type drill-in concrete anchors.

G. Vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not permitted.

H. Where piping passes through walls, floors or ceilings, the contractor shall provide wall seals or resilient packed pipe sleeves.

I. Air handling equipment and centrifugal fans shall be protected against excessive displacement which results from high air thrust in relation to the equipment weight. Horizontal thrust restraints shall be those described in the specification when horizontal motion exceeds 3/8".

3.2 EQUIPMENT INSTALLATION

A. Equipment shall be isolated and restrained as per Table A at the end of this section.

B. Place floor mounted equipment on 4" high concrete housekeeping pads properly doweled or expansion shielded to the deck to meet acceleration criteria. Anchor isolators and/or bases to housekeeping pads. Concrete work is specified under concrete in the specifications of the contract.

C. Additional Requirements

1. The minimum operating clearance under all isolated components bases shall be 2".
2. All bases shall be placed in position and supported temporarily by blocks or shims, as appropriate, prior to the installation of the equipment, isolators and restraints.
3. The equipment shall be installed on blocks to the operative heights of the isolators. After the entire installation is complete, and under full operational load, the isolators shall be adjusted so that the load is transferred from the blocks to the isolators. Remove all debris from beneath the equipment and verify that there are no short circuits of the isolation. The equipment shall be free in all directions.

3.3 PIPING AND DUCTWORK ISOLATION

A. Vibration Isolation of Piping

1. Water Piping: All spring type isolation hangers shall be precompressed if isolators are installed prior to fluid charge. If installed afterwards, standard, non-precompressed isolators can be used. All piping in the machine room shall be isolated as well as pressurized runs in other locations of the building 6" and larger. Horizontal pressurized runs in all other locations of the building shall be isolated by Type E hangers. Floor supported piping shall rest on Type B isolators. Heat exchangers and expansion tanks are considered part of the piping run. The first 3 isolators from the isolated equipment will have the same static deflection as specified for the mountings under the connected equipment. If piping is connected to equipment located in basements and hangs from ceilings under occupied spaces, the first 3 hangers shall have 0.75" deflection for pipe sizes up to and including 3", 1-3/8" deflection for pipe sizes thereafter. Where column spacing exceeds 35', isolation hanger deflection shall be 2-1/2" for pipes exceeding 3" diameter. Type L hangers may be substituted for the above where isolation hangers are required.
2. Steam and Condensate Piping: All ceiling suspended piping in the mechanical equipment room shall be isolated with Type D hangers. All floor supported piping shall be supported with Type F isolators.
3. Riser Location: All risers shall be supported on Type J or K anchors or guide restrains positive attached to both the riser and structure. Spiders welded to the pipe can substitute for Type K guides using J Type anchors.
4. Control Air Piping: Where control air piping is connected to mechanical piping equipment shall be flexibly connected in horizontal and vertical plane with Type FC-2 flexible connectors.

B. Vibration Isolation of Ductwork

1. All discharge runs for a distance of 50' from the connected equipment shall be isolated from the building structure by means of Type E combination spring/elastomer hanger or Type A floor spring isolators. Spring deflection shall be a minimum of 0.75".
2. All duct runs having air velocity of 1500 feet per minute (fpm) or more shall be isolated from the building structure by Type E combination spring/elastomer hangers or Type A floor spring supports. Spring deflection shall be a minimum of 0.75".

HVAC EQUIPMENT TABLE "A"

		On Grade, Basement or Slab on Grade					Above Grade			
Equipment (See Note!)		MTNG	ISOL	DEFL (in.)	BASE	RESTR	ISOL	DEFL (in.)	BASE	RESTR
Condensing Outdoor Units		Roof	--	--	--	IV	B	2.50 (minimum)	B-5	IV
Base Mounted Pumps	To 15HP	Flr	B	0.75	B-2	IV	B	0.75	B-2	IV
	>15 HP	Flr	B	0.75	B-2	IV	B	1.50	B-2	IV
Boilers		Flr	G	0.10	--	IV	B	0.75	--	IV
Cabinet Fans & Packaged AHU Indoor	To 1 HP	Flr	F	0.20	--	IV	B	0.75	--	IV
		Clg	D	0.35	--	V	E	0.75	--	V
	>1 HP	Flr	B	0.75	--	IV	B	See Guide	--	IV
		Clg	E	0.75	--	V	E	See Guide	--	V
Centrifugal Chillers		Flr	B	0.75	--	IV	B	1.50	--	IV
Centrifugal Fans Arr. 1 & 3	Class 1	Flr	B	0.75	B-1	IV	B	See Guide	B-1	IV
	Class 2&3	Flr	B	0.75	B-2	IV	B	See Guide	B-2	IV
Condensate Pumps		Flr	F	0.20	If req.	IV	F	0.20	If req.	IV
Cooling Towers		Flr	B	0.75	--	IV	B	2.50	B-5 opt.	IV
Curb Mtd. Equip. (Non-Isol.)		Roof	--	--	--	IV	--	--	B-6	IV
Fan Coil Units		Flr	F	0.20	--	IV	B	0.75	--	IV
		Clg	D	0.35	--	V	E	0.75	--	V
Rooftop	<10 Ton	Roof	--	--	--	IV	B	1.50	B-3*(3,4)	IV
	>10 Ton	Roof	--	--	--	IV	B	2.50	B-3*(3,4)	IV
Unit/Cabinet Heaters		Clg	D	0.30	--	V	D	0.30	--	V

Minimum Deflection Guide for Table "A"

R.P.M.	DEFLECTION
Less than 400	3.50"
401 to 600	250"

601 to 900	1.50"
OVER 900	0.75"

Note for TABLES A, B:

GENERAL: ISO = ISOLATOR; DEFL = DEFLECTION, MTNG = MOUNTING. ALL DEFLECTION INDICATED ARE IN INCHES.

Note 1: For equipment with variable speed driven components having driven operating speed below 600 rpm, select isolation deflection from minimum deflection guide.

Note 2: For roof applications, use base Type B-5.

Note 3: Curb Type B-3 shall use sound barrier RPFMA when there is no concrete under roof top units. Curbs can be used for return plenums. (See Option #1). Where on steel dunnage and isolation rails, sound barrier and sound attenuation does not apply.

Note 4: Where curbs require supply and return sound attenuation package type SRRFMA shall be used. (See Option #2)

Note 5: Units may not be capable of point support. Refer to separate air handling unit specification section. If base is not provided by that section and external isolation is required, provide Type B-1 base by this section for entire unit.

Note 6: Static deflection shall be determined based on the deflection guide for Table "A".

Note 7: Deflection indicated are minimums at actual load and shall be selected for manufacturer's nominal 5", 4", 3", 2" and 1" deflection spring series, RPM is defined as the lowest operating speed of the equipment.

Note 8: Single stroke compressors may require inertia bases with thickness greater than 14" maximum as described for base B-2. Inertia base mass shall be sufficient to maintain double amplitude for 1/8".

Note 9: Curb mounted fans with curb area less than 9 square feet are excluded.

Note 10: For equipment with multiple motors, horsepower classification applies to largest single motor.

END OF SECTION 23 05 46

SECTION 23 05 53 - IDENTIFICATION FOR HVAC

PART 1 - GENERAL

1.1 STIPULATIONS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Sections, apply to this Section.

1.2 WORK INCLUDED

A. This Section includes the following mechanical identification materials and their installation:

1. Equipment nameplates.
2. Access panel and door markers.
3. Pipe markers.
4. Duct markers.
5. Valve tags.
6. Valve schedules.

1.3 RELATED WORK

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

1.4 REFERENCES

A. ASTM C 1036-91 (Reapproved 1997): Specification for flat glass.

B. ASTM D 709-92 (Reapproved 1997): Specification for laminated thermo-setting materials.

C. ASME A13.1-96: Scheme for the identification of piping systems.

1.5 SUBMITTALS

A. Submit product data.

B. Submit list of wording, symbols, letter size and color coding for mechanical identification.

C. Submit valve chart and schedule, including valve tag number, location, function and valve manufacturer’s name and model number. (also include maintenance manuals)

D. Submit manufacturer's installation instructions.

1.6 QUALITY ASSURANCE

A. ASME Compliance: comply with ASME A13.1, "Scheme for the Identification of Piping Systems", for letter size, length of color field, colors and viewing angles of identification devices for piping.

1.7 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with location of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Color: Unless specified otherwise, conform the ANSI/ASME A13.1.

B. Plastic Nameplates: Laminated three-layer plastic with engraved black letters on light contrasting background.

C. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.

D. Plastic Pipe Markers: As indicated herein.

2.2 EQUIPMENT IDENTIFICATION DEVICES

A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.

1. Data:

a. Manufacturer, product name, model number and serial number.
b. Capacity, operating and power characteristics and essential data.
c. Labels of tested compliances.

2. Location: Accessible and visible.
3. Fasteners: As required to mount on equipment.

B. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive.

1. Terminology: Match schedules as closely as possible.
2. Data:

a. Name and plan number.
b. Equipment service.
c. Design capacity.
d. Other design parameters such as pressure drop, entering and leaving conditions and speed.

3. Size: 2-1/2 by 4 inches for control devices, dampers and valves; 4-1/2 by 6 inches for equipment.

C. Access Panel and Door Markers: 1/16-inch-thick, engraved laminated plastic with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch center hole for attachment. Markers for chemical fume or bio-hazard service shall be labeled accordingly.

1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.3 PIPING IDENTIFICATION DEVICES

A. Manufactured Pipe markers, General: Preprinted, color-coded, with lettering indicating service and showing direction of flow.

1. Colors: Comply with ASME A13.1, unless otherwise indicated.
2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.
3. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers extending 360 degrees around pipe at each location.
4. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or strip-type markers at least three times letter height and of length required for label.
5. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.

B. Pre-tensioned Pipe Markers: Pre-coiled semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive.

C. Shaped Pipe Markers: Preformed semi-rigid plastic formed to partially cover circumference of pipe and to attach to pipe with mechanical fasteners that do not penetrate insulation vapor barrier.

2.4 DUCT IDENTIFICATION DEVICES

A. Duct Markers: Engraved, color-coded laminated plastic. Include direction and quantity of airflow and duct service (such as supply, return and exhaust). Include contact-type, permanent adhesive. Markers for chemical fume or bio-hazard service shall be labeled accordingly.

2.5 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers, with numbering scheme approved by Architect. Provide 5/32-inch hole for fastener.

1. Material: 0.032-inch-thick brass.
2. Valve-Tag Fasteners: Brass S-hook.

2.6 VALVE SCHEDULES

A. Valve Schedules: For each piping system, on standard-size bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.
2. Frame: Extruded aluminum.
3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

A. Products specified are for applications referenced in other Division 23 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

3.2 EQUIPMENT IDENTIFICATION

A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:

1. Fuel-burning units, including boilers and heaters.
2. Pumps, chillers, condensers, and similar motor-driven units.

3. Coils, heat recovery units, and similar equipment.
4. Fans, blowers, primary balancing dampers, and VAV units.
5. Packaged rooftop units.

B. Install equipment markers with permanent adhesive on or near each major item of mechanical equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated.

1. Letter Size: Minimum 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.
2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
3. Locate markers where accessible and visible. Include markers for the following general categories of equipment:

a. Main control and operating valves, including safety devices and hazardous units.
b. Meters, gages, thermometers, and similar units.
c. Fuel-burning units, including boilers and heaters.
d. Pumps, chillers and similar motor-driven units.
e. Coils, heat recovery units, and similar equipment.
f. Fans, blowers, primary balancing dampers, and VAV units.
g. Packaged HVAC central-station and zone-type units.
h. Tanks and pressure vessels.
i. Strainers, filters, humidifiers, water-treatment systems, and similar equipment.

C. Install access panel markers with screws on equipment access panels.

3.3 PIPING IDENTIFICATION

A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.

1. Pipes with OD, Including Insulation: Pre-tensioned pipe markers. Use size to ensure a tight fit.

B. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior non-concealed 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 non-accessible enclosures.
4. At access doors, 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 markers.

3.4 DUCT IDENTIFICATION

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

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

B. Locate markers 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.

3.5 VALVE-TAG INSTALLATION

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

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following:

1. Valve-Tag Size and Shape:

   a. Chilled Water: 1-1/2 inches round.
   b. Heating Water: 1-1/2 inches round.

2. Valve-Tag Color:

   a. Chilled Water: Natural
   b. Heating Water: Natural

3. Letter Color:

   a. Chilled Water: Black.
   b. Heating Water: Black.

3.6 VALVE-SCHEDULE INSTALLATION

A. Mount valve schedule on wall in accessible location in each major equipment room.

3.7 ADJUSTING

A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

3.8 CLEANING

A. Clean faces of mechanical identification devices and glass frames of valve schedules.

END OF SECTION 23 05 53

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

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 WORK INCLUDED

A. The work included under this section of the specifications consists of the furnishing of all labor, materials, equipment and service necessary to complete the inspections, testing, guarantee and acceptance of all HVAC work as shown on the drawings and specified herein.

B. All work shall be tested to satisfaction of the Architect/Engineer, for leaks, faulty joints, improper operation and inefficiency.

C. Provide test pump, gauges, meters, other instruments, materials, and labor in connection with tests.

D. Do not cover or paint any part of piping or connect equipment, before testing and obtaining approval.

E. All equipment and piping shall be thoroughly cleaned of iron cutting and other refuse during assembly, installation and before testing.

F. The work included under this section of specifications also consists of the furnishing of all labor, materials, equipment and service necessary to perform air and water balancing for the HVAC work on water circulating systems, on hot water heating, chilled water, air distribution and exhaust systems as shown on the drawings and as called for in these specifications.

G. The balancing work shall include, but not be limited to the following items.

1. The setting and adjusting of all dampers and accessories to achieve proper air distribution and patterns in all parts of the air supply and exhaust systems.
2. The setting and adjusting of all belted fan speeds as may be required to attain proper total CFM deliveries.
3. The inspection of the function and operation of all ATC air and hydronic controls to insure proper operation and control cycles.
4. The setting and adjusting of all balancing cocks to attain the proper GPM deliveries in the various water piping systems.
5. Verify the setting and flow through all factory set automatic balancing air and water devices.
6. The setting and adjusting of all valves and pressure relief valves.

1.3 RELATED SECTIONS

A. Division 23 – Scope of Work

B. Division 23 – Common Work Results for HVAC

C. Division 23 – Vibration Isolation

D. Division 23 – Hydronic Specialties

E. Division 23 – HVAC Commissioning

F. Division 23 – HVAC Pumps

G. Division 23 – Dehumidification Unit

H. Division 23 – Condensing Boilers

I. Division 23 – Air-Cooled Chiller

J. Division 23– Water Source Heat Pump

K. Division 23 – Terminal Heat Transfer Units.

L. Division 23 – Power Ventilators

M. Division 23 – Ductwork

N. Division 23 – Ductwork Accessories

O. Division 23 – Air Terminal Units

P. Division 23 – Air Outlets and Inlets

Q. Division 23 – Sequence of Operation

1.4 REFERENCES

A. AABC – Associated Air Balance Council – National Standards for Field Measurement and Instrumentation, Total System Balance.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 – "Air Balancing".

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 – "System Balancing".

D. NEBB – National Environmental Balancing Bureau – Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.

E. TABB – Testing, Adjusting and Balancing Bureau.

1.5 SUBMITTALS

A. Quality-Assurance Submittals: Within 30 days from the Contractor's Notice to Proceed, submit two (2) copies of evidence that the testing, adjusting, and balancing Agent and this Project's testing, adjusting, and balancing team members meet the qualifications specified in the "Quality Assurance" Article below.

B. Certified Testing, Adjusting and Balancing Reports: Submit three (3) copies of reports prepared, as specified in this Section, on approved forms certified by the testing, adjusting and balancing Agent.

1.6 QUALITY ASSURANCE

A. The Contractor shall procure the services of an independent air balancing and test agency who shall not have any affiliation with construction contractors, equipment sales or design engineering firms.

B. The balancing agency shall specialize in the balancing and testing of heating, ventilating and air conditioning systems and shall provide proof of having successfully completed at least five projects of similar size and scope.

C. The testing and balancing agency shall be approved and acceptable to the Architect/Engineer and shall not be replaced without the written approval and consent of the Architect/Engineer. All field work shall be under the direct supervision of a registered professional engineer who is a full time employee of the balancing agency.

D. Submit biographic data on the balancing firm certification and certification of employees performing the work. Submit instrumentation types and proof of recent calibration. The instrumentation shall include electronic flow foods, meters that accept pressure measurement and/with temperature compensation and other such modern industry accepted instrumentation.

E. The testing and balancing agency shall be a certified member of the AABC, NEBB or TABB, unless otherwise approved.

1.7 PREPARATION FOR TESTING AND BALANCING

A. The balancing agency shall report to and review the work required with the Design Engineer before beginning field balance work. The balancing agency shall make at least two inspection of the air system during construction and shall report its findings in writing to the Design Engineer. Prior to start of balancing systems; submit to the Engineer written procedures on balancing procedures.

B. The balancing agency shall cooperate with the Design Engineer and the Contractor to effect smooth coordination of the balancing work with the job schedule. Final balancing shall be done at a time agreeable to the Architect.

C. The balancing agency shall be responsible for getting the various systems into proper operation. They shall enlist the aid of the ATC subcontractor, equipment suppliers, and Contractor as may be required to effect proper operation consistent with the Contract Plans and Specifications.

D. The Engineer shall have the option to spot check system balance and the balancing agency shall provide all equipment and labor as required.

1.8 JOB CONDITIONS

A. Air balance and testing shall not begin until system has been completed and is in full working order with the specified filters in place. Place all systems and equipment into full operations and continue the operation during each working day of testing and balancing.

B. Procedure and test shall be as specified. Procedure and test not specified shall be in accordance with Associated Air Balance Council publication, "National Standards for Field Measurements and Instrumentation, Total System Balance" and 2011 ASHRAE HVAC Applications Guide Chapter 57 "Testing Adjusting and Balancing."

C. Partial Owner Occupancy: The Owner may occupy completed areas of the building before Substantial Completion. Cooperate with the Owner during testing, adjusting, and balancing operations to minimize conflicts with the Owner's operations.

D. The Contractor shall make any replacements in fan drive, sheaves and belts, and furnish additional dampers, balancing valves, cocks and fittings required for correct balance as required to meet design data.

E. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by the instrument manufacturer.

1.9 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist testing, adjusting and balancing activities.

B. Notice: Provide 7 days advance notice for each test. Include scheduled test dates and times.

C. Perform testing, adjusting and balancing after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS

A. Not Applicable

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Contract Documents to become familiar with project requirements and to discover conditions in systems' designs that may preclude proper testing, adjusting, and balancing of systems and equipment.

1. Contract Documents are defined in the General and Supplementary Conditions of the Contract.
2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine project record documents described in Division 01 Section "Project Record Documents."

D. Examine Architect's and Engineer's design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Specification Sections have been performed.

F. Examine system and equipment test reports.

G. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

H. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

I. Examine air-handling equipment to ensure clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes and mixing boxes, to verify that they are accessible and their controls are connected and functioning.

K. Examine plenum ceilings, utilized for supply air, to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

L. Examine 3-way valves for proper installation for their intended function of diverting or mixing fluid flows.

M. Examine open-piping system pumps to ensure absence of entrained air in the suction piping.

N. Examine automatic temperature system components to verify the following:

1. Dampers, valves, and other controlled devices operate by the intended controller.
2. Dampers and valves are in the position indicated by the controller.
3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multi-zone units, mixing boxes, and variable-air-volume terminals.
4. Automatic modulating and shutoff valves, including 2-way valves and 3-way mixing and diverting valves, are properly connected.
5. Thermostats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.
7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at design values. Observe and record system reactions to changes in conditions. Record default set points if different from design values.
9. Interlocked systems are operating.
10. Changeover from heating to cooling mode occurs according to design values.

O. Report deficiencies discovered before and during performance of testing, adjusting, and balancing procedures.

3.2 GENERAL PROCEDURES

A. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to the insulation Specifications for this Project.

B. Mark equipment settings with paint or other suitable, permanent identification material, including damper-control positions, valve indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

3.3 AIR DISTRIBUTION TEST AND BALANCE

A. All filters shall be clean and in place before starting fans. All air filters shall be artificially loaded by partial blanking or other means to produce air pressure drop midway between clean and dirty as specified. Controls and dampers shall be set for normal full air flow testing and balancing.

B. During testing and balancing period, all supply, return and exhaust air fans shall have speeds adjusted and drives changed where necessary so that fans deliver design CFM at the actual static pressure developed by the installed system. Increasing static pressure by dampering at fan or closing all volume dampers to induce system static will not be permitted. External static pressure noted in schedules on drawings included drops through duct systems, terminal units

and diffusers. Total static pressures must be calculated by adding pressure drops through unit mounted coils and dirty filter conditions, and unit conversion losses if applicable to that of the previously mentioned components. Provide minimum one (1) fan sheave and drive change per fan system.

C. Adjust all air ducts to proper design CFM. Air quantities shall be adjusted by volume or splitter dampers. Dampers and other balancing devices shall have their adjusted positions marked in an inconspicuous permanent manner.

D. Test and adjust each heat pump, diffuser, grille, register and primary within plus or minus 10 percent of design CFM requirements, but total air for each system shall be not less than indicated. Volume adjusters may be used to balance air quantities at outlets and inlets providing final adjustments do not produce objectionable drafts or sound levels in excess of specified limits. Design positive and negative pressure in each area must be maintained.

E. Diffusers, register, grilles, heat pumps shall be adjusted to minimize drafts in all areas.

F. Diffusers, registers, grilles, heat pumps shall be identified on test report as to location and areas.

G. Reading and test of diffusers, registers, heat pumps shall include required FPM velocity and test resultant velocity, required CFM and test resultant CFM after adjustments.

H. Record design and test CFM, static pressure, motor voltage and amps (nameplate and test) for each fan.

I. Record design and test static pressure, in order of physical arrangement, for each system component, i.e., louver, filter, cooling coil, fan heating coil, etc., and the most remote terminal unit.

J. With controls functioning properly water flow rates, test and record air dry bulb for supply air, and air entering and leaving each coil for each heat pump. Where feasible, measure air dry bulb and wet bulb temperatures with the mechanically aspirated psychrometer.

K. Air distribution test and balance report shall include:

1. Schematic diagram of each system showing size and CFM (design and actual) for main ducts; all dampers and regulating devices; terminal units; and each inlet and outlet with design and actual CFM.
2. Test data form for each fan, heat pump.
3. Tabulation of design, preliminary and final CFM for each diffuser, register, mixing box or other terminal. Summary of CFM tabulations by systems and comparison with respective fan data.

L. Automatically operated dampers shall operate as specified or indicted. Testing agency shall check all controls that regulate air flow and pressure for proper calibrations and list controls requiring adjustment.

M. As determined by the Engineer, for 10 percent of total rooms, tests and record hourly for four hours, the following:

1. Room design condition D.B. Heating and Cooling and W.B. cooling.
2. Room actual condition D.B. Heating and Cooling and W.B. cooling.

N. For variable-air volume systems, develop a plan to simulate diversity.

O. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

P. Check the airflow patterns from the outside-air louvers and dampers and the return and exhaust air dampers, through the supply-fan discharge and mixing dampers.

Q. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

R. Verify that motor starters are equipped with properly sized thermal protection.

S. Check dampers for proper position to achieve desired airflow path.

T. Check for airflow blockages.

U. Check for proper sealing of air-handling unit components.

V. Compensating for Diversity: When the total airflow of all terminal units is more than the fan design airflow volume, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the design airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

3.4 WATER TEST AND BALANCE

A. Preparation: Prepare water systems for balancing in the following manner:

1. Open all valves to full open position.
2. Assure that all strainers have been cleaned.
3. Examine water in system. If dirty or untreated, drain system, and refill with clean treated water.
4. Check pump rotation and correct if necessary.
5. Check expansion tanks to determine that they are not air-bound or water-bound and that system is completely full of water.
6. Check all air vents at high points on water systems and determine all are installed and operating freely.
7. Set all temperature controls so coils are calling for full cooling. This should close all automatic bypass valves at coil and converters. Same procedure when balancing hot water coils, set on full call for heating.
8. Check operation of automatic bypass valve.
9. Complete air balance must have been accomplished before actual water balance begins.
10. Automatically operated valves shall operate as specified or indicated. Testing agency shall check all controls that regulate hydronic flow and pressure for proper calibration and list controls requiring adjustment.

B. Adjustment: Proceed as follows:

1. Set pumps to proper gallons per minute delivery.
2. Adjust water flow.
3. Check leaving water temperatures and return water temperatures. Reset to correct design temperature.
4. Check water temperature at inlet side of coils. Record rise or drop of temperatures from sources.
5. Proceed to balance each coil.

C. Readjustment: Proceed as follows:

1. After adjustment to coils are made, recheck settings at pump and readjust if required.
2. Install pressure gages on coil, read pressure drop through coil at set flow rate on call for full cooling and full heating. Set pressure drop across bypass valve to match coil full flow pressure drop. This prevents unbalanced flow conditions when coils are on full bypass.
3. Check record and include in the test report the following items.

    1) After adjustments to coils are made, recheck settings at pump and readjust if required.
    2) Install pressure gages on coil, read pressure drop through coil at set flow rate on call for full cooling and full heating. Set pressure drop across bypass valve to match coil full flow pressure drop. This prevents unbalanced flow conditions when coils are on full bypass.
    3) Check record and include in the test report the following items.

        a) Inlet water and air temperatures (dry bulb and wet bulb) at each coil.
        b) Leaving water and air temperatures (dry bulb and wet bulb) at each coil.
        c) GPM and pressure drop at each coil, heat exchanger, boiler, chiller and other similar devices.
        d) Pressure drop across each coil bypass where obtainable.
        e) Operating suction and discharge pressures and final T.D.H. for each pump.

    4) List all mechanical specifications of pumps; pump head, gpm and horsepower.
    5) List rated and actual running amperage of pump motor.
    6) Check water metering device readings.

3.5 TEST AND BALANCE REPORTS

A. All tests and balance reports and other requirements of this section will be completed and furnished to Engineer prior to Final Inspection. Submit four copies. Use format similar to forms of Sheet Metal & Air Conditioning Contractors Association, Inc., Washington, D.C., or Associated Air Balance Council, Los Angeles, California.

B. Types, serial numbers, and date of calibration of all instruments shall be included.

C. Reports shall identify conspicuously items not conforming to contractor requirements, or obvious maloperation and design deficiencies.

3.6 MARKING OF SETTINGS

A. Following final acceptance of Certified Reports by the Architect, the setting of all valves, dampers and other adjustment devices shall be permanently marked by the Contractor, so that adjustment can be restored if disturbed at any time. Devices shall not be marked until after final acceptance.

B. Marking of the set point shall be with an arrow indicator. Method shall be by stamping or cutting the balance post or lever. A waterproof marker may be used for indication on non wear surfaces.

C. Temporary marks shall be used during rough balance and before approval of the balance report for reference. Temporary marks shall be removed upon final marking.

3.7 PIPING SYSTEMS TESTS

A. Pressure tests shall be performed on all piping before equipment is hooked up to the piping.

B. Refer to Division 23 Piping Specifications for requirements.

3.8 SPECIAL TESTING

A. Test and set relief valves to specified relief pressure. Test and adjust pressure reducing valves to specified reduced pressure. Test and adjust meters and other instruments, after installation, to assure accurate operation. Replace all gauges and thermometers that are out of calibration.

3.9 ADJUSTMENTS, REPAIRS AND RETESTS

A. Adjust, repair and retest the systems as specified herein.

B. Correct defects disclosed by tests or inspection; replace defective parts when directed. In replacing defective parts, use only new material; in the case of pipe replace with same length as defective piece. Caulking of screwed joints and peeling of welds will not be permitted. Repeat tests after defects have been corrected and part replaced, as directed until pronounced satisfactory.

C. The cost of repairs and restoration of work of other trades damaged by tests or cutting that had to done in connection with test, shall be made at no extra cost to the Owner.

3.10 OIL AND SERVICING

A. All bearings and packing glands shall be properly protected during installation. Before the equipment is placed in operation, they shall be filled with the type of lubricant recommended by the manufacturer of the apparatus. Prior to final acceptance all equipment flanks shall be repacked and all valve packing glands tightened.

B. At completion of the work, prior to is operation by the Owner, all overload devices in motor starters shall be replaced or adjusted as required for proper operation of the motors. All damage to materials, equipment or finish of any part of the work resulting from the final adjusting of the equipment all be repaired to match the new condition of work.

C. All such repairs shall be the responsibility of the contractor who shall have mechanics of the trade who originally installed the work make the repairs.

3.11 PERFORMANCE TESTS AND ACCEPTANCE

A. Before final acceptance of the HVAC system, the contractor shall test the HVAC systems under normal conditions for two 8-hour days or longer when so directed to determine that they fulfill requirements of plans, specifications and that they operate satisfactorily.

B. Contractor shall cooperate with the temperature control manufacturer to integrate the control system with the HVAC system.

C. Heating system operating test shall be made during the heating season of the first year of operation at time when directed, for proper setting and adjustment of control under peak load conditions.

D. Air condition operating test shall be made during the summer months of the first year of operating at time when directed for proper setting and adjusting of controls under peak load conditions.

E. Contractor shall subject ventilating systems to operating tests for a period of two hours minimum for each system to demonstrate that each complied with the requirements of plans and specifications, that controls are functioning properly, and equipment operates satisfactorily.

F. Any defects made manifest by those tests shall be immediately and promptly made good after which the system shall be retested as required and/or directed.

G. Under no conditions will final payment be considered until results of all tests and adjustments have been submitted to and approved by the Architect.

3.12 INSPECTION

A. This contractor shall obtain all inspections required by laws, ordinances, rules and regulations of State, Local authority having jurisdiction, and he shall obtain certificates of such inspections and submit them to the Architect and shall pay all fees, charges, and other expenses in connection with the same, and include same in contract price.

B. This contractor shall furnish and install such test fees and plug fittings in his work as may be required by local authorities for their test and any other test required and shall ascertain information from local authorities as to all requirements before installation of work. No claims for extension of time will be entertained which arise from failure to obtain this information in time, or securing the necessary permits and arranging for required inspection.

3.13 ACCEPTANCE TESTING

A. An acceptance test of the HVAC system shall be performed by the Contractor in the presence of the Owner's representative and the Local Fire Marshal. Upon completion of the successful test, the Contractor shall so certify in writing to the Owner and General Contractor.

B. The Contractor shall also utilize all sub-contractors such as sheetmetal, balancing, piping, controls and commissioning agent, and other contractors such as electrical, plumbing, fire alarm and communications as required to perform this acceptance test.

C. The acceptance test shall be performed to determine that the protective measures required as outlined in NFPA 90A and shall function when needed in order to restrict the spread of fire and smoke.

D. The acceptance test shall include testing the HVAC system to determine its full functionability and in compliance with NFPA 90A and the sequence of operation. All controls and equipment shall be modulated throughout their entire ranges and adjustments shall be made for optimum performance.

1. Portions of control or alarm systems are permitted to have standby power or other emergency modes of operation.
2. The tests shall be performed to determine that the system operates under the standby power or emergency operation mode as well as under normal conditions.

E. All fire, smoke, combination fire/smoke dampers and ceiling dampers shall be operated and tested by Contractor prior to occupancy of a building to determine that they function in accordance with NFPA 90A, compliance report must be forwarded to Engineer and Owner.

END OF SECTION 23 05 93

SECTION 23 07 13 - DUCT INSULATION

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Ductwork insulation.

B. Insulation jackets.

C. Breeching insulation.

D. Acoustical insulation.

E. Kitchen grease duct insulation.

1.2 RELATED WORK

A. Division 23 – Scope of Work

B. Division 23 – Common Work Results for HVAC

1.3 REFERENCES

A. ANSI/ASTM C533 – Calcium Silicate Block and Pipe Thermal Insulation.

B. ANSI/ASTM C534 – Flexible Elastomeric Cellular Thermal Insulation.

C. ANSI/ASTM C612 – Mineral Fiber Blocks and Board Thermal Insulation.

D. ASTM E84 – Surface Burning Characteristics of Building Materials.

E. NFPA 255 – Surface Burning Characteristics of Building Materials.

F. UL 723 – Surface Burning Characteristics of Building Materials.

G. International Energy Conservation Code latest edition.

H. Energy Conservation Construction Code of New York State, latest edition.

I. ASHRAE 90.1 latest edition.

1.4 QUALITY ASSURANCE

A. Applicator: Company specializing in ductwork insulation application with five (5) years minimum experience of projects of similar size and scope.

B. Materials: UL listed; frame spread/smoke developed rating of 25/50 or less in accordance with ASTM E84.

1.5 SUBMITTALS

A. Submit product data under provisions of Division 23 – Basic Mechanical Requirements.

B. Include product description, list of materials and thickness for each service, and locations.

C. Submit sound transmission loss for 125 to 4000 Hz frequencies on Type E insulation.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURES – INSULATION

A. Owens-Corning

B. Johns Manville

C. Certainteed

D. Knauf

E. Armacell

F. Thermal Ceramics

2.2 MATERIALS

A. Type A: Flexible glass fiber; ANSI/ASTM C553 and ASTM C 1290; commercial grade; "k" value of 0.26 at 75 degrees F; rated to 250 degrees F; 3/4 lb. density; foil scrim kraft facing ASTM C1136 for air conditioning ducts. Johns Manville Microlite FSK (Basis of Design).

B. Type B: Rigid glass fiber; ANSI/ASTM C612, Class 1; "k" value of 0.23 at 75 degrees F; 3 lb./cu. ft. density; rated to 450 degrees F; foil scrim facing ASTM C1136 Type II for air conditioning ducts. Johns Manville Series 800 Spin-Glass Board (Basis of Design).

C. Type C: Flexible glass fiber; ANSI/ASTM C553; "k" value of 0.24 at 75 degrees F; coated air side for maximum 4,000 ft./min. air velocity. Johns Manville Linacoustic RC (rectangular), Spiracoustic Plus (round).

		Sound Absorption Coefficients						
Type Duct	**Thickness**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**NRC**
Rectangular	1"	.08	.31	.64	.84	.97	1.03	.70
Rectangular	2"	.25	.66	1.00	1.05	1.02	1.01	.95
Round	1"	.05	.21	.71	1.01	1.07	1.04	.75
Round	2"	.17	.63	1.10	1.05	1.04	1.06	.95

D. Type D: Hydrous calcium silicate; ANSI/ASTM C533; rigid white; asbestos free; "k" value of 0.44 at 300 degrees F; rated to 1200 degrees F; 15 pcf. Manville Thermo 12/Gold.

E. Type E: HUSHCORE™ *Deck*™ System In-Curb Multi-Layer Acoustical Treatment

1. Component products shall be as listed:

   a. HUSHCORE™ DS-52 acoustical composite
   b. HUSH BATT™ DS-49 Deck System
   c. HUSH SEALANT™ HSAC-100 acoustical caulk

2. HUSHCORE™ DS-52 acoustical composite

   a. The composite shall meet ASTM E-84 Class “A” for flammability.
   b. The overall installed composite shall have an installed thickness of 8” for the DS-52 composite.
   c. The installation DS-52 shall have a thermal value of R-27.
   d. The composite panels shall get HUSH SEALANT™ model HSAC-100 acoustical grade caulk at seams and all perimeter edges inside the curb.
   e. Seams for each layer shall be staggered.
   f. Acoustical composite shall have 65% post-consumer recycled content.

3. HUSH SEALANT™ HSAC-100 acoustical caulk

   a. Shall be a non-hardening formulation
   b. The acoustical sealant must be applied around the entire perimeter of the curb, around duct drop penetrations of the decking, and at all seams between Hush Core composite panels.

4. Where acoustical treatment is exposed to the air stream, model DS-49 Deck System, rated at STC 49 shall be supplied. The DS-49 in-curb is rated Class A for flammability per ASTM 84.
5. BRD Noise and Vibration Control, as Basis of Design.
6. Exceptions must be submitted and approved prior to project bid date as “or equal” compliant.
7. HUSHCORE™ In-Curb Acoustic Treatment Acoustical Performance

   a. The combination of all layers shall be tested for Sound Transmission Loss in accordance with procedure ASTM E-90-10. The assembly shall be rated at not less than STC-52 with 1/3 octave performance values as listed below for sound radiation through the deck inside the curb.

Freq. (Hz)	80	100	125	160	200	250	315	400	500	630	800	1K
TL (dB)	26	27	33	32	35	42	45	45	50	56	59	60
Freq. (Hz)	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	STC	
TL (dB)	62	63	64	65	67	71	74	78	80	80	52	

F. Type F: Flexible elastomeric rubber; ASTM C534, 0.08 perm-in water vapor permeability; 0.28 “k” valve of 0.25 at 75 degrees F; 25/50 flame/smoke developed rating per ASTM E84. Armacell AP/Armaflex as Basis of Design.

G. Type G: Ceramic fiber; 1.45 "k" valve at 1500 degrees F; 2300 degrees F service temperature; zero inch to combustibles 0/0 flame/smoke spread per ASTM E84; 8 pcf density; reinforced foil facing jacket. UL classified 2 hour rated enclosure meeting NFPA 96 service limit 2300 degrees F. Thermal Ceramics FireMaster, Firewrap XL Blanket as Basis of Design.

H. Type H: Mineral wool; 0.25 “k” value at 70 degrees F: 2000 degrees F service temperature; zero inch to combustibles 0/0 flame/smoke spread per ASTM E84: 2 pcf density; unfaced batts. Moisture Resistance – less than 0.03% by volume per ASTM C1104. ASTM C665 corrosion resistance compliance. Zero mold growth per ASTM C1338. Environmental Product Declaration (EPD): UL certified EPD in accordance with EN 15804 and ISO 14025. Greenguard Gold Certified. Johns Manville TempControl Batts or Rockwool Comfort Batt.

I. Type I: Rigid polyisocyanurate foam; ANSI/ASTM C1289 and ASTM C236/C518 0.14 “k” value at 75 degrees F. Closed-cell polyisocyanurate foam core with continuous sheet of aluminum foil face on one side and three-ply laminate of kraft and aluminum foil on the other. DOW TUFF-R (Basis of Design).

J. Adhesives: Waterproof (fire-retardant) type.

K. Finishing Cement: Fire resistive to ASTM E84.

L. Joint Tape: Foil backed.

M. Tie Wire: Annealed steel, 16 gage.

N. Glass Cloth Jacket: MIL-C-20079H, plain weave, 8 oz/sq yd.

O. Aluminum Jackets: ASTM B209; 0.020 inch thick; smooth finish.

P. EPDM Jackets – 0.060" thick, adhered, Mule-Hyde.

PART 3 - EXECUTION

3.1 DECKING

A. Decking shall be maintained inside the RTU roof curb to a clearance of ¼" maximum around all duct drops but never contact the duct.

1. Pack all air gaps around duct drops for return and supply with HBNF-400 and seal with HUSH SEALANT™ HSAC-100.

3.2 INSPECTIONS

A. The manufacturer or their local authorized agent shall inspect the in-curb deck system work on site prior to lowering of the units and issue a letter of certification stating that the products have been properly installed and sealed around all ductwork and drops to eliminate air gaps which can compromise performance.

3.3 PREPARATION

A. Install materials after ductwork has been tested and approved.

B. Clean surfaces for adhesives.

3.4 GENERAL APPLICATION REQUIREMENTS

A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of ducts and fittings.

B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each duct system.

C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attach insulation or jacket in either wet or dry state.

D. Apply multiple layers of insulation with longitudinal and end seams staggered.

E. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.

F. Keep insulation materials dry during application and finishing.

G. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

H. Apply insulation with the least number of joints practical.

I. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic. Apply insulation continuously through hangers and around anchor attachments.

J. Insulation Terminations: For insulation application where vapor retarders are indicated, seal ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

K. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.
2. Joints and Seams: Cover with tape and vapor retarder as recommended by insulation material manufacturer to maintain vapor seal.
3. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.

M. Install vapor-retarder mastic on ducts and plenums scheduled to receive vapor retarders.

1. Ducts with Vapor Retarders: Overlap insulation facing at seams and seal with vapor-retarder mastic and pressure-sensitive tape having same facing as insulation. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-retarder seal.
2. Ducts without Vapor Retarders: Overlap insulation facing at seams and secure with outward clinching staples and pressure-sensitive tape having same facing as insulation.

N. Roof Penetrations: Apply insulation for interior applications through the roof encapsulating the duct until termination.

1. Seal penetrations with vapor-retarder mastic.
2. Apply insulation for exterior applications tightly jointed to interior insulation ends.
3. Seal insulation to roof flashing with vapor-retarder mastic.

O. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.

P. Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire/smoke damper sleeves for fire-rated wall and partition penetrations.+

Q. Insulate diffuser plenums and housings with Type A or B, 2” thickness in a neat manner with vapor barrier jacket and continuous insulation from flex duct to diffuser at ceiling.

3.5 INSTALLATION

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

B. Provide insulation with vapor barrier when air conveyed may be below 60 deg. F. All supply air ductwork throughout shall be insulated with the minimum 1 ½" insulation, type A, unless specifically scheduled. (See 3.5 Schedule)

C. Continue insulation with vapor barrier through penetrations.

D. Where intended lining is used, external insulation may be deleted unless indicated otherwise. Internal insulation shall be of sufficient thickness/R-Value to comply with the energy code where external insulation is deleted.

E. Insulate outdoor ductwork externally even if insulated internally.

F. Duct work insulation that is exposed in occupied spaces, shall have an additional layer of Kraft paper jacket with vapor sealing tape and/or an 8 oz./sq. yd. canvas cloth wrap, glued with two coats of sizing. Finish by painting with two coats of latex based paint. Color to be selected by Architect.

G. Where ductwork penetrates the building envelope, ductwork insulation shall extend through the penetration continuous. Provide an additional layer of insulation to fill any voids surrounding the duct to provide a minimum insulation value of R-12.

H. Ductwork which penetrates the building envelope shall receive a minimum of Type A insulation 1.5 inches thick from the penetration to a distance 5'- 0" into the building. The insulation is to be applied to exterior penetrations, to prevent condensation during cold outdoor conditions. Ducts which are indicated to receive insulation per 3.7 Schedule shall follow the schedule value.

I. Type A Application

1. Secure insulation with vapor barrier on all ductwork and conveying components with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.
2. Secure insulation without vapor barrier with staples, tape or wires.
3. Install without sag on underside of ductwork. Use adhesive or mechanical fasteners when necessary to prevent sagging. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

J. Type B Application

1. Secure insulation with mechanical fasteners on 15 inch centers. Butt all joints tight.
2. On insulation with vapor barrier, cover all mechanical fasteners and joints with foil back adhesive tape.
3. On non-vapor barrier ducts, use plain white facing on insulation.
4. On exterior applications, finish with .060" thick "Mule-Hyde", EPDM top jacket.
5. Duct work insulation that is exposed in occupied spaces, shall have an additional layer of Kraft paper jacket with vapor sealing tape and/or an 8 oz./sq. yd. canvas cloth wrap, glued with two coats of sizing. Finish by painting with two coats of latex based paint. Color to be selected by Architect.

K. Type C Application

1. Adhere insulation with adhesive for 100 percent coverage. Secure insulation with mechanical fasteners on 15 inch centers maximum on top and side of ductwork where dimension exceeds 20 inches. Seal and smooth joints. Do not use nail-type fasteners. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
2. Ductwork dimensions indicated are net inside dimensions required for air flow. Increase ductwork to allow for insulation thickness.
3. Use galvanized sheet metal nosing at the beginning of each lined run.
4. Refer to Division 23 Section “Ductwork” for the double wall ductwork specifications and requirements.
5. Provide internal liner downstream of VAV boxes or other air control devices (including upstream of exhaust valves). Eliminate internal liner in healthcare/hospital applications.

L. Type D Application

1. Apply in sheets directly to duct with all edges butted and joints staggered. Secure block in place with 16 gauge wire or 1/2 inch stainless steel bands on 12 inch centers. Where required, provide welded studs, clips, angles or clips as anchors for the wires or bands.
2. Where standing seams or flanges are encountered, weld 6 inch by 6 inch road mesh over the stiffeners. Apply insulation over the mesh.
3. Provide a skim coat of mineral-fiber, hydraulic setting cement to surfaces. When dry, apply a flood coat of lagging adhesive and embed one layer of glass cloth; overlap edges. Apply a finish coat of lagging adhesive over jacket; finish to a smooth coat. OR Provide aluminum top jacket, secured in place with bands.

M. Type E Application

1. Mechanically fasten double composite to 20-gauge sheetmetal backing and line all inside faces of roof curb. Also, lay within roof curb. (2 layers)
2. Use double composite with (2) layers of drywall for enclosure below rooftop unit. Materials and labor by General Contractor.

N. Type F Application

1. Apply in sheets; adhered 100% coverage to ductwork after ductwork has been cleaned as per manufacturer's recommendations to duct with all edges butted and joints. Overlap joints for installation of multiple layers.

O. Type G Application

1. Apply two (2) overlapping layers as required by the manufacturer’s installation instructions.
2. Mechanically fasten using welded pins and speed slips on maximum 18" centers on flat surfaces and maximum 12" centers on cylindrical surfaces. Overlap all joints 1 1/2" and secure with 3/4" x –015" thick stainless-steel bands. For multiple layers, stagger joints. Install per the manufacturer's instructions and per the authorities having jurisdiction.

P. Type H Application

1. Do not compress insulation to fit in spaces.
2. Fit insulation closely around electrical boxes, pipes, ducts, fumes and other projects in or passing through insulation.
3. Keep insulation minimum 3" from heat emitting devices such as recessed light fixtures and minimum 2" from sidewalls of chimneys and vents.

Q. Type I Application

1. Apply in sheets; adhered 100% coverage to ductwork after ductwork has been cleaned as per manufacturer's recommendations with all edges butted and joints. Overlap joints for installation of multiple layers.

3.6 SCHEDULE

DUCTWORK	TYPE	MINIMUM THICKNESS (Inch)*	MINIMUM INSTALLED R-VALUE
Supply & Return Air Duct (Mechanical Rooms)	B	2.0	R-8
Supply and Return Air Duct (Outdoor)	I	2.0	R-12
Supply Air Duct (Exposed in Conditioned Space)	B	1.5	R-5
Supply & Return Air Duct (Unconditioned Concealed)	A	2.0	R-6
Supply & Return Air Duct in Shaft on Outside Wall or Ceiling w/Roof above	A or B	2.0	R-8
Supply Located Sound Attenuators	B	2.0	R-8
Supply Air Duct** (Return Air Plenum and other non-exposed areas)	A	1.5	R-5
Outside Air Intake	F	2.0	R-7
Back of Diffusers in Areas of Ducted Return	A or B		
Internal Acoustical Lining	C	2.0	R-5
Plenums	B	2.0	R-5
Boiler Breeching	D	2.0	N/A
Indoor Condenser Intake and Exhaust	F	2.0	R-7
Kitchen Grease Duct	G	1.5 OR 3	N/A
Board Below Heat Pump	E	2.0	N/A
Board Below Roof Mounted Unit	E	4.0	N/A
Smoke Purge Intake	A or B	-	R-8
Exhaust Duct (Outdoor)	None	EPDM Jacket Only Ventureclad 1577CW not	

		acceptable	
All Ductwork not initiated to be insulated within which penetrates the building Envelope. ***	A	1.5	R-5
Duct Penetrations through the building exterior.	H	3.0	R-12

*Listed thickness is the minimum thickness commonly available. Provide insulation with greater thickness, if required, to meet the installed R-Value. Insulation thickness less than listed must get approval for use from the engineer.

**Supply Air Ducts within Return Air Plenums or Supply Air Ducts not insulated/described within Schedule shall receive insulation as indicated herein: Type A, 1.5, R-5.

***Insulation shall extend from the exterior penetration to 5'- 0" into the building interior.

END OF SECTION 23 07 13

SECTION 23 07 19 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Piping insulation.

B. Jackets and accessories

1.2 RELATED WORK

A. Division 23 – HVAC Scope of Work

B. Division 23 – Common Work Results for HVAC

1.3 REFERENCES

A. ANSI/ASTM C195 – Mineral Fiber Thermal Insulation Cement.

B. ANSI/ASTM C533 – Calcium Silicate Block and Pipe Thermal Insulation

C. ANSI/ASTM C547 – Mineral Fiber Preformed Pipe Insulation.

D. ANSI/ASTM C552 – Cellular Glass Block and Pipe Thermal Insulation.

E. ANSI/ASTM C534 – Flexible Elastomeric Cellular Thermal Insulation.

F. ASTM B209 – Aluminum and Aluminum-Alloy Sheet and Plate.

G. ASTM C449 – Mineral Fiber Hydraulic-setting Thermal Insulating and Finishing Cement.

H. ASTM E84 – Surface Burning Characteristics of Building Materials.

I. NFPA 255 – Surface Burning Characteristics of Building Materials.

J. UL 723 – Surface Burning Characteristics of Building Materials.

K. International Energy Conservation Code latest edition.

L. Energy Conservation Construction Code of New York State, latest edition.

M. ASHRAE 90.1, latest edition.

1.4 QUALITY ASSURANCE

A. Applicator: Company specializing in piping insulation application with five (5) years minimum experience of projects of similar size and scope.

B. Materials: Flame spread/fuel contributed/smoke developed rating of 25/50 in accordance with ASTM E84.

1.5 SUBMITTALS

A. Submit product data under provisions of Division 23 – Common Work Results for HVAC.

B. Include product description, list of materials and thickness for each service, and locations.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Owens-Corning

B. Johns Manville

C. Certainteed

D. Armacell

E. Pittsburgh Corning

F. Knauf

2.2 INSULATION

A. Type A: Glass fiber insulation; ANSI/ASTM C547; "k" value of 0.24 at 75 degrees F; noncombustible.

B. Type B: Hydrous calcium silicate; ANSI/ASTM C533; rigid white; asbestos free; "k" value of 0.44 at 300 degrees F, 15 pcf. Rated to 1200 degrees as per ASTM C411, Manville Thermo 12/Gold.

C. Type C: Elastomeric rubber; ANSI/ASTM C534; rigid closed cell; maximum water vapor transmission rating of 0.01 perms; "k" value 0.25 at 75 degrees F. Armacell AP/Armaflex as Basis of Design.

D. Type D: Rigid closed cell; all glass structure; ANSI/ASTM C552; "k" value of .35 at 75 degrees F; maximum water vapor transmission rating of .0005 perms; non-combustible; 8.5 pcf density. Pittsburgh Corning Foamglass.

2.3 JACKETS

A. Interior Applications

1. All Service Jackets: Kraft reinforced foil vapor barrier with self-sealing adhesive joints.
2. PVC Jackets: One piece premolded type. PVC jackets not allowed in return air plenums unless ASTM E84 25/50 rated.
3. Glass Cloth Jacket: MIL-C-20079H, plain weave, 8 oz/sq yd.

B. Exterior Applications

1. Aluminum Jackets: ASTM B209; 0.020 inch thick; smooth finish.

2.4 ACCESSORIES

A. Metal Jacket Bands: 3/8 inch wide; 0.15 inch thick aluminum.

B. Adhesives: Compatible with insulation.

PART 3 - EXECUTION

3.1 PREPARATION

A. Install materials after piping has been tested and approved.

3.2 INSTALLATION

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

B. Continue insulation through all penetrations including roofs, floors and walls.

C. In exposed piping, locate insulation and cover seams in least visible locations.

D. Provide an insert, not less than 6 inches long, of same thickness and contour as adjoining insulation, between support shield and piping, but under the finish jacket, on piping 2 inches diameter or larger, to prevent insulation from sagging at support points. Inserts shall be cork or the heavy density insulating material suitable for the planned temperature range. Factory fabricated inserts may be used.

E. Neatly finish insulation at supports, protrusions and interruptions. Insulate over heat traced sections of pipe, provide heat transfer compound.

F. Install Type B and Type D insulation with aluminum bands, stagger joints for multiple layers. Use pre-molded sections on valves, fittings, devices, etc. Wire mold fitting in place without deforming insulation.

G. For Type B insulation, indoors: provide a skim coat of mineral-fiber, hydraulic setting cement to surfaces. When dry, apply a flood coat of lagging adhesive and embed one layer of glass cloth; overlap edges. Apply a finish coat of lagging adhesive over jacket; finish to a smooth coat.

H. Jackets

1. Indoor, Concealed Applications: Insulated pipes conveying fluids above ambient temperature shall have all service jackets, factory-applied. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjoining pipe, and finish with PVC jackets.
2. Indoor, Cold Applications: Insulated pipes conveying fluids below ambient temperature shall have vapor barrier jackets, factory-applied. Insulate fittings, Joints, and valves with molded insulation of like material and thickness as adjacent pipe and finish with PVC jackets. Leave no metal surfaces exposed.
3. Exterior Applications: Provide all service jackets with aluminum jacket with seams located on bottom side of horizontal piping. Insulate fittings, joints and valves with insulation of like material and thickness as adjoining pipe, and finish with aluminum jackets. Cover small areas of exposed insulation with Johns Manville Insulkote primer and finish coating.
4. Calcium Silicate: Glass cloth jacket on indoor insulation. Use aluminum jacket on outdoor insulation.
5. PVC Jackets: Factory preformed, 30 mil thickness , UV resistant, noncombustible and 25/50 rated as per ASTM E84, nonconductive. Johns Manville Zeston 2000 PVC. Secure with solvent adhesive. Cover joints and fittings with preformed PVC covers.

3.3 SCHEDULE: TYPE AND JACKET

PIPING	TYPE	VAPOR BARRIER
Glycol Piping (Indoor)	A	YES
Heating Water Supply and Return	A	NO
Low/Medium/High Pressure Steam Piping	A	NO
Low/Medium/High Pressure Steam Condensate	A	NO
Chilled Water (Indoors)	A	YES
Cold Condensate Drains	A	YES
Refrigerant Suction	C	YES
Refrigerant Hot Gas	A	YES
Glycol Piping (Outdoors)	D	YES
Pumped Condensate Return	A	NO
Chilled Water Piping (Outdoors)	D	YES
Heating Water Piping (Outdoors)	D	YES
Steam (Outdoors)	D	YES
Glycol Piping (In Mechanical Rooms)	C	YES
Chilled Water Piping (In Mechanical Rooms)	C	YES
Generator Exhaust	B	NO
Radiant Heating and Cooling Tubing Above Slab	C	YES
Radiant Heating and Cooling Manifolds	C	YES

Note: Insulate all existing piping in addition to the new.

SCHEDULE: THICKNESS

MINIMUM PIPE INSULATION ****

INSULATION THICKNESS FOR PIPES SIZES

		Pipe Size					
Piping System Types	Fluid Temperature Range	Runouts* Less Than1 in.	Less than 1 in.	1 - <1-1/2 in.	1-1/2 - < 4 in.	4 - <8 in	8 in. & Larger
Hot Temperature Piping High Pressure Steam, Hot Water or other fluid	306-1200	3.0	4.5	5.0	5.0	5.0	5.0
Medium Pressure Steam, Hot Water or other fluid	251-305	2.0	3.0	4.0	4.5	4.5	4.5
Low Pressure Steam, Hot Water or other fluid	201-250	1.5	2.5	2.5	2.5	3.0	3.0
Hot Water or other fluid**	100-200	1.5	1.5	1.5	2.0	2.0	2.0
Steam Condensate	Any	1.5	1.5	1.5	2.0	2.0	2.0
Low Temperature Piping Cold Water and Drain Lines, Refrigerant, *** Chilled Water	40-55 <40	1.5 1.5	1.5 1.5	1.5 1.5	1.5 1.5	1.5 1.5	1.5 1.5

* Runouts to individual coils between control valve and coil (not exceeding 4 ft. in length).

** Include refrigerant hot gas.

*** Include refrigerant suction. Liquid line insulation is not required.

**** Increase insulation thickness for exterior piping by .5 inches minimum.

END OF SECTION 23 07 19

SECTION 23 08 00 - HVAC COMMISSIONING

PART 1 - GENERAL

1.1 GENERAL: Furnish labor and material to accomplish complete HVAC commissioning as specified herein. If this Contractor cannot meet the specification herein, the Contractor shall employ the services of an independent commissioning expert.

1.2 PURPOSE

A. Verify operation and functional performance of HVAC systems for compliance with design intent, drawings and specifications.

B. Document HVAC test inspections.

C. Verify application of operation and maintenance manuals, as-built documents, spare parts listing, special tool listing, and other items that support the HVAC systems and equipment.

D. Coordinate and direct training to personnel for operation and maintenance of HVAC systems and equipment.

1.3 QUALITY ASSURANCE: Reference ASHRAE Guideline 1-1996, Guideline for Commissioning of HVAC Systems, and SMACNA HVAC System Commissioning Manual.

1.4 COMMISSIONING TEAM SHALL CONSIST OF:

A. The contractor's representative

B. The controls sub-contractor's representative

C. The sheet metal sub-contractor's representative

D. The electrical sub-contractor's representative

E. The engineer's representative

F. The equipment vendors representative

G. The testing, adjusting and balancing Contractor's representative

H. The owner's representative

1.5 CONTRACTOR RESPONSIBILITY

A. Plan, organize, and implement the commissioning process as specified herein.

B. Prepare the commissioning plan and ensure its distribution for review and comment.

C. Revise the commissioning plan as required during construction.

D. Chair commissioning meetings and prepare and distribute minutes to all commissioning team members, whether or not they attend the meeting.

E. Coordinate commissioning activities among all contractors, sub-trades, and suppliers.

F. Carry out all required system readiness checks and documents the results as the checks are done.

G. In cooperation with the controls sub-contractor, ensure all control point checkouts are carried out and the results documented as the checks are done.

H. Observe or verify all start-ups and initial system operations tests and checks, which shall encompass all specified functional performance tests, ensuring the results are documents as the tests and checks are done.

I. Ensure equipment and systems are operated for functional performance verification purposes.

J. Ensure all required instruction and demonstrations are provided to the owner's designated operating staff.

1.6 COMMISSIONING PLAN

A. Within one month after award of contract, the contractor shall review the design intent and intended commissioning procedure with the engineer. Within 3 months of award of contract, the contractor shall submit a detailed Commissioning Plan to the engineer for review. The Commissioning Plan shall contain the information necessary to document the commissioning process as it progresses from pre-start-up checks, to start-up, and initial operation and finally to functional performance verification of all systems. The Commissioning Plan must include detailed check lists, relevant to guiding and carrying out. ASHRAE Guideline 1 should be used as outline.

B. Phase 1 – Systems Readiness and Start-up:

Before starting any equipment or systems, complete the system readiness or pre-start checks in the commissioning plan and document the results. The following conditions and items shall be completed as applicable.

1. Piping systems have been pressure tested as specified, found to be tights, with reports submitted.
2. Equipment has been lubricated.
3. Air system cleaning is complete, and particulate filters have been installed.

4. Vibration isolation and seismic restraints have been installed to specification and adjusted.
5. Equipment drives have been aligned.
6. Electrical services have been installed and checked.
7. Control point checkouts have been completed.
8. Safety controls have been installed and operation checked.
9. Major equipment start-up has been carried out by manufacturer's representative and required start-up reports completed, submitted and approved.

All checks shall be documented on the relevant checklists as they are carried out. Deficiencies or incomplete work shall be corrected, and the checks repeated until the installation is ready for operation, before proceeding to Phase 2 of the process.

C. Phase 2 – Initial Operation:

In Phase 2 of the commissioning process, the contractor completes the testing, balancing, and calibration of all components and systems. They also operate all systems through all specified modes of operation, and test system responses to specified abnormal or emergency conditions.

Work carried out during this phase of commissioning shall include the following:

1. Air systems balancing, including positioning of all balance valve.
2. Correction of problems revealed during balancing, including changes to fan speeds or blade pitch as necessary.
3. Setting up and calibrating all automatic temperature control devices, including adjustments to control valves and damper actuators.
4. Verify the balancing contractor, and controls contractor are working together, setting up air flows and controls calibrations for variable volume terminal units and air valves where applicable.
5. Checking operation of all fire dampers, as was done in Phase 1, all checks and tests shall be documented on the relevant checklists as they are carried out.

   Deficiencies or incomplete work shall be corrected, and the checks or test repeated until correct installation and function has been confirmed and the installation is ready for engineer verification.

D. Phase 3 – Functional Performance Verification

All equipment and systems shall be operated through the entire specified sequence of operations, as directed by the engineer for witnessing and verifying acceptable operation.

During this phase of commissioning, the following checks and test may be required by the engineer and shall be allowed for:

1. Checking the location and accessibility of all access panels.
2. Operation of all controls systems devices, both sensors and actuators.
3. Demonstration of acceptable noise and vibration levels from any equipment, under its full range of operational conditions.

4. Operation of equipment and systems under every specified mode of operation and sequence of control.
5. Operation of equipment and systems under normal, abnormal, and emergency conditions.
6. Acceptance testing as indicated in 3.3 herein.

E. Phase 4 – Demonstration and Instruction:

The formal demonstration and instruction for operating staff shall commence once the Phase 3 commissioning is complete and substantial completion achieved.

Demonstration and instruction shall cover all equipment and systems, and their controls. Detailed requirements are listed in the following sections of the specification.

PART 2 - PRODUCTS

2.1 INSTRUMENTATION

Instrumentation will be provided by agency performing prior tests. Instruments will be operated by individual agency requested by the HVAC Commissioning Authority, as specified elsewhere herein.

PART 3 - EXECUTION

3.1 HVAC Commissioning shall begin after HVAC equipment and systems, along with related equipment, systems, structures and areas are complete.

3.2 THE FOLLOWING SYSTEMS SHALL BE COMMISSIONED:

A. Hot Water and Chilled Water Piping Systems – pressure tests; expansion tanks; flow balancing verification.

B. Duct Systems – Installation checks; flow balancing verification; leak testing.

C. Refrigerant Systems and Chillers – Installation checks; checkout and start-up by manufacturer's representative; performance measurements, including capacity, evaporator and condenser flows, motor amperage, and controls operation (e.g., staging and capacity modulation). Leak testing, dehydration charging.

D. Pumps – Checks on alignment, rotation, motor current draw, flows, and pressures.

E. Rooftop Units – Installation checks; capacity tests for heating, cooling, air flow, and static pressures; operation of all controls.

F. Air Terminal Devices – Installation checks; for constant and variable air volume VAV units, flow adjustments and calibration coordinated with controls and air balancing; controls operation, including flow modulation, reheat, controls responses.

G. Controls and EMCS – Installation and operation of all devices; complete operation of all controls sequences in coordination with commissioning of all controlled systems.

H. Heating System and Boilers – Installation checks; checkout and start-up by manufacturer's representative; performance measurements, including capacity and flow rate. Verify control operation. (i.e., staging and modulation).

3.3 ACCEPTANCE TESTING

A. An acceptance test of the HVAC system shall be performed by the Contractor in the presence of the Owner's representative and the Local Fire Marshal. Upon completion of the successful test, the Contractor shall so certify in writing to the Owner and General Contractor.

B. The Contractor shall also utilize all sub-contractors such as sheet metal, balancing, piping, controls and commissioning agent, and other contractors such as electrical, plumbing, fire alarm and communications as required to perform this acceptance test.

C. The acceptance test shall be performed to determine that the protective measures required as outlined in NFPA 90A and shall function when needed in order to restrict the spread of fire and smoke.

D. The acceptance test shall include testing the HVAC system to determine its full functionability and in compliance with NFPA 90A and the sequence of operation. All controls and equipment shall be modulated throughout their entire ranges and adjustments shall be made for optimum performance.

1. Portions of control or alarm systems are permitted to have standby power or other emergency modes of operation.
2. The tests shall be performed to determine that the system operates under the standby power or emergency operation mode as well as under normal conditions.

E. All fire, smoke, combination fire/smoke dampers and ceiling dampers shall be operated and tested by Contractor prior to occupancy of a building to determine that they function in accordance with NFPA 90A, compliance report must be forwarded to Engineer and Owner.

END OF SECTION 23 08 00

SECTION 23 09 00 - DIRECT DIGITAL CONTROL FOR HVAC

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Control Equipment

B. Software

1.2 DESCRIPTION OF WORK

A. Furnish all labor, materials, equipment, and service necessary to provide a complete and operating DDC temperature control system. System shall use Direct Digital Controls, electronic interfaces and actuation devices, as shown on the drawings and as described herein.

1.3 CONNECTION TO EXISTING CONTROL SYSTEM

A. The BAS system is an extension of the existing DDC controls system as manufactured by Andover. The intent of this project is to extend the existing BMS system that is currently installed on the campus to communicate with new stand-alone equipment.

B. The BAS is manufactured by Automated Logic Corporation (ALC). The intent of this project is to extend the existing BAS system that is currently installed on the campus to communicate with new stand-alone equipment.

Contact:
James Chesko
Air Temp.
(607) 772-8362
Email: jchesko@airtemphvac.com

C. All controls products, control equipment, software, hardware, programming, graphics, wiring and conduit specified in this section shall be provided by Environmental Control Corp. All control system requirements specified in this section shall connect to the existing Controls network

D. All new control equipment must integrate seamlessly with existing DDC system. All new digital controllers are required to communicate fully with the existing temperature control network.

E. All new controllers provided under this project must be connected to the existing BAS System. Extend network (including software) as required to provide a fully integrated control system.

F. All software and graphics to be modified on existing server for all newly installed or modified equipment for this project. All new equipment shall be seamlessly compatible with the existing system and capable of being serviced by BAS manufacturer.

1.4 CONTROL SYSTEM DESCRIPTION

A. Provide labor, controls materials, controls equipment and services as required for a complete BACnet Building Automation System (BAS), to perform the functions described in this Section. Controls System shall be Web-based and accessible either directly connected and/or through the owners BACnet network.

B. It is the BAS manufacturer's responsibility to provide all the design, engineering, and field coordination required to ensure all equipment sequence of operations are met as specified and the designated BAS operators have the capability of managing the building mechanical system.

C. The BAS shall meet BACnet communication standards to ensure the system maintains "interoperability" to avoid proprietary arrangements that will make it difficult for the Owner to consider other BAS manufacturers in future projects.

D. BAS controllers shall be listed by BACnet Testing Laboratories (BTL) with appropriate classification.

E. Direct Digital Control (DDC) technology shall be used to provide the functions necessary for control of mechanical systems and equipment on this project.

F. The BAS manufacturer shall provide all hardware and software necessary to implement the functions and sequence of operations specified.

1.5 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Hydronic Piping

1. Control Valves
2. Flow Switches
3. Temperature Sensor Wells and Sockets
4. Hydronic Pressure Taps
5. Hydronic Flow meters

B. Ductwork Accessories

C. Automatic Dampers

1.6 SUMMARY

A. Furnish all labor, materials, equipment, and service necessary for a complete and operating Building Automation System (BAS), utilizing Direct Digital Controls as shown on the drawings

and as described herein. Drawings are diagrammatic only. The BAS shall be capable of total integration of the facility infrastructure systems with user access to all system data either locally over a secure Intranet within the building or by remote access by a standard WEB Browser over the internet. This shall include HVAC control, electrical, gas and water metering, energy management, alarm monitoring, security and personnel access control, and all trending, reporting and maintenance management functions related to normal building operations all as indicated on the drawings or elsewhere in this specification.

1.7 SYSTEM DESCRIPTION

A. The entire Building Automation System (BAS) shall be compromised of a network of interoperable, stand-alone digital controllers and/or controllers provided by equipment manufacturers communicating on a native BACnet open protocol communication network and communicating via the intranet to provide remote computer access. The system shall operate on the facility Ethernet via BACnet IP. The BAS shall communicate to third party systems such as self-contained units, roof-top systems, energy metering systems, other energy management systems, access control systems, fire-life safety systems and other building management related devices via open protocol.

B. The new DDC controls being provided shall be the responsibility of the ATC Subcontractor to the Division 23 Contractor to provide all necessary updated license files, programming, commissioning and graphics at the operator workstation. All points, including, but not limited to, temperature sensors, fan control, damper control, cooling control, heating control, setpoint adjustment, scheduling, trending, etc. shall be completely accessible and adjustable through the software; systems requiring software drivers or gateways to accomplish this will NOT be acceptable. The ATC Subcontractor to the Division 23 Contractor shall take full responsibility for all network communications and warranties associated with both new equipment that may be effected as part of this project. This shall include any and all available software and firmware upgrades throughout the warranty period. Bidders must be factory authorized training certificated and current software licensing for the system.

1.8 OVERVIEW

A. This document contains the specification and input/output summaries for the Building Automation System (BAS). The system architecture shall utilize intelligent distributed control modules, which communicate over a local controller network. The BAS shall provide Direct Digital Control (DDC), monitored and adjusted by the Architecture software, both via Microsoft Internet Explorer, the thin-client user interface. This BAS for the air conditioning, heating and ventilating systems shall interface with other microprocessor-based building subsystems as shown on the drawings as specified.

B. Electrical power for all control panels, transformers, controllers, relays, dampers and valve actuators, etc. that are required for the control system shall be the responsibility of the Mechanical Contractor and/or the Temperature Control Subcontractor. Connect to nearest available 120-volt power circuits, coordinate with the Electrical Contractor.

C. Where HVAC equipment is being provided the controls contractor shall incorporate interfacing to the BAS. Controls contractor is to provide all necessary programming and software to bring the published list of the manufacturer's data points into the BAS system. Field re-wiring of the HVAC Equipment is not permitted. Equipment manufacturer is to provide communications card. Mechanical contractor is responsible to coordinate equipment and controls interfacing to make sure the two are compatible.

D. The Building Automation System (here-in-after referred to as BAS) shall have the following capabilities as described in these specifications:

1. Building Controller units and the Operator Workstation(s) shall be connected directly to the Owners Ethernet Network. The Building Automation System shall include 25% availability for future controller expansion availability.
2. System shall be capable of offsite access for Owner's personnel and shall have full workstation capability from remote locations. Identical graphical displays shall be provided for offsite access to match the displays at the on-site Operator Workstation. Connection to the site shall be via a high-speed Ethernet connection or modem. BAS contractor shall coordinate with the Owner's IT professionals for high-speed system access and shall comply with Owner's requirements to maintain the level of security required by the Owner.
3. BAS system shall be capable of e-mailing Critical alarms to the email addresses as provided by the Owner.
4. All system variables in the BAS system shall be Microsoft variables allowing them to be display and manipulated in other Microsoft products.
5. Network controllers shall all be flash up-gradable and not require changing chips for upgrades.
6. Short-term logging of historical data shall be provided for every DDC input and output in the system. Each point shall be logged for a minimum of 2 days.
7. All Building Controllers, Application Specific controllers and Operator Workstation software shall meet BACnet Standard 135. Proprietary controllers and software are not acceptable.

1.9 QUALITY ASSURANCE

A. All labor, material, equipment and software necessary to meet the functional intent of the system, as specified herein and as shown on the drawings, shall be provided by one of the manufacturers listed in Part 2 - Products. Equipment and labor not specifically referred to herein or on the plans, which are required to meet the functional intent, shall be provided without additional cost to the Owner. This contractor also is responsible for all costs of changes in the work required by substitute equipment.

B. The BAS Contractor must have been in business for not less than 10 years. BAS Contractor must be an authorized distributor or branch office of the manufacturers specified. BAS Contractor must have a trained staff of application engineers, project managers, software engineers, commissioning staff, and service staff experienced in the configuration, programming and service of the automation system.

C. Manufacturer: A firm regularly engaged in manufacture of microprocessor temperature control equipment, of types and sizes which are similar to required equipment, and which have been in satisfactory use for not less than 10 years, in similar service.

D. Electrical standards: Provide electrical products that comply with the following agency approvals:

1. UL-916; Energy Management Systems for BAS components and ancillary equipment.
2. UL-873; Temperature Indication and Regulating Equipment.
3. FCC, Part 15, Subpart J, Class A Computing Devices.

E. All products shall be labeled with the appropriate approval markings. System installation shall comply with NFPA, NEMA, Local and National codes.

1.10 SCOPE OF WORK

A. Except as otherwise noted, the control system shall consist of all Ethernet Network controllers, operator workstations, software, sensors, relays, valves, dampers, damper operators and other accessory equipment, along with a complete system of electrical interlocking wiring as required to fill the intent of the specification and provide for a complete and operable system. This includes staging of units where multiple stages of heat or cool are within one unit and/or when multiple units are within one system.

B. Except as otherwise specified, provide operators for equipment such as dampers if the equipment manufacturer does not provide these. Coordinate requirements with the various Contractors.

C. The BAS contractor shall review and study all Mechanical and Electrical drawings and the entire specification to familiarize himself with the equipment and system operation and to verify the quantities and types of dampers, operators, alarms, etc. to be provided.

D. All interlocking, wiring and installation of control devices associated with the equipment listed below shall be provided under this Contract. When the BAS system is fully installed and operational, the BAS Contractor shall review and check out the system. At that time, the BAS contractor shall demonstrate the operation of the system to the Owner and prove that it complies with the intent of the drawings and specifications.

E. Provide services and manpower necessary for commissioning of system in coordination with the Mechanical Contractor, Balancing Subcontractor and Owner’s representative. Commissioning reports showing the testing of each DDC point on the system shall be submitted to the Engineer for review and approval upon completion of the commissioning process.

F. All work performed under this section of the specifications shall comply with all codes, laws and governing bodies. If the drawings and/or specifications are in conflict with governing codes, the Contractor shall submit a proposal with appropriate modifications to the project for code compliance. If this specification and associated drawings exceed governing code requirements, the specification shall govern. The Contractor shall obtain and pay for all necessary construction permits and licenses.

1.11 TRAINING

A. The BAS Contractor shall provide on-site training to the Owner's representative and maintenance personnel per the following description:

1. Training shall consist of a minimum of 2-4 hours of hands-on instruction geared at the operation and maintenance of the systems. This shall be done over a minimum of Five (5) 8-hour sessions, 1 session per month for the 1st 5 months. Sessions can be held on-site or off-site (in a classroom environment) or in any combination as preferred by the owner. The final session shall occur at least one month prior to the end of the warranty period. Sessions can be videotaped by the owner if necessary. The A/E representative shall be present for at least one of the sessions. The curriculum shall include:

   a. System Overview
   b. System Software and Operation

      1) 1) System access
      2) 2) Software features overview
      3) 3) Changing setpoints and other attributes
      4) 4) Scheduling
      5) 5) Editing programmed variables
      6) 6) Displaying color graphics
      7) 7) Running reports
      8) 8) Workstation maintenance
      9) 9) Application programming

   c. Operational sequences including start-up, shutdown, adjusting and balancing.
   d. Equipment maintenance.

1.12 SYSTEM DESCRIPTION

A. The BAS shall consist of PC-based workstations and microcomputer controllers of modular design providing distributed processing capability and allowing future expansion of both input/output points and processing/control functions. Further, the system shall be the backbone framework for future Security/Card Access/CCTV system through the front-end software. For this project the system shall consist of the following components:

1. Operator Workstation(s): The BAS Contractor shall furnish, (1) Laptop Operator Workstation Computer(s), and (1) printer(s) as described in Part 2 of the specification. These workstations shall be running the standard workstation software developed and tested by the manufacturer of the network controllers and the standalone controllers. No third-party front-end workstation software will be acceptable.
2. Ethernet-based Network Controller(s): The BAS Contractor shall furnish Ethernet-based network controller as described in Part 2 of the specification. These controllers shall connect directly to the Operator Workstation over Ethernet, provide communication to the Standalone Digital Control Units and/or other Input/Output Modules and serve as a gateway to equipment furnished by others (if applicable).

3. Building and Application Specific Unit Control Units: Provide the necessary quantity and types to meet the requirements of the project for mechanical equipment control including air handlers, central plant control, and terminal unit control. Each shall operate completely standalone, containing all of the I/O and programs to control its associated equipment.

4. A high-speed Ethernet connection to the site shall be used for offsite access to the site. BAS contractor shall coordinate with the Owners IT professionals for high-speed system access and shall comply with Owner's requirements to maintain the level of security required by the Owner. Coordinate with Owner and provide VPN (Virtual Private Network) as required, to comply with the Owner's IT professional's requirements.

1.13 WORK BY OTHERS

A. The BAS Contractor shall cooperate with other contractors performing work on this project necessary to achieve a complete and neat installation. To that end, each contractor shall consult the drawings and specifications for all trades to determine the nature and extent of others' work.

B. The BAS Contractor shall furnish all control valves, sensor wells, flow meters and other similar equipment specified in this section for installation by the Mechanical Contractor.

C. The BAS Contractor shall provide field supervision to the designated contractor for the installation of the following:

1. Automatic Control Dampers
2. Automatic Control Valves.
3. Temperature Sensing Thermal Wells
4. Pressure Control Sensing Taps

1.14 WARRANTY AND ACCEPTANCE

A. The BAS subcontractor shall warrant the entire DDC control system (new and existing) installed or modified in this contract to be free from defects in material and workmanship, except for damages from other causes, for a period of one year after final acceptance from the owner. The microprocessor temperature control contractor shall be responsible for all necessary revisions to the software required for a workable system performance through the first three (3) year of operation. Any changes in the software shall be transmitted immediately to the owner. The software responsibility is for a complete and workable system as described in the control cycle description of the specification. The software shall become the property of the owner.

B. Updates to the manufacturer's software shall be provided at no charge during the warranty period, including labor to install updates.

C. All equipment required to maintain operation of the temperature control system for the project shall be stocked in the microprocessor temperature control contractor's local facility. It shall be immediately available in the event of component failure. A spare or loaner piece of equipment shall be installed immediately when a failure occurs and the equipment shall be returned to the factory for repair.

D. Prior to award of BAS contract, BAC contractor is to submit a proposal to provide all services, materials and the equipment necessary for preventative maintenance on the entire control system for a period of one, two and 3 years for review and approval by the owner. The work covered in this proposal shall include maintenance of the control equipment including all computer equipment, CPU, peripherals, transmission equipment, and related HVAC controllers and devices. Engineer/Owner have right to reject bids based on service contract review.

1.15 SUBMITTALS

A. Shop drawings shall include a riser diagram depicting locations of all controllers and workstations, with associated network wiring. Also included shall be individual schematics of each mechanical system, matching the format of the design/bid control schematics completely, showing all connected points with reference to their associated controller. Typical schematics will be allowed where appropriate.

1. Each drawing containing an equipment schematic shall contain a table indicating what equipment is covered by this drawing (i.e. equipment "tag #") and which drawing in the Construction Document set this piece of equipment is shown on.

B. Submittal data shall contain manufacturer's data on all hardware and software products required by the specification. Valve, damper and airflow station schedules shall indicate size, configuration, capacity and location of all equipment.

C. Software submittals shall contain narrative descriptions of sequences of operation, program listings, point lists, and a complete description of the graphics, reports, alarms and configuration to be furnished with the workstation software. Information shall be bound or in a three-ring binder with an index and tabs. Color printouts of proposed equipment graphics shall be included for all systems.

D. Submit five (5) copies of submittal data and shop drawings to the Engineer for review prior to ordering or fabrication of the equipment. Prior to submitting, the Contractor shall check all documents for accuracy.

E. The Engineer will make corrections, if required, and return to the Contractor. The Contractor shall then resubmit with the corrected or additional data. This procedure shall be repeated until all corrections are made to the satisfaction of the Engineer and the submittals are fully approved.

F. Each point in the system shall be tested for both hardware and software functionality. In addition, each mechanical and electrical system under control of the BAS shall be tested against the appropriate sequence of operation specified herein. Successful completion of the system test shall constitute the beginning of the warranty period. A written report shall be submitted to the owner indicating that the installed system functions in accordance with the plans and specifications.

G. The BAS contractor shall commission and set in operating condition all major equipment and systems, such as the hot water and all air handling systems, in the presence of the equipment manufacturer's representatives, as applicable, and the Owner's and Architect's representatives.

H. The BAS Contractor shall provide all manpower and engineering services required to assist the HVAC Contractor and Balancing Contractor in testing, adjusting, and balancing all systems in the building. The BAS Contractor shall have a trained technician available on request during the balancing of the systems. The BAS Contractor shall coordinate all requirements to provide a complete air balance with the Balancing Contractor and shall include all labor and materials in his contract.

1.16 OPERATING AND MAINTENANCE MANUALS

A. Controls contractor shall submit Five (5) sets of hardcopy O&M's with each set containing a CD with a single PDF file of the entire control system.

B. The operation and maintenance manuals shall contain all information necessary for the operation, maintenance, replacement, installation, and parts procurement for the entire BAS. This documentation shall include specific part numbers and software versions and dates. A complete list of recommended spare parts shall be included with the lead-time and expected frequency of use of each part clearly identified.

C. Following project completion and testing, the BAS contractor shall submit as-built drawings reflecting the exact installation of the system as well as floor plans indicating locations of HVAC equipment, sensor, controllers and OWS. The as-built documentation shall also include a copy of all application software in written form.

1.17 ACCEPTABLE MANUFACTURERS

A. Automated Logic Corporation (ALC)

Contact:
James Chesko
Air Temp.
(607) 772-8362
Email: jchesko@airtemphvac.com

PART 2 - PRODUCTS

2.1 UNACCEPTABLE BIDS

A. Acceptable manufacturer bids only. Bids by wholesalers, Mechanical Contractors, Electrical Contractors, or any other firm whose principal business is not that of manufacturing or installing automatic temperature control systems shall not be acceptable. BAS submittal packages that are not complete or take exception to any of the capabilities defined within these documents shall not be acceptable.

2.2 SYSTEM ARCHITECTURE

A. The BAS shall consist of Building Control Units (BCU), a family of standalone Application Specific Controllers (ASC), Input/Output Unit Modules (IOU Modules), Operator Workstations (OWs), and one File Server to support system configurations where more than one operator workstation is required. The BAS shall provide control, alarm detection, scheduling, reporting and information management for the entire facility, and Wide Area Network (WAN) if applicable, from a single ODBC-compliant database.

B. Level 1 Network Description: Level 1, the main backbone of the system, shall be an Ethernet LAN/WAN. Network Control Units, Operator Workstations, and the Central File Server shall connect directly to this network without the need for Gateway devices.

C. Level 2 Network Description: Level 2 of the system shall consist of one or more field buses managed by the Network Control Units. The Level 2 field buses may consist of one or both of the following types:

1. An RS485, token passing bus that supports up to 127 Terminal Control Units (SDCUs) for operation of HVAC equipment and lighting, or
2. An RS485 field bus that supports up to 32 devices from a family of plug-in, IOU modules.
3. These IOU modules may be mounted within the NCU enclosure or remotely mounted via a single, twisted, shielded pair of wires.

D. The BAS shall be capable of being segmented, through software, into multiple local area networks (LANs) distributed over a wide area network (WAN), sharing a single file server. This enables workstations to manage a single LAN (or building), and/or the entire system with all devices being assured of being updated by and sharing the most current database. In the case of a single workstation system, the workstation shall contain the entire database – with no need for a separate file server.

E. Standard Network Support: All BCUs, Workstation(s) and File Server shall be capable of residing directly on the Owner's Ethernet TCP/IP LAN/WAN with no required gateways. Furthermore, the BCU's, Workstation(s) and File Server shall be capable of using standard, commercially available, off-the-shelf Ethernet infrastructure components such as routers, switches and hubs. With this design, the Owner may use the investment of an existing or new enterprise network or structured cabling system. This also allows the option of the maintenance of the LAN/WAN to be performed by the Owner's Information Systems Department as all devices use standard TCP/IP components.

1. SNMP Support:
2. Remote Communications: In addition to the above LAN/WAN architecture support, the same workstation software (front end) shall be capable of managing remote systems via standard dial-up phone lines as a standard component of the software. Front-end "add-on" software modules to perform remote site communication shall not be acceptable.

F. System Expansion: The BAS system shall be scalable and expandable at all levels of the system using the same software interface, and the same Level 1 and Level 2 controllers. Systems that require replacement of either the workstation software or field controllers in order to expand the system shall not be acceptable.

1. The system shall use the same application programming language for all levels: Operator Workstation, Network Control Unit, Remote Site Control Unit and Standalone Digital Control Unit. Furthermore, this single programming language shall be used for all applications: environmental control, card access control, intrusion detection and security, lighting control, leak detection/underground storage tank monitoring, and digital data communication interfaces to third party microprocessor-based devices.

G. Support for Open Systems Protocols: The BAS design shall include solutions for the integration of the following "open systems" protocols: BACnet, Modbus, and digital data communication to third party microprocessors such as chiller controllers, fire panels and variable frequency drives (VFDs).

1. The system shall also provide the ability to program custom ASCII communication drivers, which shall reside in the NCU, for communication to third party systems and devices. These drivers shall provide real time monitoring and control of the third-party systems.

2.3 BUILDING CONTROLLER UNIT (BCU)

A. General: Building Control Units shall be microprocessor based, multi-tasking, multi-user, and employ a real-time operating system. Each BCU control panel shall consist of modular hardware including power supply, CPU board, and input/output modules. A sufficient number of BCU's shall be supplied to fully meet the requirements of this specification and the points list on the drawings.

B. Hardware Specifications:

1. Memory: A minimum of 4MB of RAM shall be provided for BCU's with expansion up to 8MB. The 8MB versions shall include a floating-point math co-processor.
2. Communication Ports: Each BCU shall provide communication to both the Workstation(s) and the field buses. In addition, each BCU shall have at least three other communications ports that support a telephone modem, portable service tool, serial printer and connection to third party controllers such as a chiller control panel. On a LAN/WAN system, the BCU shall be provided with a 10Mbps plug-in Ethernet TCP/IP network interface card (NIC).
3. Input/Output (I/O): Each BCU shall support the addition of the following types of inputs and outputs:

    a. Digital Inputs for status/alarm contacts
    b. Counter Inputs for summing pulses from meters.
    c. Thermistor inputs for measuring temperatures in space, ducts and thermos-wells.
    d. Analog inputs for pressure, humidity, flow and position measurements.
    e. Digital Outputs for on/off equipment control.

f. Analog Outputs for valve and damper position control, and capacity control of primary equipment.

4. Modular Expandability: The system shall employ a modular I/O design to allow easy expansion. Input and output capacity is to be provided through plug-in modules of various types or DIN-mountable IOU modules. It shall be possible to combine I/O modules as desired to meet the I/O requirements for individual control applications.
5. Real Time Clock (RTC): Each GC shall include a battery-backed, real-time clock, accurate to 10 seconds per day. The RTC shall provide the following: time of day, day, month, year, and day of week. In normal operation, the system clock shall be based on the frequency of the AC power. The system shall automatically correct for daylight savings time and leap years and be Year 2000 compliant.
6. Power Supply: The power supply for the BCU's shall be auto sensing, 120-220VAC, 60/50 Hz power, with a tolerance of +/- 20%. Line voltage below the operating range of the system shall be considered outages. The controller shall contain over voltage surge protection and require no additional AC power signal conditioning. Optionally, if indicated on the drawings, the power supply shall accept an input voltage of (–48 VDC).
7. Automatic Restart after Power Failure: Upon restoration of power after an outage, the BCU shall automatically and without human intervention: Update all monitored functions; resume operation based on current, synchronized time and status, and implement special start-up strategies as required.
8. Battery backup: Each BCU with the standard 120-220VAC power supply shall include a programmable DC power backup system rated for a minimum of 72 hours of battery backup to maintain all volatile memory or, a minimum of 2 hours of full UPS including modem power. This power backup system shall be configurable such that at the end of a settable timeframe (such as 1 hour) of running on full UPS, the unit shall shut off full UPS and switch to memory retention-only mode for the remainder of the battery power. The system shall allow the simple addition of more batteries to extend the above minimum battery backup times.

C. Software Specifications

1. General: The BCU shall contain flash ROM as the resident operating system. Application software shall be RAM resident. Application software shall only be limited by the amount of RAM memory. There shall be no restrictions placed on the type of application programs in the system. Each BCU shall be capable of parallel processing, executing all control programs simultaneously. Any program may affect the operation of any other program. Each program shall have the full access of all I/O facilities of the processor. This execution of control function shall not be interrupted due to normal user communications including interrogation, program entry, printout of the program for storage, etc.
2. User Programming Language: The application software shall be user programmable. This includes all strategies, sequences of operation, control algorithms, parameters, and setpoints. The source program shall be English language-based and programmable by the user. The language shall be structured to allow for the easy configuration of control programs, schedules, alarms, reports, telecommunications, local displays, mathematical calculations, passwords, and histories. The language shall be self-documenting. Users shall be able to place comments anywhere in the body of a program. Program listings shall be configurable by the user in logical groupings.

D. Control Software:

1. The BCU shall have the ability to perform the following pre-tested control algorithms:

   a. Proportional, Integral plus Derivative Control (PID)
   b. Two Position Control
   c. Digital Filter
   d. Ratio Calculator
   e. Equipment Cycling Protection

2. Mathematical Functions: Each controller shall be capable of performing basic mathematical functions (+, -, *, /), square roots, exponential, logarithms, Boolean logic statements, or combinations of both. The controllers shall be capable of performing complex logical statements including operators such as >, <, =, and, or, exclusive or, etc. These shall be able to be used in the same equations with the mathematical operators and nested up to five parentheses deep.
3. Energy Management Applications: BCU's shall have the ability to perform any or all of the following energy management routines:

   a. Time of Day Scheduling
   b. Calendar Based Scheduling
   c. Holiday Scheduling
   d. Temporary Schedule Overrides
   e. Optimal Start
   f. Optimal Stop
   g. Night Setback Control
   h. Enthalpy Switchover (Economizer)
   i. Peak Demand Limiting
   j. Temperature Compensated Duty Cycling

4. History Logging: Each controller shall be capable of logging any system variable over user defined time intervals ranging from 1 second to 1440 minutes. Any system variables (inputs, outputs, math calculations, flags, etc.) can be logged in history. A maximum of 32,767 values can be stored in each log. Each log can record either the instantaneous, average, minimum or maximum value of the point. Logs can be automatic or manual. Logged data shall be downloadable to the Operator Workstation for long term archiving based upon user-defined time intervals, or manual command.
5. Alarm Management: For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms shall be tested each scan of the BCU and can result in the display of one or more alarm messages or reports.

   a. Up to 8 alarms can be configured for each point in the controller.
   b. Messages and reports can be sent to a local terminal, to the front-end workstation(s), or via modem to a remote-computing device.
   c. Alarms shall be generated based on their priority. A minimum of 255 priority levels shall be provided.
   d. If communication with the Operator Workstation is temporarily interrupted, the alarm shall be buffered in the BCU. When communications return, the alarm shall

be transmitted to the Operator Workstation if the point is still in the alarm condition.

6. Reporting: The BCU shall be able to generate user-definable reports to a locally connected printer or terminal. The reports shall contain any combination of text and system variables. Report templates shall be able to be created by users in a word processing environment. Reports can be displayed based on any logical condition or through a user command.

2.4 TERMINAL UNIT CONTROLLER (TUC)

A. General: Standalone Terminal Control Units shall provide control of HVAC and lighting. Each controller shall have its own control programs and shall continue to operate in the event of a failure or communication loss to its associated BCU.

B. Memory: Control programs shall be stored in battery backed-up RAM and EPROM. Each controller shall have a minimum of 32K bytes of user RAM memory and 128K bytes of EPROM.

C. Communication Ports: Controllers shall provide a communication port to the field bus. In addition, a port shall be provided for connection of a portable service tool to support local commissioning and parameter changes with or without the BCU online. It shall be possible from a service port on any TUC to view, enable/disable, and modify values of any point or program on any controller on the local field bus, any BCU or any TUC on a different field bus.

D. Input/Output: Each TUC shall support the addition of the following types of inputs and outputs:

1. Digital Inputs for status/alarm contacts
2. Counter Inputs for summing pulses from meters.
3. Thermistor Inputs for measuring temperatures in space, ducts and thermos-wells.
4. Analog inputs for pressure, humidity, flow and position measurements.
5. Digital Outputs for on/off equipment control.
6. Analog Outputs for valve and damper position control, and capacity control of primary equipment.

E. Expandability: Input and output capacity shall be expandable through the use of plug-in modules. A minimum of two modules shall be added to the base TUC before additional power is required.

F. Networking: Each TUC shall be able to exchange information on a peer-to-peer basis with other Standalone Digital Control Units during each field bus scan. Each TUC shall be capable of storing and referencing global variables (on the LAN) with or without any workstations online. Each TUC shall be able to have its program viewed and/or enabled/disabled either locally through a portable service tool or through a workstation connected to a BCU.

G. Indicator Lamps: TUC's shall have as a minimum, LED indication of CPU status, and field bus status.

H. Real Time Clock (RTC): A TUC shall have a real time clock in either hardware or software. The accuracy shall be within 10 seconds per day. The RTC shall provide the following information: time of day, day, month, year, and day of week. Each TUC shall receive a signal every hour over the network from the BCU, which synchronizes all TUC real time clocks.

I. Automatic Restart After Power Failure: Upon restoration of power, the TUC shall automatically and without human intervention, update all monitored functions, resume operation based on current, synchronized time and status, and implement special start-up strategies as required.

J. Battery Back Up: Each TUC shall have at least 3 years of battery back up to maintain all volatile memory.

K. Alarm Management: For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms shall be tested each scan of the TUC and can result in the display of one or more alarm messages or reports.

1. Up to 8 alarms can be configured for each point in the controller enabling the escalation of the alarm priority (urgency) based upon which alarm(s) is/are triggered.
2. Alarm messages can be sent to a local terminal or modem connected to an BCU or to the Operator's Workstation(s).
3. Alarms shall be generated based on their priority. A minimum of 255 priority levels shall be provided.
4. If communication with the BCU is temporarily interrupted, the alarm shall be buffered in the TUC. When communications return, the alarm shall be transmitted to the BCU if the point is still in the alarm condition.

L. Rooftop Unit and Self-Contained Unit Controllers: RTU and Self-Contained Unit Controllers shall be provided and installed by unit manufacturer and capable of meeting the requirements of the sequence of operation found in the Execution portion of this specification and for future expansion.

1. RTU and Self-Contained Unit Controllers shall interface and support all the necessary point inputs and outputs as required by the sequence and operate in a standalone fashion.

M. Unitary Application Specific Controller:

1. Unitary Controllers shall support, but not be limited to, the control of the following systems as described in the Execution portion of this specification, and for future expansion:

   a. Hydronic Radiation
   b. Unit heaters

2. The I/O of each Unitary Controller shall contain the sufficient quantity and types as required to meet the sequence of operation found in the Execution portion of this specification. In addition, each controller shall have the capability for time-of-day scheduling, occupancy mode control, after hour operation, lighting control, alarming, and trending.

2.5 OPERATOR WORKSTATION REQUIREMENTS

A. General: The BAS workstation software shall be configurable as either a single workstation system (with a local database) or multi-workstation system where the database is located on a central file server. The client software on multi-workstation system shall access the file server database program via an Ethernet TCP/IP network running at either 10MBPS or 100MBPS.

1. The application software shall be capable of communication to all Controllers, feature high-resolution color graphics, alarming, reporting, and be user configurable for all data collection and data presentation functions.

B. Provide one (1) new Operator Workstation(s), New PC's shall consist of the following at a minimum:

1. Latitude D520: Intel® Core™ 2 Duo T5500 (1.66GHz) 2M L2 Cache, 667Mhz Dual Core, 512MB, DDR2-667 SDRAM, 1 DIMM, 80GB Hard Drive, 9.5MM, 5400RPM
2. 15-inch XGA LCD Panel
3. 24X CD-RW/DVD w/Cyberlink PowerDVD™
4. Dell Wireless™ 1390 802.11g Mini Card
5. Docking Solution: D/Port Advanced Port Replicator with External Monitor: Dell 17-inch E773c CRT Color Monitor (16.0 VIS), Mouse: Dell USB 2-Button Black Optical Mouse, External Keyboard: Dell USB Enhanced Multimedia Black Keyboard with built-in 2-port USB Hub
6. Operating Systems: Genuine Windows XP Professional, SP2, with media
7. Manufacturer Disks for Hard Drives and Video Adapters

C. Printer: Provide a workstation printer to display alarms and graphics. The printer is to be a HP Officejet Pro K550 color printer or equivalent.

2.6 OPERATOR WORKSTATION SOFTWARE

A. General Description:

1. The software architecture shall be object-oriented in design, a true 32-bit application suite utilizing Microsoft's OLE, COM, DCOM and ODBC technologies. These technologies shall make it easy to fully utilize the power of the operating system to share, among applications (and therefore to the users of those applications), the data available from the BAS.

a. The workstation functions shall include monitoring and programming of all BAS controllers. Monitoring consists of alarming, reporting, graphic displays, long-term data storage, automatic data collection, and operator-initiated control actions such as schedule and setpoint adjustments.
b. Programming of controllers shall be capable of being done either off-line or on-line from any operator workstation. All information shall be available in graphic or text displays. Graphic displays shall feature animation effects to enhance the presentation of the data, to alert operators of problems, and to facilitate location of information throughout the BAS. All operator functions shall be selectable through a mouse.

2. System Database: The file server database engine shall be Microsoft SQL Server, or another ODBC-compliant, relational database program. This ODBC (Open Database Connectivity) compliant database engine shall allow for an owner to utilize "their" choice of database and due to its "open" architecture, shall allow an owner to write custom applications and/or reports that communicate directly with the database avoiding data transfer routines to update other applications. The system database shall contain all point configurations and programs in each of the controllers that have been assigned to the network. In addition, the database shall contain all workstation files including color graphic, alarm reports, text reports, historical data logs, schedules, and polling records.
3. User Interface: The BAS workstation software shall allow the creation of a custom, browser-style interface linked to the user that has logged into the workstation software. This interface shall support the creation of "hot-spots" that the user may link to view/edit any object in the system or run any object editor or configuration tool contained in the software. Furthermore, this interface shall be able to be configured to become a user's "PC Desktop" – with all the links that a user needs to run other applications. This, along with the Windows 2000 user security capabilities, shall enable a system administrator to setup workstation accounts that not only limit the capabilities of the user within the BAS software but may also limit what a user can do on the PC and/or LAN/WAN. This might be used to ensure, for example, that the user of an alarm monitoring workstation is unable to shut-down the active alarm viewer and/or unable to load software onto the PC. At a minimum, provide the following graphics with all point values displayed dynamically:

    a. Site plan showing all buildings under control with a point and click capability to select any building to see additional detail. By selecting a building, floor plans shall be displayed showing the room numbers, and space temperatures. Space temperatures outside of a predefined range shall be displayed in a different color then temperatures within range. This graphic shall also include key plans of the entire building to allow point and click selection of other areas of the building in order to display the detailed floor plan for that area. Floor plans will be provided in .dxf or .dwg format by the Architect/Engineer. When the floor plans are displayed, the user shall be able to point and click on any room to bring up detail on the rooms terminal HVAC unit. Unit graphic shall include information on all the points provided for that particular unit such as fan status, mixed air temperatures, discharge temperature, damper position, valve position, current mode of operation, space setpoint, space temperature, etc. Buttons shall also be available to bring up graphics displaying similar items for central equipment such as Air Handling Units, Boiler Plant, Chiller Plant, etc.

4. User Security: The software shall be designed so that each user of the software can have a unique username and password. This username/password combination shall be linked to a set of capabilities within the software, set by and editable only by, a system administrator. The sets of capabilities shall range from View only, acknowledge alarms, Enable/disable and change values, Program, and Administer. The system shall allow the above capabilities to be applied independently to each and every class of object in the system. The system shall allow a minimum of 256 users to be configured per workstation. There shall be an inactivity timer adjustable in software that automatically logs off the current operator after the timer has expired.

5. Configuration Interface: The workstation software shall use a familiar Windows Explorer style interface for an operator or programmer to view and/or edit any object (controller, point, alarm, report, schedule, etc.) in the entire system. In addition, this interface shall present a "network map" of all controllers and their associated points, programs, graphics, alarms, and reports in an easy to understand structure. All object names shall be alphanumeric and use Windows long filename conventions. Object names shall not be required to be unique throughout the system allowing for point naming convention consistency. For example, each VAV controller can have an input called Space Temperature and a setpoint called CFM Setpoint. The VAV controller name shall be unique such as VAV Day Room 120.

    a. The configuration interface shall also include support for template objects. These template objects shall be used as building blocks for the creation of the BAS database. The types of template objects supported shall include all data point types (input, output, string variables, setpoints, etc.), alarm algorithms, alarm notification objects, reports, graphics displays, schedules, and programs. Groups of template object types shall be able to be set up as template subsystems and systems. The template system shall prompt for data entry if necessary. The template system shall maintain a link to all "child" objects created by each template. If a user wishes to make a change to a template object, the software shall ask the user if he/she wants to update all of child objects with the change. This template system shall facilitate configuration and programming consistency and afford the user a fast and simple method to make global changes to the BAS.

6. Color Graphic Displays: The system shall allow for the creation of user defined, color graphic displays for the viewing of mechanical and electrical systems or building schematics. These graphics shall contain point information from the database including any attributes associated with the point (engineering units, etc.). In addition, operators shall be able to command equipment or change setpoints from a graphic using the mouse. Requirements of the color graphic subsystem include:

    a. SVGA, bit-mapped displays. The user shall have the ability to import AutoCAD generated picture files as background displays.
    b. A built-in library of animated objects such as dampers, fans, pumps, buttons, knobs, gauges, and graphs that can be "dropped" on a graphic using a software configuration "wizard". These objects shall enable operators to interact with the graphic displays in a manner that mimics their mechanical equivalents found on field installed control panels. Using the mouse, operators shall be able to adjust setpoints, start or stop equipment, modify PID loop parameters, or change schedules.
    c. Status changes or alarm conditions shall be able to be highlighted by objects changing screen location, size, color, text, blinking or changing from one display to another.
    d. Graphic panel objects shall be able to be configured with multiple "tabbed" pages allowing an operator to quickly view individual graphics of equipment, which make up a subsystem or system.
    e. Ability to link graphic displays through user-defined objects, alarm testing, or the result of a mathematical expression. Operators shall be able to change from one graphic to another by selecting an object with a mouse - no menus will be required.

7. Automatic monitoring: The software shall allow for the automatic collection of data and reports from any controller through either hardwire or modem communication link. The frequency of data collection shall be completely user configurable.
8. Alarm Management: The software shall be capable of accepting alarms directly from controllers, or generating alarms based on evaluation of data in controllers and comparing to limits or conditional equations configured through the software. Any alarm (regardless of its origination) shall be integrated into the overall alarm management system and shall appear in all standard alarm reports, be available for operator acknowledgement, and have the option for displaying graphics, or reports. Alarm management features shall include:

    a. A minimum of 255 alarm notification levels, or classes of alarms. Each notification level shall establish a unique set of parameters for controlling alarm display, acknowledgement, keyboard annunciation, alarm printout and record keeping.
    b. Automatic logging in the database of the alarm message, point name, point value, connected controller, timestamp, username and time of acknowledgement, username and time of alarm silence (soft acknowledgement)
    c. Automatic printing of the alarm information or alarm report to an alarm printer or report printer.
    d. Playing an audible beep or audio (wav) file on alarm initiation or return to normal.
    e. Sending an email or alphanumeric page to anyone listed in a workstation's email account address list on either the initial occurrence of an alarm and/or if the alarm is repeated because an operator has not acknowledged the alarm within a user-configurable timeframe. The ability to utilize email and alphanumeric paging of alarms shall be a standard feature of the software integrated with the operating system's mail application interface (MAPI). No special software interfaces shall be required.
    f. Individual alarms shall be able to be re-routed to a workstation or workstations at user-specified times and dates. For example, a critical high temperature alarm can be configured to be routed to a Facilities Dept. workstation during normal working hours (7am-6pm, Mon-Fri) and to a Central Alarming workstation at all other times.
    g. An active alarm viewer shall be included which can be customized for each user or user type to hide or display any alarm attributes.
    h. The font type and color, and background color for each alarm notification level as seen in the active alarm viewer shall be customizable to allow easy identification of certain alarm types or alarm states.
    i. The active alarm viewer can be configured such that an operator shall type in text in an alarm entry and/or pick from a drop-down list of user actions for certain alarms. This ensures accountability (audit trail) for the response to critical alarms.

9. Custom Report Generation: The software shall contain a built-in custom report generator, featuring word processing tools for the creation of custom reports. These custom reports shall be able to be set up to automatically run or be generated on demand. Each workstation shall be able to associate reports with any word processing or spreadsheet program loaded on the machine. When the report is displayed, it shall automatically spawn the associated report editor such as MS Word, WordPerfect, NotePad, or Lotus 123.

a. Reports can be of any length and contain any point attributes from any controller on the network.
b. The report generator shall have access to the user programming language in order to perform mathematical calculations inside the body of the report, control the display output of the report, or prompt the user for additional information needed by the report.
c. It shall be possible to run other executable programs whenever a report is initiated.
d. Report Generator activity can be tied to the alarm management system, so that any of the configured reports can be displayed in response to an alarm condition.

e. Standard reports shall include:

1) Points in each controller
2) Points in alarm
3) Disabled points
4) Overridden points
5) Operator activity report
6) Alarm history log
7) Program listing by controller with status
8) Network status of each controller

10. Spreadsheet-style reports: The software shall allow the simple configuration of row/column (spreadsheet-style) reports on any class of object in the system. These reports shall be user-configurable and shall be able to extract live (controller) data and/or data from the database. The user shall be able to set up each report to display in any text font, color and background color. In addition, the report shall be able to be configured to filter data, sort data, and highlight data that meets user-defined criteria.
11. HTML Reporting: The above spreadsheet-style reports shall be able to be run to an HTML template file. This feature shall create an HTML "results" file in the directory of the HTML template. This directory can be shared with other computer users, which shall allow those users with access to the directory to "point" their web browser at the file and view the report.
12. Scheduling: It shall be possible to configure and download from the workstation schedules for any of the controllers on the network.

a. Time of day schedules shall be in a calendar style and shall be programmable for a minimum of one year in advance. Each standard day of the week and user-defined day types shall be able to be associated with a color so that when the schedule is viewed it is very easy, at-a-glance, to determine the schedule for a particular day even from the yearly view. To change the schedule for a particular day, a user shall simply click on the day and then click on the day type.
b. Each schedule shall appear on the screen viewable as the entire year, monthly, week and day. A simple mouse click shall allow switching between views. It shall also be possible to scroll from one month to the next and view or alter any of the schedule times.
c. Schedules shall be assigned to specific controllers and stored in their local RAM memory. Any changes made at the workstation shall be automatically updated to the corresponding schedule in the controller.

13. Programmer's Environment: The programmer's environment shall include access to a superset of the same programming language supported in the controllers. In this environment, the programmer shall be able to configure application software off-line (if desired) for custom program development, write global control programs, system reports, wide area networking data collection routines, and custom alarm management software. On the same screen as the program editor, the programming environment shall include dock-able debug and watch bars for program debugging and viewing updated values and point attributes during programming. In addition, a wizard tool shall be available for loading programs from a library file in the program editor.
14. Saving/Reloading: The workstation software shall have an application to save and restore field controller memory files. This application shall not be limited to saving and reloading an entire controller – it shall also be able to save/reload individual objects in the controller. This allows off-line debugging of control programs, for example, and then reloading of just the modified information.
15. Data Logging: The workstation software shall have the capability to easily configure groups of data points with trend logs and display the trend log data. A group of data points shall be created by drag-and-drop method of the points into a folder. The trend log data shall be displayed through a simply menu selection. This data shall be able to be saved to file and/or printed.
16. Audit Trail: The workstation software shall automatically log and timestamp every operation that a user performs at a workstation, from logging on and off a workstation to changing a point value, modifying a program, enabling/disabling an object, viewing a graphic display, running a report, modifying a schedule, etc.
17. Fault Tolerant File Server Operation: The system shall provide the option to provide fault tolerant operation in the event of the loss of the CPU, disk drives, or other hardware required to maintain the operational integrity of the system. Operational integrity includes all user interfaces, monitoring of alarm points and access points, and executing access control functions. Fault tolerant technology is not provided unless specifically stated.

    a. The switchover mechanism provided shall be automatic. Should the failure be caused by hardware, then the system shall immediately switch to the Backup computer. Should the system failure be caused by software (instruction or data), the system shall not pass the faulted code to the Backup computer, otherwise the Backup shall fail in the same manner of the Primary computer.
    b. Switchover to the Backup computer shall be initiated and effective (complete) in a manner and time frame that precludes the loss of event data, and shall be transparent to the system users, except for an advisory alarm message indicating that the switchover has occurred.
    c. When the system fails-over from the Primary to the Backup computer, no alarm or other event shall be lost, and the Backup computer shall take control of all system functions.
    d. A single component failure in the system shall not cause the entire system to fail. All system users shall be informed of any detectable component failure via an alarm event. System users shall not be logged off as a result of a system failure or switchover.
    e. The Primary computer shall provide continual indication that the Backup computer is unavailable until such time that the fault has been purged.

2.7 FIELD DEVICES

A. General: Where indicated on the drawings, schedules or sequence of operations, provide equipment that conforms to the following specifications:

B. Temperature Sensors:

1. All temperature devices shall use precision thermistors accurate to +/- 0.36°F over a range of –30 to 230°F.
2. In all area's a standard space sensor shall be provided in an off-white enclosure for mounting on a standard electrical box, provide a push button for selecting after hours operation, provide slider with warmer/colder adjustment.
3. Duct temperature sensors shall incorporate a thermistor bead embedded at the tip of a stainless-steel tube. Probe style duct sensors shall be used in air handling applications where the air stream temperature is consistent and is not stratified.
4. Averaging sensors shall be employed in all mixing plenum applications and in any other application where the temperature might otherwise be stratified. The averaging sensor tube shall contain at least four thermistor sensors.
5. Immersion sensors shall be employed for measurement of temperature in all chilled water, hot water and glycol applications. Thermal wells shall be brass or stainless steel for non-corrosive fluids below 250 degrees F and 300 series stainless steel for all other applications.

C. Humidity Sensors:

1. Humidity sensors shall be polymer resistance type.
2. Space humidity sensors shall have a sensing range of 05 to 95% with accuracy of +/- 3% RH.
3. Duct sensors and Outdoor air humidity sensors shall have a sensing range of 05 to 95% RH with accuracy of +/- 3% RH. Sensors shall be suitable for ambient temperature conditions of -40 to 212°F.
4. Equipment shall be able to demonstrate that accuracy is NIST traceable calibration.

D. Enthalpy Sensor:

1. Temperature Ratings: -25°F to 125°F, humidity ratings 5% to 95% RH, power supply 24 vac, 50/60 Hz, power consumption 5.5 VA. Design basis Honeywell C7400.

E. Static Pressure Sensor:

1. Accuracy of 1% FS, output signal 4-20 mA or 0-5 Vdc as required, plastic cover for wall mount applications. Design Basis Setra Model 264.

F. Electronic Damper and Valve Actuator:

1. 24 VAC, fully modulating, spring return.
2. Design Basis Belimo:

   a. Series TR, LR, AR for CCV control valves.
   b. Series NVF for G2/G3 control valves.

c. Series AF for F6/F7 control valves.

G. Two and Three-Way control valves:

1. Temperature and pressure requirements as per the Basis of Design valves below:

a. Design Basis Belimo CCV B2/B3 Series for valves under 1”
b. Design Basis Belimo G2/G3 Series for valves under 1-2”
c. Design Basis Belimo F6/F7 Series for valves over 2”

2. For valves greater than 2”, globe body, ANSI Class 125, rated for 250°F and 365 psig. Glove style flange. For use in up to 200°F heating water service. Design Basis Belimo NV Series.
3. Three-way valves designed and manufactured specifically for mixing or diverting applications as indicated on drawings.
4. Close-off pressure shall be no less than 200psi for valves under 2”.

H. Water flow sensor:

1. Field adjustable setpoint, 220°F maximum temperature, snap switch, brass body, and water-proof enclosure. Design Basis Flotect Series V6.

I. Air temperature high limit:

1. Manual reset dpdt, setpoint temperature 125°F. Design Basis Johnson ak70kal.

J. Air temperature low limit:

1. Manual reset, 20-foot capillary element dpdt, sensitive to lowest temperature, set point adjustable. Design Basis Kreuter Model CTE-3017.

K. Aquastat:

1. Strap on type, circulating control and high limit or low limit, maximum water temperature 200 degrees F, Design Basis Powers 141-0519.

L. Electric Thermostat:

1. Forward or reverse acting, line voltage, bimetallic element, snap action, temperature range 50-90 degrees, include subbase for reverse acting applications with hand-off auto switch. Design Basis Dynacon TE Series.

M. Thermostat/Space Sensor Guard:

1. Clear lexon lockable type for programmable thermostats, clear plastic tamper proof for sensors and pneumatic or electric thermostats. Design Basis STI.

N. Electrical Power Current Sensor:

1. Amperage rating 0-135 amps continuous, trip setpoint .5 amps, NEMA enclosure, mounting bracket, output signal 4-20 mA. Design Basis Hawkeye Model H-800.

O. Pipe Water Temperature Sensor:

1. Accuracy of +/- 0.5°F at 77°F, probe type well sensor sized for pipe as required. Design Basis Greyston TE Series.

P. Pressure Sensors:

1. Air pressure or differential pressure measurements in the range of 0 to 10" water column shall be accurate to +/- 1% of range using a solid-state sensing element. The range of the instrument selected shall be 2 times the operating pressure of the sensed variable. Acceptable manufacturer shall be Setra model C-264.
2. Liquid pressure or differential pressure measurements shall be accurate to +/- 0.25% of range using a solid-state sensing element. The range of the instrument selected shall be 2 times the operating pressure of the sensed variable. Acceptable manufacturer shall be Setra model C-230.

PART 3 - EXECUTION

3.1 CONTRACTOR RESPONSIBILITIES

A. General: Installation of the building automation system shall be performed by the Temperature Controls Contractor or a Subcontractor. However, all installation shall be under the personal supervision of the Temperature Controls Contractor. The Temperature Controls Contractor shall certify all work is proper and complete. The design, scheduling, coordination, programming, training, and warranty requirements for the project be performed by the Temperature Controls Contractor.

B. Demolition: Remove controls that do not remain as part of the building automation system, including all associated abandoned wiring, conduit, and pneumatic tubing. The Owner will inform the Contractor of any equipment that is to be removed that will remain the property of the Owner. This equipment shall be handled with care so as not to damage it. All other equipment that is removed shall be disposed of by the Contractor.

C. Cleanup: At the completion of the work, all equipment pertinent to this section shall be checked and thoroughly cleaned, and all other areas shall be cleaned around equipment provided under this section. Clean the exposed surfaces of tubing, hangers, and other exposed metal of grease, plaster, or other foreign materials.

3.2 WIRING, CONDUIT AND CABLE

A. All high voltage wiring (50 volts and greater) and conduit is to be installed in accordance with local and national electrical codes and Division 16 (Electrical division) specification.

B. All temperature control cable less than 50 volts is to be considered low voltage.

C. All low voltage cable is to be run in EMT or flexible conduit within mechanical rooms. Wiring in accessible areas (above ceilings, crawl spaces) may be run exposed, not in conduit, with proper support with bridle rings. Wiring is to be run parallel and perpendicular to building lines in a neat and workmanlike manner and bundled with nylon tie wraps.

D. Conduit sleeves shall be run through any concrete or block walls for low voltage cable to be run through such walls.

E. All low voltage cable shall be run separate from high voltage cable. All microprocessor communications cable shall be run separate from any low or high voltage cable.

F. Any cable running in plenum rated areas shall be plenum rated cable.

G. Coaxial cable shall conform to RG62 or RG59 rating. Provide plenum rated coaxial cable when running in return air plenums.

H. Fiber optic cable shall include the following sizes; 50/125, 62.5/125 or 100/140.

I. Only glass fiber is acceptable, no plastic will be allowed.

J. Fiber optic cable shall only be installed and terminated by an experienced contractor.

K. Wires and tubing shall be installed a minimum of three (3) inches from hot water, steam, or condensate piping.

L. A true earth ground shall be available in the building. Ground shall be run from the source electrical panel ground to each temperature control panel or controller.

M. Metallic surface raceway may be used in finished areas on non-accessible masonry walls AS APPROVED BY OWNER AND/OR ARCHITECT/ENGINEER. All surface raceway in finished areas shall be color matched to the existing finish within the limitations of standard manufacturer's colors.

3.3 SPACE SENSOR/THERMOSTAT MOUNTING HEIGHTS

A. Mount all space sensors and/or space thermostats at four feet above finished floor, unless noted otherwise on drawings.

3.4 HARDWARE INSTALLATION

A. Installation Practices for Field Devices

1. Actuators shall be firmly mounted to give positive movement, and linkage shall be adjusted to give smooth continuous movement throughout 100 percent of the actuator stroke.

2. Actuators shall be stroked ~5%, tightened and returned to normal position to give a positive seal.
3. Relay outputs shall include transient suppression across all coils. Suppression devices shall limit transients to 150% of the rated coil voltage.
4. Waterline mounted sensors shall be removable without shutting down the system in which they are installed.
5. For duct static pressure sensors, the high-pressure port shall be connected to a metal static pressure probe inserted into the duct pointing upstream. The low-pressure port shall be left open to the plenum area at the point that the high-pressure port is tapped into the ductwork.
6. For building static pressure sensors, the high-pressure port shall be inserted into the space via a metal tube. The low-pressure port shall be piped to the outside of the building.

B. Enclosures:

1. For all I/O requiring field interface devices, these devices where practical shall be mounted in a field interface panel (FIP). The Contractor shall provide an enclosure that protects the device(s) from dust and moisture and conceals integral wiring and moving parts.
2. FIPs shall contain power supplies for sensors, interface relays and contractors, safety circuits, and I/P transducers.
3. The FIP enclosure shall be of steel construction with baked enamel finish, NEMA 1 rated with a hinged door and keyed lock. All locks shall be keyed identically.
4. All outside mounted enclosures shall meet the NEMA-4 rating.

3.5 SOFTWARE INSTALLATION

A. General: The Contractor shall provide all labor necessary to install, initialize, start-up and debug all system software as described in this section. This includes any operating system software or other third-party software necessary for successful operation of the system.

B. Database Configuration: The Contractor shall provide all labor to configure those portions of the database that are required by the points list and sequence of operation.

C. Color Graphic Slides: Unless otherwise directed by the owner, the Contractor shall provide color graphic displays as depicted in the mechanical drawings for each system and floor plan. For each system or floor plan, the display shall contain the associated points identified in the point list and allow for setpoint changes as required by the Owner.

D. Reports: The Contractor shall configure a minimum of 4 reports for the owner as listed below:

1. Unit Ventilator Status Report
2. Space Temperature Report
3. Specialty Equipment Status Report

E. Documentation: As built software documentation shall include the following:

1. Descriptive point lists
2. Application program listing

3. Application programs with comments
4. Printouts of all reports
5. Alarm list
6. Printouts of all graphics

3.6 EXISTING CONTROL DEVICES

A. The bid for the control work shall be based on the premise that existing control devices (i.e. valves & damper operators) are operational and are not in need of repair or replacement, unless otherwise noted.

B. This contractor shall notify the Owner's Representative of existing control devices that need to be replaced or repaired that may be noticed in the process of installation of new work.

3.7 COMMISSIONING AND SYSTEM STARTUP

A. Point to Point Checkout: Each I/O device (both field mounted and those located in FIPs) shall be inspected and verified for proper installation and functionality. A checkout sheet itemizing each device shall be filled out, dated and approved by the Project Manager for submission to the owner or owner's representative.

B. Controller and Workstation Checkout: A field checkout of all controllers and front-end equipment (computers, printers, modems, etc.) shall be conducted to verify proper operation of both hardware and software. A checkout sheet itemizing each device and a description of the associated tests shall be prepared and submitted to the Owner or Owner's representative by the completion of the project.

1. System Acceptance Testing:

   a. All application software shall be verified and compared against the sequences of operation. Control loops shall be exercised by inducing a setpoint shift of at least 10% and observing whether the system successfully returns the process variable to setpoint. Record all test results and attach to the Test Results Sheet.
   b. Test each alarm in the system and validate that the system generates the appropriate alarm message, that the message appears at all prescribed destinations (workstations or printers), and that any other related actions occur as defined (i.e. graphic panels are invoked, reports are generated, etc.). Submit a Test Results Sheet to the Owner.
   c. Perform an operational test of each unique graphic display and report to verify that the item exists, that the appearance and content are correct, and that any special features work as intended. Submit a Test Results Sheet to the Owner.
   d. Perform an operational test of each third-party interface that has been included as part of the automation system. Verify that all points are properly polled, that alarms have been configured, and that any associated graphics and reports have been completed. If the interface involves a file transfer over Ethernet, test any logic that controls the transmission of the file, and verify the content of the specified information.

3.8 FAN SHUTDOWN

A. All units connected to and controlled by the building DDC control system shall have shutdown provided by the DDC control system.

B. Duct smoke detectors shall be provided and wired to the fire alarm system by the Electrical Contractor for all units of 2000 cfm or greater or as indicated on the drawings.

C. Fire alarm contractor shall be responsible for all fan shut down on fire alarm.

3.9 CONTROL SEQUENCES

A. Refer to specification 23 09 93. Work required includes but is not limited to what is indicated. Refer to Paragraph 1.1.

END OF SECTION 23 09 00

SECTION 23 09 23 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Section 23 09 13.23 - Sensors and Transmitters

1. Hydronic temp sensor wells and sockets

B. Section 23 09 13.33 - Control Valves

1. Control valves

1.2 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

A. None

1.3 PPRODUCTS NOT FURNISHED OR INSTALLED UNDER BUT INTEGRATED WITH THE WORK OF THIS SECTION

A. None

1.4 RELATED SECTIONS

A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.

B. The following sections constitute related work:

1. Section 23 05 00 - Common Work Results for HVAC
2. Section 23 05 66 – Anti Microbial Ultraviolet Emitters for HVAC
3. Section 23 21 16 - HVAC Piping
4. Section 23 21 23 – HVAC Pumps
5. Section 23 31 13 – Ductwork
6. Section 23 33 10 – Ductwork Accessories
7. Section 23 34 23 – HVAC Power Ventilators
8. Section 23 36 00 – Air Terminal Units
9. Section 23 40 00 - HVAC Air Cleaning Devices
10. Section 23 57 00 – Heat Exchangers
11. Section 23 74 00 – Packaged Rooftop Units
12. Section 23 81 26 – Ductless Split Systems
13. Section 23 82 00 – Hydronic Terminal Heating Units

1.5 DESCRIPTION

A. General: The control system shall consist of a high-speed, peer-to-peer network of DDC controllers, a control system server, and a web-based operator interface.

B. System software shall be based on a server/thin client architecture, designed around the open standards of web technology. The control system server shall be accessed using a Web browser over the control system network, the owner's local area network, and (at the owner's discretion) over the Internet. The intent of the thin-client architecture is to provide operators complete access to the control system via a Web browser. No special software other than a web browser shall be required to access graphics, point displays, and trends, configure trends, configure points and controllers, or download programming into the controllers.

C. System shall use the BACnet protocol for communication to the operator workstation or web server and for communication between control modules. I/O points, schedules, setpoints, trends and alarms specified in 23 09 93 – "Sequence of Operations for HVAC Controls" shall be BACnet objects.

D. All new HVAC equipment and systems shall be provided with new DDC controls and be an extension of the existing Automated Logic system (ALC).

E. Existing HVAC equipment in the Middle School which are currently not on the ALC system shall be converted under this project. See Appendix C.

1.6 APPROVED CONTROL SYSTEM MANUFACTURERS

A. The following are approved control system suppliers, manufacturers, and product lines:

Supplier	Manufacturer	Product Line
Any	Automated Logic Corporation	WebCTRL

The above list does not indicate order of preference. Inclusion on this list does not guarantee acceptance of products or installation. Control systems shall comply with the terms of this specification.

1. The Contractor shall use only operator workstation software, controller software, custom application programming language, and controllers from the corresponding manufacturer and product line unless Owner approves use of multiple manufacturers.
2. Other products specified herein (such as sensors, valves, dampers, and actuators) need not be manufactured by the above manufacturers.

1.7 QUALITY ASSURANCE

A. Installer and Manufacturer Qualifications

1. Installer shall have an established working relationship with Control System Manufacturer.

2. Installer shall have successfully completed Control System Manufacturer's control system training. Upon request, Installer shall present record of completed training including course outlines.

1.8 CODES AND STANDARDS

A. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with the current editions in effect 30 days prior to the receipt of bids of the following codes:

1. National Electric Code (NEC)
2. International Building Code (IBC)

    a. Section 719 Ducts and Air Transfer Openings
    b. Section 907 Fire Alarm and Detection Systems
    c. Section 909 Smoke Control Systems
    d. Chapter 28 Mechanical

3. International Mechanical Code (IMC)
4. ANSI/ASHRAE Standard 135, BACnet - A Data Communication Protocol for Building Automation and Control Systems

1.9 SYSTEM PERFORMANCE

A. Performance Standards: System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).

1. Graphic Display: A graphic with 20 dynamic points shall display with current data within 10 sec.
2. Graphic Refresh: A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.
3. Configuration and Tuning Screens: Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.
4. Object Command: Devices shall react to command of a binary object within 2 sec. Devices shall begin reacting to command of an analog object within 2 sec.
5. Alarm Response Time: An object that goes into alarm shall be annunciated at the workstation within 45 sec.
6. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.
7. Performance: Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.
8. Multiple Alarm Annunciation: Each workstation on the network shall receive alarms within 5 sec of other workstations.

9. Reporting Accuracy: System shall report values with minimum end-to-end accuracy listed in Table 1.
10. Control Stability and Accuracy: Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2.

Table-1

Reporting Accuracy

Measured Variable	Reported Accuracy
Space Temperature	±0.5ºC (±1ºF)
Ducted Air	±0.5ºC (±1ºF)
Outside Air	±1.0ºC (±2ºF)
Dew Point	±1.5ºC (±3ºF)
Water Temperature	±0.5ºC (±1ºF)
Delta-T	±0.15º (±0.25ºF)
Relative Humidity	±5% RH
Water Flow	±2% of full scale
Airflow (terminal)	±10% of full scale (see Note 1)
Airflow (measuring stations)	±5% of full scale
Airflow (pressurized spaces)	±3% of full scale
Air Pressure (ducts)	±25 Pa (±0.1 in. w.g.)
Air Pressure (space)	±3 Pa (±0.01 in. w.g.)
Water Pressure	±2% of full scale (see Note 2)
Electrical	±1% of reading (see Note 3)
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO2)	±50 ppm

Note 1: Accuracy applies to 10%–100% of scale
Note 2: For both absolute and differential pressure
Note 3: Not including utility-supplied meters

Table 2

Control Stability and Accuracy

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±50 Pa (±0.2 in. w.g.) ±3 Pa (±0.01 in. w.g.)	0–1.5 kPa (0–6 in. w.g.) -25 to 25 Pa (-0.1 to 0.1 in. w.g.)
Airflow	±10% of full scale	
Space Temperature	±1.0ºC (±2.0ºF)	
Duct Temperature	±1.5ºC (±3ºF)	
Humidity	±5% RH	
Fluid Pressure	±10 kPa (±1.5 psi) ±250 Pa (±1.0 in. w.g.)	MPa (1–150 psi) 0–12.5 kPa (0–50 in. w.g.) differential

1.10 SUBMITTALS

A. Product Data and Shop Drawings: The contractor shall provide shop drawings or other submittals on hardware, software, and equipment to be installed or provided. No work may begin on any segment of this project until submittals have been approved for conformity with design intent. Provide drawings as AutoCAD compatible files on magnetic or optical disk (file format: .DWG, .DXF, .VSD, or comparable) and three 11" x 17" prints of each drawing. When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawing shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work. Submittal approval does not relieve Contractor of responsibility to supply sufficient quantities to complete work. Submittals shall be provided within 12 weeks of contract award. Submittals shall include:

1. DDC System Hardware

   a. A complete bill of materials to be used indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.
   b. Manufacturer's description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below and for relevant items not listed below:

      1) Direct digital controllers (controller panels)
      2) Transducers and transmitters
      3) Sensors (including accuracy data)
      4) Actuators
      5) Valves
      6) Relays and switches
      7) Control panels
      8) Power supplies
      9) Batteries
      10) Operator interface equipment
      11) Wiring

   c. Wiring diagrams and layouts for each control panel: Show termination numbers.
   d. Schematic diagrams for all field sensors and controllers: Provide floor plans of all sensor locations and control hardware. Riser diagrams showing control network layout, communication protocol, and wire types.

2. Central System Hardware and Software

   a. A complete bill of material of equipment used indicating quantity, manufacturer, model number, and relevant technical.
   b. Manufacturer's description and technical data such as product specifications and installation and maintenance instructions for items listed below and for relevant items furnished under this contract not listed below:

      1) Central Processing Unit (CPU) or web server

2) Monitors
3) Keyboards
4) Power supplies
5) Battery backups
6) Interface equipment between CPU or server and control panels
7) Operating System software
8) Operator interface software
9) Color graphic software
10) Third-party software

c. Schematic diagrams for all control, communication, and power wiring: Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show interface wiring to control system.
d. Network riser diagrams of wiring between central control unit and control panels.

3. Controlled Systems

a. Riser diagrams showing control network layout, communication protocol, and wire types.
b. A schematic diagram of each controlled system: The schematics shall have all control points labeled with point names shown or listed. The schematics shall graphically show the location of all control elements in the system.
c. A schematic wiring diagram of each controlled system: Label control elements and terminals. Where a control element is also shown on control system schematic, use the same name.
d. An instrumentation list (Bill of Materials) for each controlled system: List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.
e. A mounting, wiring, and routing plan-view drawing. The design shall take into account HVAC, electrical, and other systems' design and elevation requirements. The drawing shall show the specific location of all concrete pads and bases and any special wall bracing for panels to accommodate this work.
f. A complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system.
g. A point list for each control system: List I/O points and software points specified in Section 23 09 93. Indicate alarmed and trended points.

4. Quantities of items submitted shall be reviewed but are the responsibility of the Contractor.
5. A description of the proposed process along with all report formats and checklists to be used in Section 23 09 23 Article3.17 (Control System Demonstration and Acceptance).
6. BACnet Protocol Implementation Conformance Statement (PICS) for each submitted type of controller and operator interface.

B. Schedules

1. Within one month of contract award, provide a schedule of the work indicating the following:

a. Intended sequence of work items
b. Start date of each work item
c. Duration of each work item
d. Planned delivery dates for ordered material and equipment and expected lead times
e. Milestones indicating possible restraints on work by other trades or situations

2. Monthly written status reports indicating work completed and revisions to expected delivery dates. Include updated schedule of work.

C. Project Record Documents: Upon completion of installation, submit three copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and shall include:

1. Project Record Drawings: As-built versions of submittal shop drawings provided as AutoCAD compatible files on magnetic or optical media (file format: .DWG, .DXF, .VSD, or comparable) and as 11" x 17" prints.
2. Testing and Commissioning Reports and Checklists: Completed versions of reports, checklists, and trend logs used to meet requirements of Section 23 09 23 Article3.17 (Control System Demonstration and Acceptance).
3. Operation and Maintenance (O&M) Manual.
4. As-built versions of submittal product data.
5. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
6. Operator's manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.
7. Programming manual or set of manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
8. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
9. Documentation of programs created using custom programming language including setpoints, tuning parameters, and object database. Electronic copies of programs shall meet this requirement if control logic, setpoints, tuning parameters, and objects can be viewed using furnished programming tools.
10. Graphic files, programs, and database on magnetic or optical media.
11. List of recommended spare parts with part numbers and suppliers.
12. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
13. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation or web server software, and graphics software.
14. Licenses, guarantees, and warranty documents for equipment and systems.
15. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

D. Training Materials: Provide course outline and materials for each class at least six weeks before first class. Training shall be furnished via instructor-led sessions, computer-based training, or web-based training. Engineer will modify course outlines and materials if necessary to meet Owner's needs. Engineer will review and approve course outlines and materials at least three weeks before first class.

1.11 WARRANTY

A. Warrant work as follows:

1. Warrant labor and materials for specified control system free from defects for a period of 12 months after final acceptance. Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner's warranty service request.
2. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.
3. If the engineer determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, the engineer will certify in writing that control system operation has been tested and accepted in accordance with the terms of this specification. Date of acceptance shall begin warranty period.
4. Provide updates to operator workstation or web server software, project-specific software, graphic software, database software, and firmware that resolve the contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner's written authorization.
5. Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Engineer's acceptance.

1.12 OWNERSHIP OF PROPRIETARY MATERIAL

A. Project-specific software and documentation shall become Owner's property. This includes, but is not limited to:

1. Graphics
2. Record drawings
3. Database
4. Application programming code
5. Documentation

1.13 DEFINITIONS

Term	Definition
BACnet Interoperability Building Blocks (BIBB)	**A BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBS are combined to build the BACnet functional requirements for a device in a specification.**
BACnet/BACnet Standard	**BACnet communication requirements as defined by the latest version of ASHRAE/ANSI 135 and approved addenda.**
Control Systems Server	**A computer(s) that maintain(s) the systems configuration and programming database.**
Controller	**Intelligent stand-alone control device. Controller is a generic reference to building controllers, custom application controllers, and application specific controllers.**
Direct Digital Control	**Microprocessor-based control including Analog/Digital conversion and program logic.**
Gateway	**Bi-directional protocol translator connecting control systems that use different communication protocols.**
Local Area Network	**Computer or control system communications network limited to local building or campus.**
Master-Slave/Token Passing	**Data link protocol as defined by the BACnet standard.**
Point-to-Point	**Serial communication as defined in the BACnet standard.**
Primary Controlling LAN	**High speed, peer-to-peer controller LAN connecting BCs and optionally AACs and ASCs. Refer to System Architecture below.**
Protocol Implementation Conformance Statement	**A written document that identifies the particular options specified by BACnet that are implemented in a device.**
Router	**A device that connects two or more networks at the network layer.**
Wiring	**Raceway, fittings, wire, boxes and related items.**

PART 2 - PRODUCTS

2.1 MATERIALS

A. Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner. Spare parts shall be available for at least five years after completion of this contract.

2.2 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135, BACnet.

B. Install new wiring and network devices as required to provide a complete and workable control network.

C. Use existing Ethernet backbone for network segments marked "existing" on project drawings.

D. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

E. Internetwork operator interface and value passing shall be transparent to internetwork architecture.

1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.
2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute control strategies specified in Section 23 09 93. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

F. Workstations, Building Control Panels, and Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated device via the internetwork. The system shall automatically adjust for daylight saving and standard time as applicable.

G. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

2.3 OPERATOR INTERFACE

A. Operator Interface: Web server shall reside on high-speed network with building controllers. Each standard browser connected to server shall be able to access all system information. The Operator Workstation or server shall conform to the BACnet Operator Workstation (B-OWS) or BACnet Advanced Workstation (B-AWS) device profile as specified in ASHRAE/ANSI 135 BACnet Annex L.

B. Communication: Web server or workstation and controllers shall communicate using BACnet protocol. Web server or workstation and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ANSI/ASHRAE 135, BACnet Annex J.

C. Hardware:

1. Workstation or web server. Industry-standard hardware shall meet or exceed DDC system manufacturer’s recommended specifications and shall meet response times specified elsewhere in this document. The following hardware requirements also apply:

a. The hard disk shall have sufficient memory to store:

1) All required operator workstation software.
2) A DDC database at least twice the size of the delivered system database.
3) One year of trend data based on the points specified to be trended at their specified trend intervals.

b. Provide additional hardware (communication ports, video drivers, network interface cards, cabling, etc.) to facilitate all control functions and software requirements specified for the DDC system.

c. Minimum hardware configuration shall include the following:

1) Quad Core Processor
2) 8 GB RAM
3) 1 TB hard disk providing data at 3.0 Gb/sec
4) 16x DVD+/-RW drive
5) Serial, parallel, and network communication ports and cables as required for proper DDC system operation

D. System Software:

1. Operating System: Web server or workstation shall have an industry-standard professional-grade operating system. Operating system shall meet or exceed the DDC System manufacturers' minimum requirements for their software. Acceptable systems include Microsoft Windows 7 or 8, Microsoft Vista, Windows Server 2008 or 2012, Red Hat Enterprise Linux, or Ubuntu Desktop 12.04.
2. System Graphics: The operator interface software shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint.

a. Functionality: Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.

b. Animation: Graphics shall be able to animate by displaying different image files for changed object status.

c. Alarm Indication: Indicate areas or equipment in an alarm condition using color or other visual indicator.

d. Format: Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in or shall only require widely available no-cost plug-ins (such as Adobe Flash).

3. Custom Graphics: Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be a graphically based system that uses the mouse to create and modify graphics that are saved in the same formats as are used for system graphics.
4. Graphics Library: Furnish a complete library of standard HVAC equipment graphics such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library also shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program.

E. System Applications: System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. If furnished as a stand-alone program, software shall be installable on standard IBM-compatible PCs with no limit on the number of copies that can be installed under the system license.

1. Automatic System Database Configuration: Each workstation or web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.
2. Manual Controller Memory Download: Operators shall be able to download memory from the system database to each controller.
3. System Configuration: The workstation software shall provide a method of configuring the system. This shall allow for future system changes or additions by users under proper password protection. Operators shall be able to configure the system.
4. On-Line Help: Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.
5. Security: Each operator shall be required to log on to the system with username and password in order to view, edit, add, or delete data.

    a. Operator Access: The username and password combination shall define accessible viewing, editing, adding, and deleting privileges for that operator. Users with system administrator rights shall be able to create new users and edit the privileges of all existing users. System Administrators shall also be able to vary and deny each operator's privileges based on the geographic location of the equipment, such as the ability to edit operating parameters in Building A, to view but not edit parameters in Building B, and to not even see equipment in Building C.
    b. Automatic Log Out: Automatically log out each operator if no keyboard or mouse activity is detected. This auto logoff time shall be user adjustable.
    c. Encrypted Security Data: Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.

6. System Diagnostics: The system shall automatically monitor the operation of all building management panels and controllers. The failure of any device shall be annunciated to the operator.

7. Alarm Processing: System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as specified in Section 23 09 93 (Sequences of Operation). Alarms shall be BACnet alarm objects and shall use BACnet alarm services.
8. Alarm Messages: Alarm messages shall use the English language descriptor for the object in alarm in such a way that the operator will be able to recognize the source, location, and nature of the alarm without relying on acronyms or mnemonics.
9. Alarm Reactions: Operator shall be able to configure (by object) what, if any actions are to be taken during an alarm. As a minimum, the workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send page, and audibly annunciate.
10. Alarm and Event log: Operators shall be able to view all system alarms and changes of state from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and delete alarms, and archive closed alarms to the workstation or web server hard disk.
11. Trend Logs: The operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to the hard disk. Configure trends as specified in Section 23 09 93 (Sequences of Operation). Trends shall be BACnet trend objects.
12. Object and Property Status and Control: Provide a method for the operator to view, and edit if applicable, the status of any object or property in the system. The status shall be available by menu, on graphics, or through custom programs.
13. Reports and Logs: Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.
14. Standard Reports: Furnish the following standard system reports:

    a. Objects: System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.
    b. Alarm Summary: Current alarms and closed alarms. System shall retain closed alarms for an adjustable period.
    c. Logs: System shall log the following to a database or text file and shall retain data for an adjustable period:

        1) Alarm History:
        2) Trend Data: Operator shall be able to select trends to be logged.
        3) Operator Activity: At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgment and deletion. System shall date and time stamp logged activity.

15. Environmental Index: System shall monitor all occupied zones and compile an index that provides a numerical indication of the environmental comfort within the zone. As a minimum, this indication shall be based upon the deviation of the zone temperature from

the heating or cooling setpoint. If humidity is being measured within the zone then the environmental index shall be adjusted to reflect a lower comfort level for high or low humidity levels. Similarly, if carbon dioxide levels are being measured as an indication of ventilation effectiveness then the environmental index shall be adjusted to indicate degraded comfort at high carbon dioxide levels. Other adjustments may be made to the environmental index based upon additional measurements. The system shall maintain a trend of the environmental index for each zone in the trend log. The system shall also compute an average comfort index for every building included in this contract and maintain trend logs of these building environmental indices. Similarly, the system shall compute the percentage of occupied time that comfortable conditions were maintained within the zones. Through the UI the user shall be able to add a weighting factor to adjust the contribution of each zone to the average index based upon the floor area of the zone, importance of the zone, or other static criteria.

16. Time Span Graphic Replay: Operator shall be able to "replay" any graphic in the system to see how key values changed over an operator-selected period of time. Operator shall be able to select the starting date/time for this display and the end date/time or the display period. On completion of the project specified herein, the BAS contractor shall demonstrate that up to 24 hours of data within the last 30 days of operation cab be instantly replayed. System shall then display the graphic as it would have looked at the beginning of that period, displaying key data, dynamic colors, etc. based upon values recorded at the start time. When the operator starts the replay the graphics and key values shall dynamically change to produce the effect of "fast forwarding" through the designated period of time. Once the system has been operational for at least 30 days, the contractor shall demonstrate that up to 24 hours of data from within the last 30 days can be replayed on any graphic page. Owner's representative shall choose the graphic pages for this demonstration at the time of the demonstration.

F. Workstation Application Editors: Each PC or browser workstation shall support editing of all system applications. The applications shall be downloaded and executed at one or more of the controller panels.

1. Controller: Provide a full-screen editor for each type of application that shall allow the operator to view and change the configuration, name, control parameters, and set points for all controllers.
2. Scheduling: An editor for the scheduling application shall be provided at each workstation. Provide a method of selecting the desired schedule and schedule type. Exception schedules and holidays shall be shown clearly on the calendar. The start and stop times for each object shall be adjustable from this interface.
3. Custom Application Programming: Provide the tools to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:

    a. Language: Language shall be graphically based and shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks.
    b. Programming Environment: Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operators shall be able to insert, add, modify, and delete custom

programming code, and to copy blocks of code to a file library for reuse in other control programs.

c. Independent Program Modules: Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.

d. Debugging and Simulation: Operator shall be able to step through the program observing intermediate values and results. Operator shall be able to adjust input variables to simulate actual operating conditions. Operator shall be able to adjust each step's time increment to observe operation of delays, integrators, and other time-sensitive control logic. Debugger shall provide error messages for syntax and for execution errors.

e. Conditional Statements: Operator shall be able to program conditional logic using compound Boolean (AND, OR, and NOT) and relational (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.

f. Mathematical Functions: Language shall support floating-point addition, subtraction, multiplication, division, and square root operations, as well as absolute value calculation and programmatic selection of minimum and maximum values from a list of values.

g. Variables: Operator shall be able to use variable values in program conditional statements and mathematical functions.

1) Time Variables: Operator shall be able to use predefined variables to represent time of day, day of the week, month of the year, and date. Other predefined variables or simple control logic shall provide elapsed time in seconds, minutes, hours, and days. Operator shall be able to start, stop, and reset elapsed time variables using the program language.

2) System Variables: Operator shall be able to use predefined variables to represent status and results of Controller Software and shall be able to enable, disable, and change setpoints of Controller Software as described in Controller Software section.

G. Portable Operator's Terminal: Provide all necessary software to configure an IBM-compatible laptop computer for use as a Portable Operator's Terminal. Operator shall be able to connect configured Terminal to the system network or directly to each controller for programming, setting up, and troubleshooting.

2.4 CONTROLLER SOFTWARE

A. Furnish the following applications for building and energy management: All software application shall reside and operate in the system controllers. Applications shall be editable through operator workstation, web browser interface, or engineering workstation.

B. System Security: See Paragraph 2.3.E.5 (Security) and Paragraph 2.3.E.14.c.iii (Operator Activity).

C. Scheduling: Provide the capability to execute control functions according to a user created or edited schedule. Each schedule shall provide the following schedule options as a minimum:

1. Weekly Schedule: Provide separate schedules for each day of the week. Each schedule shall be able to include up to 5 occupied periods (5 start-stop pairs or 10 events).
2. Exception Schedules: Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule has executed, the system shall discard and replace the exception schedule with the standard schedule for that day of the week.
3. Holiday Schedules: Provide the capability for the operator to define up to 24 special or holiday schedules. These schedules will be repeated each year. The operator shall be able to define the length of each holiday period.

D. System Coordination: Operator shall be able to group-related equipment based on function and location and to use these groups for scheduling and other applications.

E. Binary Alarms: Each binary object shall have the capability to be configured to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.

F. Analog Alarms: Each analog object shall have both high and low alarm limits. The operator shall be able to enable or disable these alarms.

G. Alarm Reporting: The operator shall be able to determine the action to be taken in the event of an alarm. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display on graphics.

H. Remote Communication: System shall automatically contact operator workstation or server on receipt of critical alarms. If no network connection is available, system shall use a modem connection.

I. Demand Limiting:

1. The demand-limiting program shall monitor building power consumption from a building power meter (provided by others) which generates pulse signals or a BACnet communications interface. An acceptable alternative is for the system to monitor a watt transducer or current transformer attached to the building feeder lines.
2. When power consumption exceeds adjustable levels, system shall automatically adjust setpoints, de-energize low-priority equipment, and take other programmatic actions to reduce demand as specified in Section 23 09 93 (Sequences of Operation). When demand drops below adjustable levels, system shall restore loads as specified.

J. Maintenance Management: The system shall be capable of generating maintenance alarms when equipment exceeds adjustable runtime, equipment starts, or performance limits. Configure and enable maintenance alarms as specified in 23 09 93 (Sequences of Operation).

K. Sequencing: Application software shall sequence chillers, boilers, and pumps as specified in Section 23 09 93 (Sequences of Operation).

L. PID Control: System shall provide direct- and reverse-acting PID (proportional-integral-derivative) algorithms. Each algorithm shall have anti-windup and selectable controlled variable, setpoint, and PID gains. Each algorithm shall calculate a time-varying analog value that can be used to position an output or tostage a series of outputs. The calculation interval, PID gains, and other tuning parameters shall be adjustable by a user with the correct security level.

M. Staggered Start: System shall stagger controlled equipment restart after power outage. Operator shall be able to adjust equipment restart order and time delay between equipment restarts.

N. Energy Calculations:

1. The system shall accumulate and convert instantaneous power (kW) or flow rates (L/s [gpm]) to energy usage data.
2. The system shall calculate a sliding-window average (rolling average). Operator shall be able to adjust window interval to 15 minutes, 30 minutes, or 60 minutes.

O. Anti-Short Cycling. All binary output objects shall be protected from short cycling by means of adjustable minimum on-time and off-time settings.

P. On and Off Control with Differential: Provide an algorithm that allows a binary output to be cycled based on a controlled variable and a setpoint. The algorithm shall be direct-acting or reverse-acting.

Q. Runtime Totalization: Provide software to totalize runtime for each binary input and output. Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit. Configure and enable runtime totalization and alarms as specified in Section 23 09 93 (Sequence of Operations).

2.5 CONTROLLERS

A. General: Provide an adequate number of Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), Smart Actuators (SA), and Smart Sensors (SS) as required to achieve performance specified in Section 23 09 23 Article 1.9 (System Performance). Every device in the system which executes control logic and directly controls HVAC equipment must conform to a standard BACnet Device profile as specified in ANSI/ASHRAE 135, BACnet Annex L. Unless otherwise specified, hardwired actuators and sensors may be used in lieu of BACnet Smart Actuators and Smart Sensors.

B. BACnet:

1. Building Controllers (BCs): Each BC shall conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L, and shall be listed as a certified B-BC in the BACnet Testing Laboratories (BTL) Product Listing.
2. Advanced Application Controllers (AACs): Each AAC shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.

3. Application Specific Controllers (ASCs): Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.
4. Smart Sensors (SSs): Each SS shall conform to BACnet Smart Sensor (B-SS) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-SS in the BACnet Testing Laboratories (BTL) Product Listing.
5. BACnet Communication:

    a. Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.
    b. BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.
    c. Each AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
    d. Each ASC shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.

    e. Each SA shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
    f. Each SS shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using ARCNET or MS/TP Data Link/Physical layer protocol.

C. Communication:

1. Service Port: Each controller shall provide a service communication port for connection to a Portable Operator's Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.
2. Signal Management: BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.
3. Data Sharing: Each BC and AAC shall share data as required with each networked BC and AAC.
4. Stand-Alone Operation: Each piece of equipment specified in Section 23 09 93 shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network such as outdoor air conditions, supply air or water temperature coming from source equipment, etc.

D. Environment: Controller hardware shall be suitable for anticipated ambient conditions.

1. Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -20°F to 140°F.
2. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 32°F to 120°F.

E. Keypad: Provide a local keypad and display for each BC and AAC. Operator shall be able to use keypad to view and edit data. Keypad and display shall require password to prevent unauthorized use. If the manufacturer does not normally provide a keypad and display for each BC and AAC, provide the software and any interface cabling needed to use a laptop computer as a Portable Operator's Terminal for the system.

F. Real-Time Clock: Controllers that perform scheduling shall have a real-time clock.

G. Serviceability: Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to a field-removable modular terminal strip or to a termination card connected by a ribbon cable. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.

H. Memory:

1. Controller memory shall support operating system, database, and programming requirements.
2. Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.
3. Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

I. Immunity to Power and Noise: Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 3 ft.

J. Transformer: ASC power supply shall be fused or current limiting and shall be rated at a minimum of 125% of ASC power consumption.

2.6 INPUT AND OUTPUT INTERFACE

A. General: Hard-wire input and output points to BCs, AACs, ASCs, or SAs.

B. Protection: All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground shall cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no controller damage.

C. Binary Inputs: Binary inputs shall allow the monitoring of ON/OFF signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against contact bounce and noise. Binary inputs shall sense dry contact closure without application of power external to the controller.

D. Pulse Accumulation Inputs: Pulse accumulation inputs shall conform to binary input requirements and shall also accumulate up to 10 pulses per second.

E. Analog Inputs: Analog inputs shall allow the monitoring of low-voltage (0–10 Vdc), current (4–20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.

F. Binary Outputs: Binary outputs shall provide for ON/OFF operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on Building Controllers shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.

G. Analog Outputs: Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0–10 Vdc or a 4–20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.

H. Tri-State Outputs: Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.

I. Universal Inputs and Outputs: Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.

J. System Object Capacity: The system size shall be expandable to at least twice the number of input/ output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system

2.7 POWER SUPPLIES AND LINE FILTERING

A. Power Supplies: Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

1. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure.

    a. Unit shall operate between 32°F and 120°F. EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
    b. Line voltage units shall be UL recognized and CSA listed.

B. Power Line Filtering:

1. Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:

a. Dielectric strength of 1000 V minimum
b. Response time of 10 nanoseconds or less
c. Transverse mode noise attenuation of 65 dB or greater
d. Common mode noise attenuation of 150 dB or greater at 40–100 Hz

2.8 AUXILIARY CONTROL DEVICES

A. Motorized Control Dampers, unless otherwise specified elsewhere, shall be as follows:

1. Type: Control dampers shall be the parallel or opposed-blade type as specified below or as scheduled on drawings.

a. Outdoor and return air mixing dampers and face-and-bypass dampers shall be parallel-blade and shall direct airstreams toward each other.
b. Other modulating dampers shall be opposed-blade.
c. Two-position shutoff dampers shall be parallel- or opposed-blade with blade and side seals.

2. Frame: Damper frames shall be 13 gauge galvanized steel channel or ⅛ in. extruded aluminum with reinforced corner bracing.
3. Blades: Damper blades shall not exceed 8 in. in width or 48 in. in length. Blades shall be suitable for medium velocity (10 m/s [2000 fpm]) performance. Blades shall be not less than 16 gauge.
4. Shaft Bearings: Damper shaft bearings shall be as recommended by manufacturer for application, oil impregnated sintered bronze, or better.
5. Seals: Blade edges and frame top and bottom shall have replaceable seals of butyl rubber or neoprene. Side seals shall be spring-loaded stainless steel. Blade seals shall leak no more than 50 $L/s \cdot m^2$ (10 cfm per ft^2) at 1000 Pa (4 in. w.g.) differential pressure. Blades shall be airfoil type suitable for wide-open face velocity of 7.5 m/s (1500 fpm).
6. Sections: Individual damper sections shall not exceed 48 in. × 60 in. Each section shall have at least one damper actuator.
7. Modulating dampers shall provide a linear flow characteristic where possible.
8. Linkages: Dampers shall have exposed linkages.

B. Electric Damper and Valve Actuators:

1. Stall Protection: Mechanical or electronic stall protection shall prevent actuator damage throughout the actuator’s rotation.
2. Spring-return Mechanism: Actuators used for power-failure and safety applications shall have an internal mechanical spring-return mechanism or an uninterruptible power supply (UPS).

3. Signal and Range: Proportional actuators shall accept a 0–10 Vdc or a 0–20 mA control signal and shall have a 2–10 Vdc or 4–20 mA operating range. (Floating motor actuators may be substituted for proportional actuators in terminal unit applications as described in paragraph 2.6H.)
4. Wiring: 24 Vac and 24 Vdc actuators shall operate on Class 2 wiring.
5. Manual Positioning: Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 7 N·m (60 in.-lb) torque capacity shall have a manual crank.

C. Control Valves:

1. Control valves shall be two-way or three-way type for two-position or modulating service as shown.
2. Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:

    a. Water Valves:

        1) Two-way: 150% of total system (pump) head.
        2) Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

    b. Steam Valves: 150% of operating (inlet) pressure.

3. Water Valves:

    a. Body and trim style and materials shall be in accordance with manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.

    b. Sizing Criteria:

        1) Two-position service: Line size.
        2) Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through heat exchanger (load), 50% of the pressure difference between supply and return mains, or 5 psi, whichever is greater.
        3) Three-way modulating service: Pressure drop equal to twice the pressure drop through the coil exchanger (load), 35 kPa (5 psi) maximum.
        4) Valves ½ in. through 2 in. shall be bronze body or cast brass ANSI Class 250, spring-loaded, PTFE packing, quick opening for two-position service. Two-way valves to have replaceable composition disc or stainless-steel ball.
        5) Valves 2½ in. and larger shall be cast iron ANSI Class 125 with guided plug and PTFE packing.

    c. Water valves shall fail normally open or closed, as scheduled on plans, or as follows:

        1) Water zone valves normally open preferred.
        2) Heating coils in air handlers normally open.

3) Chilled water control valves normally closed.
4) Other applications as scheduled or as required by sequences of operation.

4. Steam Valves:

a. Body and trim materials shall be in accordance with manufacturer's recommendations for design conditions and service with linear ports for modulating service.
b. Sizing Criteria:

1) Two-position service: pressure drop 10% to 20% of inlet psig.
2) Modulating service: 100 kPa (15 psig) or less; pressure drop 80% of inlet psig.
3) Modulating service: 101 to 350 kPa (16 to 50 psig); pressure drop 50% of inlet psig.
4) Modulating service: over 350 kPa (50 psig); pressure drop as scheduled on plans.

D. Binary Temperature Devices:

1. Low-Voltage Space Thermostats: Low-voltage space thermostats shall be 24 V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed setpoint adjustment, 55°F–85°F setpoint range, 2°F maximum differential, and vented ABS plastic cover.
2. Line-Voltage Space Thermostats: Line-voltage space thermostats shall be bimetal-actuated, open-contact type or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listing for electrical rating, concealed setpoint adjustment, 55°F–85°F setpoint range, 2°F maximum differential, and vented ABS plastic cover.
3. Low-Limit Thermostats: Low-limit airstream thermostats shall be UL listed, vapor pressure type. Element shall be at least 20 ft long. Element shall sense temperature in each 1 ft section and shall respond to lowest sensed temperature. Low-limit thermostat shall be manual reset only.

E. Temperature Sensors:

1. Type: Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor.
2. Duct Sensors: Duct sensors shall be single point or averaging as shown. Averaging sensors shall be a minimum of 5 ft in length per 10 ft^2 of duct cross-section.
3. Immersion Sensors: Provide immersion sensors with a separable stainless steel well. Well pressure rating shall be consistent with system pressure it will be immersed in. Well shall withstand pipe design flow velocities.
4. Space Sensors: Space sensors shall have setpoint adjustment, override switch, display, and communication port as shown.
5. Differential Sensors: Provide matched sensors for differential temperature measurement.

F. Humidity Sensors:

1. Duct and room sensors shall have a sensing range of 20%–80%.
2. Duct sensors shall have a sampling chamber.

3. Outdoor air humidity sensors shall have a sensing range of 20%–95% RH and shall be suitable for ambient conditions of -40°F–170°F.
4. Humidity sensors shall not drift more than 1% of full scale annually.

G. Flow Switches: Flow-proving switches shall be paddle (water service only) or differential pressure type (air or water service) as shown. Switches shall be UL listed, SPDT snap-acting, and pilot duty rated (125 VA minimum).

1. Paddle switches shall have adjustable sensitivity and NEMA 1 enclosure unless otherwise specified.
2. Differential pressure switches shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

H. Relays:

1. Control Relays: Control relays shall be plug-in type, UL listed and shall have dust cover and LED “energized” indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
2. Time Delay Relays: Time delay relays shall be solid-state plug-in type, UL listed and shall have adjustable time delay. Delay shall be adjustable ±100% from setpoint shown. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure for relays not installed in local control panel.

I. Override Timers:

1. Unless implemented in control software, override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration required by application. Provide 0–6-hour calibrated dial unless otherwise specified. Flush mount timer on local control panel face or where shown.

J. Current Transmitters:

1. AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4–20 mA two-wire output. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.
2. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.
3. Unit shall be split-core type for clamp-on installation on existing wiring.

K. Current Transformers:

1. AC current transformers shall be UL/CSA recognized and shall be completely encased (except for terminals) in approved plastic material.
2. Transformers shall be available in various current ratios and shall be selected for ±1% accuracy at 5 A full-scale output.
3. Use fixed-core transformers for new wiring installation and split-core transformers for existing wiring installation.

L. Voltage Transmitters:

1. AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4–20 mA output with zero and span adjustment.

2. Adjustable full-scale unit ranges shall be 100–130 Vac, 200–250 Vac, 250–330 Vac, and 400–600 Vac. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.
3. Transmitters shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized at 600 Vac rating.

M. Voltage Transformers:

1. AC voltage transformers shall be UL/CSA recognized, 600 Vac rated, and shall have built-in fuse protection.
2. Transformers shall be suitable for ambient temperatures of 4°C–55°C (40°F–130°F) and shall provide ±0.5% accuracy at 24 Vac and 5 VA load.
3. Windings (except for terminals) shall be completely enclosed with metal or plastic.

N. Power Monitors:

1. Selectable rate pulse output for kWh reading, 4–20 mA output for kW reading, N.O. alarm contact, and ability to operate with 5.0 amp current inputs or 0–0.33 volt inputs.
2. 1.0% full-scale true RMS power accuracy, +0.5 Hz, voltage input range 120–600 V, and auto range select.
3. Under voltage/phase monitor circuitry.
4. NEMA 1 enclosure.
5. Current transformers having a 0.5% FS accuracy, 600 VAC isolation voltage with 0–0.33 V output. If 0–5 A current transformers are provided, a three-phase disconnect/shorting switch assembly is required.

O. Hydronic Flowmeters:

1. Insertion-Type Turbine Meter:

a. Dual counter-rotating axial turbine elements, each with its own rotational sensing system, and an averaging circuit to reduce measurement errors due to swirl and flow profile distortion. Single turbine for piping 2 inches and smaller. Flow sensing turbine rotors shall be non-metallic and not impaired by magnetic drag.
b. Insertion type complete with ‘hot-tap’ isolation valves to enable sensor removal without water supply system shutdown.
c. Sensing method shall be impedance sensing (non-magnetic and non-photoelectric)
d. Volumetric accuracy:

1) ± 0.5% of reading at calibrated velocity
2) ± 1% of reading from 3 to 30 ft/s (10:1 range)
3) ± 2% of reading from 0.4 to 20 ft/s (50:1 range)

e. Each sensor shall be individually calibrated and tagged accordingly against the manufacturer’s primary standards which must be accurate to within 0.1% of flow rate and traceable to the National Institute of Standards and Technology (NIST).

f. Maximum operating pressure of 400 psi and maximum operating temperature of 200°F continuous (220°F peak).
g. All wetted metal parts shall be constructed of 316 stainless steel.

h. Analog outputs shall consist of non-interactive zero and span adjustments, a DC linearly of 0.1% of span, voltage output of 0-10 Vdc, and current output of 4-20 mA.

2. Magnetic Flow-Tube Type Flowmeter:

a. Sensor shall be a magnetic flowmeter, which utilizes Faraday's Law to measure volumetric fluid flow through a pipe. The flowmeter shall consist of two elements, the sensor and the electronics. The sensor shall generate a measuring signal proportional to the flow velocity in the pipe. The electronics shall convert this EMF into a standard current output.
b. Electronic replacement shall not affect meter accuracy (electronic units are not matched with specific sensors).
c. Four-wire, externally powered, magnetic type flow transmitter with adjustable span and zero, integrally mounted to flow tube. Output signal shall be a digital pulse proportional to the flow rate (to provide maximum accuracy and to handle abrupt changes in flow). Standard 4-20 mA or 0-10 Vdc outputs may be used provided accuracy is as specified.
d. Flow Tube:

1) ANSI class 150 psig steel
2) ANSI flanges
3) Protected with PTFE, PFA, or ETFE liner rated for 245°F minimum fluid temperature

e. Electrode and grounding material:

1) 316L Stainless steel or Hastelloy C
2) Electrodes shall be fused to ceramic liner and not require o-rings.

f. Electrical Enclosure: NEMA 4, 7
g. Approvals:

1) UL or CSA
2) NSF Drinking Water approval for domestic water applications.

h. Performance:

1) Accuracy shall be ±0.5% of actual reading from 3 to 30 ft/s flow velocities, and 0.015 ft/s from 0.04 to 3 ft/s.
2) Stability: 0.1% of rate over six months.
3) Meter repeatability shall be ±0.1% of rate at velocities > 3 ft/s.

3. Magnetic Insertion-Type Flowmeter:

a. Magnetic Faraday point velocity measuring device.

b. Insertion type complete with hot-tap isolation valves to enable sensor removal without water supply system shutdown.
c. 4-20 mA transmitter proportional to flow or velocity.
d. Accuracy: larger of 1% of reading and 0.2 ft/s.
e. Flow range: 0.2 to 20 ft/s, bi-directional.
f. Each sensor shall be individually calibrated and tagged accordingly against the manufacturer's primary standards which must be accurate to within 0.1% of flow rate and traceable to the National Institute of Standards and Technology (NIST).

4. Vortex Shedding Flowmeter:

a. Output: 4-20 mA, 0-10 Vdc, 0-5 Vdc.
b. Maximum Fluid Temperature: 800ºF.
c. Wetted Parts: Stainless Steel.
d. Housing: NEMA 4X.
e. Turndown: 25:1 minimum.
f. Accuracy: 0.5% of calibrated span for liquids, 1% of calibrated span for steam and gases.
g. Body: Wafer style or ANSI flanged to match piping specification.

5. Transit-Time Ultrasonic Flowmeter

a. Clamp-On transit-time ultrasonic flowmeter
b. Wide-Beam transducer technology
c. 4-20 mA transmitter proportional to flow or velocity.
d. Accuracy: 0.5% of reading in range 1 to 30 ft/s, 0.001 ft/s sensitivity.

P. Thermal Energy Meters:

1. Matched RTD, solid state, or thermistor temperature sensors with a differential temperature accuracy of ±0.15°F.
2. Flow meter: See "Hydronic Flowmeters" section.
3. Unit accuracy of ±1% factory calibrated, traceable to NIST with certification.
4. NEMA 1 enclosure.
5. Panel mounted display.
6. UL listed.
7. Isolated 4–20 ma signals for energy rate and supply and return temperatures and flow.

Q. Current Switches:

1. Current-operated switches shall be self-powered, solid-state with adjustable trip current. Select switches to match application current and DDC system output requirements.

R. Pressure Transducers:

1. Transducers shall have linear output signal and field-adjustable zero and span.
2. Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage.

3. Water pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Transducer shall have 4–20 mA output, suitable mounting provisions, and block and bleed valves.
4. Water differential pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Over-range limit (differential pressure) and maximum static pressure shall be 2000 kPa (300psi.) Transducer shall have 4–20 mA output, suitable mounting provisions, and 5-valve manifold.

S. Differential Pressure Switches: Differential pressure switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum) and shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

T. Pressure-Electric (PE) Switches:

1. Shall be metal or neoprene diaphragm actuated, operating pressure rated for 0–175 kPa (0–25 psig), with calibrated scale minimum setpoint range of 14–125 kPa (2–18 psig) minimum, UL listed.
2. Provide one- or two-stage switch action (SPDT, DPST, or DPDT) as required by application. Electrically rated for pilot duty service (125 VA minimum) and/or for motor control.
3. Switches shall be open type (panel-mounted) or enclosed type for remote installation. Enclosed type shall be NEMA 1 unless otherwise specified.
4. Each pneumatic signal line to PE switches shall have permanent indicating gauge.

U. Occupancy Sensors: Occupancy sensors shall utilize Passive Infrared (PIR) and/or Microphonic Passive technology to detect the presence of people within a room. Sensors shall be mounted as indicated on the approved drawings. The sensor output shall be accessible by any lighting and/or HVAC controller in the system. Occupancy sensors shall be capable of being powered from the lighting or HVAC control panel, as shown on the drawings. Occupancy sensor delay shall be software adjustable through the user interface and shall not require manual adjustment at the sensor.

V. Local Control Panels:

1. All indoor control cabinets shall be fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable subpanels. A single key shall be common to all field panels and subpanels.
2. Interconnections between internal and face-mounted devices shall be prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600-volt service, individually identified per control/ interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.
3. Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.

2.9 WIRINGS AND RACEWAYS

A. General. Provide copper wiring, plenum cable, and raceways as specified in applicable sections of Division 26.

B. Insulated wire shall use copper conductors and shall be UL listed for 200°F minimum service.

2.10 FIBER OPTIC CABLE SYSTEM

A. Optical Cable. Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. Sheath shall be UL listed OFNP in accordance with NEC Article 770. Optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125mm.

B. Connectors. Field terminate optical fibers with ST type connectors. Connectors shall have ceramic ferrules and metal bayonet latching bodies.

PART 3 - EXECUTION

3.1 EXAMINATION

A. The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the engineer for resolution before rough-in work is started.

B. The contractor shall examine the drawings and specifications for other parts of the work. If headroom or space conditions appear inadequate or if any discrepancies occur between the plans and the contractor's work and the plans and the work of others, the contractor shall report these discrepancies to the engineer and shall obtain written instructions for any changes necessary to accommodate the contractor's work with the work of others. Any changes in the work covered by this specification made necessary by the failure or neglect of the contractor to report such discrepancies shall be made by and at the expense of this contractor.

3.2 PROTECTION

A. The contractor shall protect all work and material from damage by his/her work or employees and shall be liable for all damage thus caused.

B. The contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The contractor shall protect any material that is not immediately installed. The contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.3 COORDINATION

A. Site:

1. Where the mechanical work will be installed in close proximity to, or will interfere with, work of other trades, the contractor shall assist in working out space conditions to make a satisfactory adjustment. If the contractor installs his/her work before coordinating with other trades, so as to cause any interference with work of other trades, the contractor shall make the necessary changes in his/her work to correct the condition without extra charge.
2. Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.

B. Submittals: See Section 23 09 23 Article 1.10 (Submittals).

C. Test and Balance:

1. The contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.
2. The contractor shall provide training in the use of these tools. This training will be planned for a minimum of 4 hours.
3. In addition, the contractor shall provide a qualified technician to assist in the test and balance process, until the first 20 terminal units are balanced.
4. The tools used during the test and balance process will be returned at the completion of the testing and balancing.

D. Life Safety:

1. Duct smoke detectors required for air handler shutdown are provided under Division 28. Interlock smoke detectors to air handlers for shutdown as specified in Section 23 09 93 (Sequences of Operation).
2. Smoke dampers and actuators required for duct smoke isolation are provided under Division 23. Interlock smoke dampers to air handlers as specified in Section 23 09 93 (Sequences of Operation).
3. Fire and smoke dampers and actuators required for fire-rated walls are provided under Division 23. Fire and smoke damper control is provided under Division 28.

E. Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the contractor as follows:

1. All communication media and equipment shall be provided as specified in Section 23 09 23 Article 2.2 (Communication).
2. Each supplier of a controls product is responsible for the configuration, programming, start up, and testing of that product to meet the sequences of operation described in Section 23 09 93.
3. The contractor shall coordinate and resolve any incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.
4. The contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.
5. The contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

3.4 GENERAL WORKMANSHIP

A. Install equipment, piping, and wiring/raceway parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.

B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

C. Install equipment in readily accessible locations as defined by Chapter 1 Article 100 Part A of the National Electrical Code (NEC).

D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

E. All equipment, installation, and wiring shall comply with industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.5 FIELD-QUALITY CONTROL

A. All work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes and ordinances as identified in Section 23 09 23 Article 1.8 (Codes and Standards).

B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship.

C. Contractor shall have work inspection by local and/or state authorities having jurisdiction over the work.

3.6 EXISTING EQUIPMENT

A. Wiring: The contractor may reuse any abandoned wires. The integrity of the wire and its proper application to the installation are the responsibility of the contractor. The wire shall be properly identified and tested in accordance with this specification. Unused or redundant wiring must be properly identified as such.

B. Local Control Panels: The contractor may reuse any existing local control panel to locate new equipment. All redundant equipment within these panels must be removed. Panel face cover must be patched to fill all holes caused by removal of unused equipment or replaced with new.

C. Repair: Unless otherwise directed, the contractor is not responsible for repair or replacement of existing energy equipment and systems, valves, dampers, or actuators. Should the contractor find existing equipment that requires maintenance, the engineer is to be notified immediately.

D. Temperature Sensor Wells: The contractor may reuse any existing wells in piping for temperature sensors. These wells shall be modified as required for proper fit of new sensors.

E. Indicator Gauges: Where these devices remain and are not removed, they must be made operational and recalibrated to ensure reasonable accuracy.

F. Room Thermostats: Room thermostats may be reused. Remove and deliver unnecessary thermostats to Owner unless otherwise noted. Patch and finish holes and marks left by removal to match existing walls.

G. Electronic Sensors and Transmitters: Unless specifically noted otherwise, existing sensors and transmitters may be reused. Remove and deliver unnecessary sensors and transmitters to Owner.

H. Controllers and Auxiliary Electronic Devices: Existing controllers and auxiliary electronic devices may be reused unless specifically noted otherwise. Recondition as necessary. Remove unnecessary sensors and transmitters.

I. Damper Actuators, Linkages, and Appurtenances: Existing damper actuators, linkages, and appurtenances may be reused unless specifically noted otherwise. Recondition as necessary. Remove and deliver unnecessary equipment to Owner.

J. Control Valves: Existing control valves may be reused unless specifically noted otherwise. Recondition as necessary.

K. Control Compressed Air Systems: Existing control compressed air systems may be reused unless specifically noted otherwise. Recondition as necessary.

L. Existing System Operating Schedule: The mechanical system must remain in operation and shall maintain space comfort at all times between the hours of 6 a.m. and 9 p.m., Monday through Friday. No modifications to the system shall cause mechanical system to be shut down for more than 15 minutes or to fail to maintain space comfort conditions during any such period. Perform cut-over controls that cannot meet these conditions outside of operational hours.

M. The scheduling of fans through existing or temporary time clocks or control system shall be maintained throughout the DDC system installation

N. Install control panels where shown.

O. Modify existing starter control circuits, if necessary, to provide hand-off-auto control of each controlled starter. If new starters or starter control packages are required, these shall be included as part of this contract.

P. Patch holes and finish to match existing walls.

3.7 WIRING

A. All control and interlock wiring shall comply with national and local electrical codes, and Division 26 of this specification. Where the requirements of this section differ from Division 26, the requirements of this section shall take precedence.

B. All NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway according to NEC and Division 26 requirements.

C. All low-voltage wiring shall meet NEC Class 2 requirements. Low-voltage power circuits shall be sub-fused when required to meet Class 2 current limit.

D. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL listed for the intended application.

E. All wiring in mechanical, electrical, or service rooms – or where subject to mechanical damage – shall be installed in raceway at levels below 10ft.

F. Do not install Class 2 wiring in raceways containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).

G. Do not install wiring in raceway containing tubing.

H. Where Class 2 wiring is run exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 10 ft intervals.

I. Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.

J. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.

K. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

L. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers.

M. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

N. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.

O. Size of raceway and size and type of wire type shall be the responsibility of the contractor in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.

P. Include one pull string in each raceway 1 in. or larger.

Q. Use color-coded conductors throughout with conductors of different colors.

R. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

S. Conceal all raceways except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 6 in. from high-temperature equipment (e.g. steam pipes or flues).

T. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.

U. Adhere to this specification's Division 26 requirements where raceway crosses building expansion joints.

V. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of vertical raceways.

W. The contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

X. Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 3 ft in length and shall be supported at each end. Flexible metal raceway less than ½ in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.

Y. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes and ends not terminating in boxes shall have bushings installed.

3.8 COMMUNICATION WIRING

A. The contractor shall adhere to the items listed in the "Wiring" article in Part 3 of the specification.

B. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling

C. Do not install communication wiring in raceways and enclosures containing Class 1 or other Class 2 wiring.

D. Maximum pulling, tension, and bend radius for the cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

E. Contractor shall verify the integrity of the entire network following cable installation. Use appropriate test measures for each particular cable.

F. When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lighting arrestor shall be installed according to manufacturer’s instructions.

G. All runs of communication wiring shall be unspliced length when that length is commercially available.

H. All communication wiring shall be labeled to indicate origination and destination data.

I. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

J. BACnet MS/TP communications wiring shall be installed in accordance with ASHRAE/ANSI Standard 135. This includes but is not limited to:

1. The network shall use shielded, twisted-pair cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 30 pF per foot.
2. The maximum length of an MS/TP segment is 4000 ft with AWG 18 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.
3. The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated by the use of repeaters.
4. An MS/TP EIA-485 network shall have no T connections.

3.9 FIBER OPTIC CABLE

A. Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post-installation residual cable tension shall be within cable manufacturer's specifications.

B. All cabling and associated components shall be installed in accordance with manufacturers' instructions. Minimum cable and unjacketed fiber bend radii, as specified by cable manufacturer, shall be maintained.

3.10 INSTALLATION OF SENSORS

A. Install sensors in accordance with the manufacturer's recommendations.

B. Mount sensors rigidly and adequately for environment within which the sensor operates.

C. Room temperature sensors shall be installed on concealed junction boxes properly supported by wall framing.

D. All wires attached to sensors shall be sealed in their raceways or in the wall to stop air transmitted from other areas from affecting sensor readings.

E. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.

F. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 1 ft of sensing element for each 1 ft^2 of coil area.

G. Do not install temperature sensors within the vapor plume of a humidifier. If installing a sensor downstream of a humidifier, install it at least 10 ft downstream.

H. All pipe-mounted temperature sensors shall be installed in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.

I. Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.

J. Differential Air Static Pressure:

1. Supply Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum.
2. Return Duct Static Pressure: Pipe high-pressure tap to duct using a pitot tube. Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor.
3. Building Static Pressure: Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.
4. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
5. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.
6. All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shut-off valves installed before the tee.

K. Smoke detectors, freezestats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

L. Install humidity sensors for duct mounted humidifiers at least 10 ft downstream of the humidifier. Do not install filters between the humidifier and the sensor.

3.11 FLOW SWITCH INSTALLATION

A. Use correct paddle for pipe diameter.

B. Adjust flow switch according to manufacturer's instructions.

3.12 ACTUATORS

A. General: Mount and link control damper actuators according to manufacturer's instructions.

1. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
3. Provide all mounting hardware and linkages for actuator installation.

B. Electric/Electronic:

1. Dampers: Actuators shall be direct mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° travel available for tightening the damper seal. Actuators shall be mounted following manufacturer's recommendations.
2. Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

C. Pneumatic Actuators:

1. Size pneumatic damper actuator to operate the related control damper(s) with sufficient reserve power to provide smooth modulating action or two-position action. Actuator also shall be sized for proper speed of response at the velocity and pressure conditions to which the control damper is subject.
2. Pneumatic damper actuators shall produce sufficient torque to close off against the maximum system pressures encountered. Size the pneumatic damper actuator to close off against the fan shutoff pressure, as a minimum.
3. Where two or more pneumatic damper actuators are installed for interrelated operation in unison, such as dampers used for mixing, provide the dampers with a positive pilot positioner. The positive pilot positioner shall be directly mounted to the pneumatic damper actuator and have pressure gauges for supply input and output pressures.
4. The total damper area operated by an actuator shall not exceed 80% of the manufacturer's maximum area rating. Provide at least one actuator for each damper section. Each damper actuator shall not power more than 20 ft^2 of damper.
5. Use line shafting or shaft couplings (jack shafting) in lieu of blade-to-blade linkages or shaft coupling when driving axially aligned damper sections.

3.13 WARNING LABELS

A. Permanent warning labels shall be affixed to all equipment that can be automatically started by the control system.

1. Labels shall use white lettering (12-point type or larger) on a red background.
2. Warning labels shall read as follows.

C A U T I O N

This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to "Off" position before servicing.

B. Permanent warning labels shall be affixed to all motor starters and control panels that are connected to multiple power sources utilizing separate disconnects.

1. Labels shall use white lettering (12-point type or larger) on a red background.
2. Warning labels shall read as follows.

C A U T I O N

This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.

3.14 IDENTIFICATION OF HARDWARE AND WIRING

A. All wiring and cabling, including that within factory-fabricated panels shall be labeled at each end within 2 in. of termination with control system address or termination number.

B. All pneumatic tubing shall be labeled at each end within 2 in. of termination with a descriptive identifier.

C. Permanently label or code each point of field terminal strips to show the instrument or item served.

D. Identify control panels with minimum ½ in. letters on laminated plastic nameplates.

E. Identify all other control components with permanent labels. All plug-in components shall be labeled such that label removal of the component does not remove the label.

F. Identify room sensors related to terminal boxes or valves with nameplates.

G. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.

H. Identifiers shall match record documents.

3.15 CONTROLLERS

A. Provide a separate controller for each AHU or other HVAC system. A DDC controller may control more than one system provided that all points associated with the system are assigned to the same DDC controller. Points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.

B. Building Controllers and Custom Application Controllers shall be selected to provide the required I/O point capacity required to monitor all the hardware points listed in Section 23 09 93 (Sequences of Operation).

3.16 PROGRAMMING

A. Provide sufficient internal memory for the specified sequences of operation and trend logging.

B. Point Naming. Name points as shown on the equipment points list provided with each sequence of operation. See Section 23 09 93 (Sequences of Operation). If character limitations or space restrictions make it advisable to shorten the name, the abbreviations given in Appendix B to Section 23 09 93 may be used. Where multiple points with the same name reside in the same

controller, each point name may be customized with its associated Program Object number. For Example, "Zone Temp 1" for Zone 1, "Zone Temp 2" for Zone 2.

C. Software Programming.

1. Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by the contractor. Embed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation. Use the appropriate technique based on the following programming types:

a. Text-based:

1) Must provide actions for all possible situations
2) Must be modular and structured
3) Must be commented

b. Graphic-based:

1) Must provide actions for all possible situations
2) Must be documented

c. Parameter-based:

1) Must provide actions for all possible situations
2) Must be documented.

D. Operator Interface.

1. Standard Graphics. Provide graphics for all mechanical systems and floor plans of the building. This includes each chilled water system, hot water system, chiller, boiler, air handler, and all terminal equipment. Point information on the graphic displays shall dynamically update. Show on each graphic all relevant input and output points for that equipment. Also show relevant calculated points such as setpoints. As a minimum, show on each equipment graphic the input and output points and relevant calculated points as indicated on the applicable Points List in Section 23 09 93.
2. The contractor shall provide all the labor necessary to install, initialize, start up, and troubleshoot all operator interface software and its functions as described in this section. This includes any operating system software, the operator interface database, and any third-party software installation and integration required for successful operation of the operator interface.

3.17 CONTROL SYSTEM CHECKOUT AND TESTING

A. Startup Testing. All testing listed in this article shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the owner’s representative is notified of the system demonstration.

1. The contractor shall furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.
2. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
3. Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturers' recommendations.
4. Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.
5. Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The contractor shall check all control valves and automatic dampers to ensure proper action and closure. The contractor shall make any necessary adjustments to valve stem and damper blade travel.
6. Verify that the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops.
7. Alarms and Interlocks:

    a. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
    b. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
    c. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action

3.18 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Demonstration.

1. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his/her own tests.
2. The tests described in this section are to be performed in addition to the tests that the contractor performs as a necessary part of the installation, start-up, and debugging process and as specified in the "Control System Checkout and Testing" article in Part 3 of this specification. The engineer will be present to observe and review these tests. The engineer shall be notified at least 10 days in advance of the start of the testing procedures.
3. The demonstration process shall follow that approved in Part 1, "Submittals." The approved checklists and forms shall be completed for all systems as part of the demonstration.
4. The contractor shall provide at least two persons equipped with two-way communication and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point and system. Any test equipment required to prove the proper operation shall be provided by and operated by the contractor.

5. As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.
6. Demonstrate compliance with Part 1, "System Performance."
7. Demonstrate compliance with sequences of operation through all modes of operation.
8. Demonstrate complete operation of operator interface.
9. Additionally, the following items shall be demonstrated:

    a. DDC loop response. The contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in set point, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the Contractor.
    b. Demand limiting. The contractor shall supply a trend data output showing the action of the demand limiting algorithm. The data shall document the action on a minute-by-minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting set point, and the status of shed-able equipment outputs.
    c. Optimum start/stop. The contractor shall supply a trend data output showing the capability of the algorithm. The change-of-value or change-of-state trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.
    d. Interface to the building fire alarm system.
    e. Operational logs for each system that indicate all set points, operating points, valve positions, mode, and equipment status shall be submitted to the architect/engineer. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and disk formats.

10. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

B. Acceptance.

1. All tests described in this specification shall have been performed to the satisfaction of both the engineer and owner prior to the acceptance of the control system as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if stated as such in writing by the engineer. Such tests shall then be performed as part of the warranty.
2. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved as required in Part 1, "Submittals."

3.19 CLEANING

A. The contractor shall clean up all debris resulting from his/her activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

B. At the completion of work in any area, the contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

C. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.20 TRAINING

A. Provide training for the designated staff of Owner's representatives. Training shall be provided via self-paced training, web-based or computer-based training, classroom training, or a combination of training methods.

B. Training shall enable students to accomplish the following objectives.

1. Day-to-day Operators:

a. Proficiently operate the system
b. Understand control system architecture and configuration
c. Understand DDC system components
d. Understand system operation, including DDC system control and optimizing routines (algorithms)
e. Operate the workstation and peripherals
f. Log on and off the system
g. Access graphics, point reports, and logs
h. Adjust and change system set points, time schedules, and holiday schedules
i. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals
j. Understand system drawings and Operation and Maintenance manual
k. Understand the job layout and location of control components
l. Access data from DDC controllers and ASCs
m. Operate portable operator's terminals

2. Advanced Operators:

a. Make and change graphics on the workstation
b. Create, delete, and modify alarms, including annunciation and routing of these
c. Create, delete, and modify point trend logs and graph or print these both on an ad-hoc basis and at user-definable time intervals
d. Create, delete, and modify reports
e. Add, remove, and modify system's physical points
f. Create, modify, and delete programming

g. Add panels when required
h. Add operator interface stations
i. Create, delete, and modify system displays, both graphical and others
j. Perform DDC system field checkout procedures
k. Perform DDC controller unit operation and maintenance procedures
l. Perform workstation and peripheral operation and maintenance procedures
m. Perform DDC system diagnostic procedures
n. Configure hardware including PC boards, switches, communication, and I/O points
o. Maintain, calibrate, troubleshoot, diagnose, and repair hardware
p. Adjust, calibrate, and replace system components

3. System Managers/Administrators:

a. Maintain software and prepare backups
b. Interface with job-specific, third-party operator software
c. Add new users and understand password security procedures

C. Organize the training into sessions or modules for the three levels of operators listed above. (Day-to-Day Operators, Advanced Operators, System Managers and Administrators). Students will receive one or more of the training packages, depending on knowledge level required.

D. Provide course outline and materials according to the "Submittals" article in Part 1 of this specification. Provide one copy of training material per student.

E. The instructor(s) shall be factory-trained and experienced in presenting this material.

F. Classroom training shall be done using a network of working controllers representative of installed hardware.

3.21 SEQUENCES OF OPERATION

A. See Section 23 09 93

3.22 CONTROL VALVE INSTALLATION

A. Valve submittals shall be coordinated for type, quantity, size, and piping configuration to ensure compatibility with pipe design.

B. Slip-stem control valves shall be installed so that the stem position is not more than 60 degrees from the vertical up position. Ball type control valves shall be installed with the stem in the horizontal position.

C. Valves shall be installed in accordance with the manufacturer's recommendations.

D. Control valves shall be installed so that they are accessible and serviceable and so that actuators may be serviced and removed without interference from structure or other pipes and/or equipment.

E. Isolation valves shall be installed so that the control valve body may be serviced without draining the supply/return side piping system. Unions shall be installed at all connections to screw-type control valves.

F. Provide tags for all control valves indicating service and number. Tags shall be brass, 1.5 inch in diameter, with ¼ inch high letters. Securely fasten with chain and hook. Match identification numbers as shown on approved controls shop drawings.

3.23 CONTROL DAMPER INSTALLATION

A. Damper submittals shall be coordinated for type, quantity, and size to ensure compatibility with sheet metal design.

B. Duct openings shall be free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting. Duct openings shall measure ¼ in. larger than damper dimensions and shall be square, straight, and level.

C. Individual damper sections, as well as entire multiple section assemblies, must be completely square and free from racking, twisting, or bending. Measure diagonally from upper corners to opposite lower corners of each damper section. Both dimensions must be within 0.3 cm (1/8 in.) of each other.

D. Follow the manufacturer's instructions for field installation of control dampers. Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.

E. Install extended shaft or jackshaft according to manufacturer’s instructions. (Typically, a sticker on the damper face shows recommended extended shaft location. Attach shaft on labeled side of damper to that blade.)

F. Damper blades, axles, and linkage must operate without binding. Before system operation, cycle damper after installation to ensure proper operation. On multiple section assemblies, all sections must open and close simultaneously.

G. Provide a visible and accessible indication of damper position on the drive shaft end.

H. Support ductwork in area of damper when required to prevent sagging due to damper weight.

I. After installation of low-leakage dampers with seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.

3.24 SMOKE DAMPER INSTALLATION

A. The contractor shall coordinate all smoke and smoke/fire damper installation, wiring, and checkout to ensure that these dampers function properly and that they respond to the proper fire alarm system general, zone, and/or detector trips. The contractor shall immediately report any discrepancies to the engineer no less than two weeks prior to inspection by the code authority having jurisdiction.

B. Provide complete submittal data to controls system subcontractor for coordination of duct smoke detector interface to HVAC systems.

3.25 DUCT SMOKE DETECTION

A. Submit data for coordination of duct smoke detector interface to HVAC systems as required in Part 1, "Submittals."

B. This Contractor shall provide a dry-contact alarm output in the same room as the HVAC equipment to be controlled.

3.26 PACKAGED EQUIPMENT CONTROLS

A. General: The electronic controls packaged with any equipment furnished under this contract shall communicate with the building's direct digital control (DDC) system. The DDC system shall communicate with these controls to read the information and change the control setpoints as shown in the points list, sequences of operation, and control schematics. The information to be communicated between the DDC system and these controls shall be in the standard object format as defined in ANSI/ASHRAE Standard 135 (BACnet). Controllers shall communicate with other BACnet objects on the internetwork using the Read (Execute) Property service as defined in Clause 15.5 of Standard 135.

B. Distributed Processing: The controller shall be capable of stand-alone operation and shall continue to provide control functions if the network connection is lost.

C. I/O Capacity: The controller shall contain sufficient I/ O capacity to control the target system.

D. The Controller shall have a physical connection for a laptop computer or a portable operator's tool.

E. Environment: The hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 40°C to 60°C (40°F to 140°F).
2. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

F. Serviceability: Provide diagnostic LEDs for power, communication, and processors. All wiring connections shall be made to field removable, modular terminal strips or to a termination card connected by a ribbon cable.

G. Memory: The Controller shall maintain all BIOS and programming information in the event of a power loss for at least 30 days.

H. Power: Controller shall be able to operate at 90% to 110% of nominal voltage rating.

I. Transformer: Power supply for the Controller must be rated at minimum of 125% of ASC power consumption and shall be fused or current limiting type.

3.27 START-UP AND CHECKOUT PROCEDURES

A. Start up, check out, and test all hardware and software and verify communication between all components.

1. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
2. Verify that all analog and binary input/output points read properly.
3. Verify alarms and interlocks.
4. Verify operation of the integrated system.

APPENDIX A: Glossary of Terms

Terms used within the Specification Text:

Advanced Application Controller (AAC):

A fully programmable control module. This control module may be capable of some of the advanced features found in Building Controllers (storing trends, initiating read and write requests, etc.) but it does not serve as a master controller. Advanced Application Controllers may reside on either the Ethernet/IP backbone or on a subnet.

Application Specific Controller (ASC):

A pre-programmed control module which is intended for use in a specific application. ASCs may be configurable, in that the user can choose between various pre-programmed options, but it does not support full custom programming. ASCs are often used on terminal equipment such as VAV boxes or fan coil units. In many vendors' architectures ASCs do not store trends or schedules but instead rely upon a Building Controller to provide those functions.

BACnet/IP:

An approved BACnet network type which uses an Ethernet carrier and IP addressing.

BACnet MS/TP:

An approved BACnet network type which uses a Master-Slave Token Passing configuration. MS/TP networks are unique to BACnet and utilize EIA485 twisted pair topology running at 9600 to 76,800 bps.

BACnet over ARCNET:

An approved BACnet network type which uses an ARCNET (attached resource computer network) carrier. ARCNET is an industry standard that can utilize several speeds and wiring standards. The most common configuration used by BACnet controllers is an EIA485 twisted pair topology running at 156,000 bps.

Building Controller (BC):

A fully programmable control module which is capable of storing trends and schedules, serving as a router to devices on a subnet, and initiating read and write requests to other controllers. Typically this controller is located on the Ethernet/IP backbone of the BAS. In many vendors' architectures a Building Controller will serve as a master controller, storing schedules and trends for controllers on a subnet underneath the Building Controller.

Direct Digital Control (DDC):

A control system in which a digital computer or microprocessor is directly connected to the valves, dampers, and other actuators which control the system, as opposed to indirectly controlling a system by resetting setpoints on an analog pneumatic or electronic controller.

PICS - Protocol Implementation Conformance Statement:

A written document, created by the manufacturer of a device, which identifies the particular options specified by BACnet that are implemented in the device.

Smart Actuator (SA):

An actuator which is controlled by a network connection rather than a binary or analog signal. (0-10v, 4-20mA, relay, etc.)

Smart Sensor (SS):

A sensor which provides information to the BAS via network connection rather than a binary or analog signal. (0-10000 ohm, 4-20mA, dry contact, etc.)

Web Services:

Web services are a standard method of exchanging data between computer systems using the XML (extensible markup language) and SOAP (simple object access protocol) standards. Web services can be used at any level within a Building Automation System (BAS), but most commonly they are used to transfer data between BAS using different protocols or between a BAS and a non-BAS system such as a tenant billing system or a utility management system.

Terms used within the Sequences of Operation:

adj.

Adjustable by the end user, through the supplied user interface.

AI, AO, etc. (Column Headings on Points List)

AI = Analog Input. A physical input to the control module.
AO = Analog Output. A physical output from the control module.
AV = Analog Value. An intermediate (software) point that may be editable or read-only. Editable AVs are typically used to allow the user to set a fixed control parameter, such as a setpoint. Read Only AVs are typically used to display the status of a control operation.
BI = Binary Input. A physical input to the control module.
BO = Binary Output. A physical output from the control module.
BV = Binary Value. An intermediate (software) point that may be editable or read-only. Editable BVs are typically used to allow the user to set a fixed control parameter, such as a setpoint. Read Only BVs are typically used to display the status of a control operation.
Loop = A control loop. Most commonly a PID control loop. Typically a control loop will include a setpoint, an input which is compared to the setpoint, and an output which controls some action based upon the difference between the input and the setpoint. A PID control loop will also include gains for the proportional, integral, and derivative response as well as an interval which controls how frequently the control loop updates its output. These gains may be adjustable by the end user for control loop "tuning," but in self-tuning control loops or loops which have been optimized for a specific application the gains may not be adjustable.
Sched = Schedule. The control algorithm for this equipment shall include a user editable schedule.
Trend. The control system shall be configured to collect and display a trend log of this object. The trending interval shall be no less than one sample every 5 minutes. (Change of Value trending, where a sample is taken every time the value changes by more than a user-defined minimum, is an acceptable alternative.)
Alarm. The control system shall be configured to generate an alarm when this object exceeds user definable limits, as described in the Sequence of Controls.

Note: If the specifications require use of the BACnet protocol, all of the above shall be provided as BACnet objects.

KW Demand Limiting: *

An energy management strategy that reduces energy consumption when a system's electric power meter exceeds an operator-defined threshold.

When power consumption exceeds defined levels, the system automatically adjust setpoints, de-energizes low priority equipment, and takes other pre-programmed actions to avoid peak demand charges. As the demand drops, the system restores loads in a predetermined manner.

Occupant Override Switch or Timed Local Override:

A control option that allows building occupants to override the programmed HVAC schedule for a limited period of time.

When the override time expires, the zone returns to its unoccupied state.

Occupant Setpoint Adjustment:

A control option that allows building occupants to adjust - within limits set by the HVAC control system - the heating and cooling setpoints of selected zones. Typically the user interface for this function is built into the zone sensor.

Optimal Start-Up: *

A control strategy that automatically starts an HVAC system at the latest possible time yet ensures comfort conditions by the time the building becomes occupied.

In a typical implementation, a controller measures the temperature of the zone and the outside air. Then, using design heating or cooling capacity at the design outside air temperature, the system computes how long a unit must run at maximum capacity to bring the zone temperature to its occupied setpoint.

The optimal start algorithm often includes a self-learning feature to adjust for variations from design capacity.

A distributed system must use Run on Request with Optimal Start. (See below.)

Requested, or Run on Request: *

A control strategy that optimizes the runtime of a source piece of equipment that supplies one or more receiving units - such as an air handler unit supplying zone terminal units with heating, cooling, ventilation, or similar service. Source equipment runs only when needed, not on a fixed schedule.

The source equipment runs when one or more receiving units request its services. An operator determines how many requests are required to start the source equipment.

For example, if all the zones in a building are unoccupied and the zone terminal units do not need heating or cooling, the AHU will shut down. However, if a zone becomes occupied or needs cooling, the terminal unit will send a run request to the AHU to initiate the start-up sequence. If this AHU depends on a central chiller, it can send a run request to the chiller.

The run on request algorithm also allows an operator to schedule occupancy for individual zones based on the needs of the occupants without having to adjust the schedules of related AHUs and chillers.

Trim and Respond, or Setpoint Optimization: *

A control strategy that optimizes the setpoint of a source piece of equipment that supplies one or more receiving units - such as an air handler unit supplying zone terminal units with heating, cooling, ventilation, or similar service.

The source unit communicates with receiving units to determine heating, cooling, and other requirements, and then adjusts its setpoint.

For example, if all zones are comfortable and do not request cooling, the AHU will gradually increase (trim) its supply air setpoint. When a zone requests cooling, the AHU responds by dropping its setpoint. The more zones that request cooling, the more it drops the setpoint. The AHU repeats this process throughout the day to keep zones cool, but with a supply air setpoint that is no cooler than necessary.

Contracting Terms:

Furnished or Provided:

The act of supplying a device or piece of equipment as required meeting the scope of work specified and making that device or equipment operational. All costs required to furnish the specified device or equipment and make it operational are borne by the division specified to be responsible for providing the device or equipment.

Install or Installed:

The physical act of mounting, piping or wiring a device or piece of equipment in accordance with the manufacturer's instructions and the scope of work as specified. All costs required to complete the installation are borne by the division specified to include labor and any ancillary materials.

Interface:

The physical device required to provide integration capabilities from an equipment vendor's product to the control system. The equipment vendor most normally furnishes the interface device. An example of an interface is the chilled water temperature reset interface card provided by the chiller manufacturer in order to allow the control system to integrate the chilled water temperature reset function into the control system.

Integrate:

The physical connections from a control system to all specified equipment through an interface as required to allow the specified control and monitoring functions of the equipment to be performed via the control system.

APPENDIX B: Abbreviations

The following abbreviations may be used in graphics, schematics, point names, and other UI applications where space is at a premium.

AC - Air Conditioning
ACU - Air Conditioning Unit
AHU - Air Handling Unit
AI - Analog Input

AO - Analog Output
AUTO - Automatic
AUX - Auxiliary
BI - Binary Input
BO - Binary Output
C - Common
CHW - Chilled Water
CHWP - Chilled Water Pump
CHWR - Chilled Water Return
CHWS - Chilled Water Supply
COND - Condenser
CW - Condenser Water
CWP - Condenser Water Pump
CWR - Condenser Water Return
CWS - Condenser Water Supply
DA - Discharge Air
EA - Exhaust Air
EF - Exhaust Fan
EVAP - Evaporators
FCU - Fan Coil Unit
HOA - Hand / Off / Auto
HP - Heat Pump
HRU - Heat Recovery Unit
HTEX - Heat Exchanger
HW - Hot Water
HWP - Hot Water Pump
HWR - Hot Water Return
HWS - Hot Water Supply
MAX - Maximum
MIN - Minimum
MISC - Miscellaneous
NC - Normally Closed
NO - Normally Open
OA - Outdoor Air
PIU - Powered Induction Unit
RA - Return Air
RF - Return Fan
RH - Relative Humidity
RTU - Roof-top Unit
SA - Supply Air
SF - Supply Fan
SP - Static Pressure
TEMP - Temperature
UH - Unit Heater
UV - Unit Ventilator
VAV - Variable Air Volume
VVTU - Variable Volume Terminal Unit
W/ - with

W/O - without
WSHP - Water Source Heat Pump

3.28 APPENDIX C: Existing Equipment to be converted to Automated Logic (ALC).

END OF SECTION 23 09 23

SECTION 23 09 72 - VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Variable frequency drives

1.2 RELATED WORK

A. Division 23 – Scope of Work

B. Division 23 – Common Work Results for HVAC

1.3 SUBMITTALS

A. Submit drawings and/or catalog cuts giving dimension, arrangement, construction materials available speed range drive horsepower rating, electrical characteristics of controller, references signal characteristics, specifications on standard components and required options and installation instructions.

1.4 DESCRIPTION

A. This specification is to cover a complete Variable Frequency motor Drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use on a standard NEMA Design B induction motor. It is required that the drive manufacturer have an existing:

1. Sales representative exclusively for HVAC products, with expertise in HVAC systems and controls.
2. An independent service organization.

B. The drive manufacturer shall supply the drive and all necessary controls as herein specified. The manufacturer shall have been engaged in the production of this type of equipment for a minimum of twenty years.

1.5 QUALITY ASSURANCE

A. Referenced Standards:

1. Institute of Electrical and Electronic Engineers (IEEE)

a. Standard 519-1992, IEEE Guide for Harmonic Content and Control.

2. Underwriters laboratories

   a. UL508C

3. National Electrical Manufacturer's Association (NEMA)

   a. ICS 7.0, AC Adjustable Speed Drives

4. IEC 16800 Parts 1 and 2

B. Qualifications:

1. VFDs and options shall be UL listed as a complete assembly. VFD's that require the customer to supply external fuses for the VFD to be UL listed are not acceptable. The base VFD shall be UL listed for 100 KAIC without the need for input fuses.
2. CE Mark – The VFD shall conform to the European Union ElectroMagnetic Compatibility directive, a requirement for CE marking. The VFD shall meet product standard EN 61800-3 for the First Environment restricted level.
3. Acceptable Manufactures

   a. ABB ACH Series
   b. Nailor

4. The VFD manufacturer shall have available a comprehensive, HVAC Drive Computer Based Training (CBT) product. The CBT product shall include detailed, interactive sections covering VFD unpacking, proper mechanical and electrical installation and programming. The CBT product shall allow the user to provide just-in-time training to new personnel or refresher training for maintenance and repair personnel at the user's site. The CBT product shall record answers to simulations and tests by student ID. The CBT product must be professionally produced and have interactive sessions, student tests and video clips of proper wiring and installation.
5. All VFD's on the project shall be of one manufacturer. Contractor to coordinate with equipment manufacturers and suppliers to meet this requirement.

1.6 SUBMITTALS

A. Submittals shall include the following information:

1. Outline dimensions, conduit entry locations and weight.
2. Customer connection and power wiring diagrams.
3. Complete technical product description include a complete list of options provided
4. Compliance to IEEE 519 – harmonic analysis for particular jobsite including total harmonic voltage distortion and total harmonic current distortion (TDD).

   a. The VFD manufacture shall provide calculations, specific to this installation, showing total harmonic voltage distortion is less than 5%. Input line filters shall be sized and provided as required by the AFD manufacturer to ensure compliance with IEEE standard 519. All VFD's shall include a minimum of 5% impedance reactors, **no exceptions**.

1.7 WARRANTY

A. Warranty shall be 24 months from the date of certified start-up, not to exceed 30 months from the date of shipment. The warranty shall include all parts, labor, travel time and expenses. There shall be 365/24 support available via a toll free phone number.

PART 2 - PRODUCTS

2.1 VARIABLE FREQUENCY DRIVES

A. The VFD package as specified herein shall be enclosed in a UL Listed/NEMA Rated Type 12 (indoor dust tight) enclosure, completely assembled and tested by the manufacturer in an ISO9001 facility. The VFD tolerated voltage window shall allow the VFD to operate from a line of +30% nominal, and -35% nominal voltage as a minimum.

1. Environmental operating conditions: 0 to 40°C continuous. VFD's that can operate at 40° C intermittently (during a 24 hour period) are not acceptable and must be oversized. Altitude 0 to 3300 feet above sea level, less than 95% humidity, non-condensing.
2. Enclosure shall be rated UL Type/NEMA 12 and shall be UL listed as a plenum rated VFD. VFD's without these ratings are not acceptable. Enclosure shall be rated UL type 12 and shall be UL listed as a plenum rated VFD. VFD's without these ratings are not acceptable.

B. All VFDs shall have the following standard features:

1. All VFDs shall have the same customer interface, including digital display, and keypad, regardless of horsepower rating. The keypad shall be removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFDs.
2. The keypad shall include Hand-Off-Auto selections and manual speed control. The drive shall incorporate "bumpless transfer" of speed reference when switching between "Hand" and "Auto" modes. There shall be fault reset and "Help" buttons on the keypad. The Help button shall include "on-line" assistance for programming and troubleshooting.
3. There shall be a built-in time clock in the VFD keypad. The clock shall have a battery back up with 10 years minimum life span. The clock shall be used to date and time stamp faults and record operating parameters at the time of fault. If the battery fails, the VFD shall automatically revert to hours of operation since initial power up. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter sets and output relays. The VFD shall have a digital input that allows an override to the time clock (when in the off mode) for a programmable time frame. There shall be four (4) separate, independent timer functions that have both weekday and weekend settings.
4. The VFD's shall utilize pre-programmed application macro's specifically designed to facilitate start-up. The Application Macros shall provide one command to reprogram all parameters and customer interfaces for a particular application to reduce programming time. The VFD shall have two user macros to allow the end-user to create and save custom settings.

5. The VFD shall have cooling fans that are designed for easy replacement. The fans shall be designed for replacement without requiring removing the VFD from the wall or removal of circuit boards. The VFD cooling fans shall operate only when required. To extend the fan and bearing operating life, operating temperature will be monitored and used to cycle the fans on and off as required.
6. The VFD shall be capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to setpoint without safety tripping or component damage (flying start).
7. The VFD shall have the ability to automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable.
8. The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds. The minimum FLA rating shall meet or exceed the values in the NEC/UL table 430-150 for 4-pole motors.
9. The VFD shall have an integral 5% impedance line reactors to reduce the harmonics to the power line and to add protection from AC line transients. The 5% impedance may be from dual (positive and negative DC bus) reactors, or 5% AC line reactors. VFD's with only one DC reactor shall add AC line reactors.
10. The input current rating of the VFD shall be no more than 3% greater than the output current rating. VFD's with higher input current ratings require the upstream wiring, protection devices and source transformers to be oversized per NEC 430-2.
11. The VFD shall include a coordinated AC transient protection system consisting of 4-120 joule rated MOV's (phase to phase and phase to ground), a capacitor clamp, and 5% impedance reactors.
12. The VFD shall be capable of sensing a loss of load (broken belt / broken coupling) and signal the loss of load condition. The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. Relay outputs shall include programmable time delays that will allow for drive acceleration from zero speed without signaling a false underload condition.
13. If the input reference (4-20mA or 2-10V) is lost, the VFD shall give the user the option of either (1) stopping and displaying a fault, (2) running at a programmable preset speed, (3) hold the AFD speed based on the last good reference received, or (4) cause a warning to be issued, as selected by the user. The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communication bus.
14. The VFD shall have programmable "Sleep" and "Wake up" functions to allow the drive to be started and stopped from the level of a process feedback signal.

C. All VFDs to have the following adjustments:

1. Three (3) programmable critical frequency lockout ranges to prevent the VFD from operating the load continuously at an unstable speed.
2. Two (2) PID Setpoint controllers shall be standard in the drive, allowing pressure or flow signals to be connected to the VFD, using the microprocessor in the VFD for the closed loop control. The VFD shall have 250 ma of 24 VDC auxiliary power and be capable of loop powering a transmitter supplied by others. The PID setpoint shall be adjustable from the VFD keypad, analog inputs, or over the communications bus. There shall be two parameter sets for the first PID that allow the sets to be switched via a digital input, serial communications or from the keypad for night setback, summer/winter setpoints, etc. There shall be an independent, second PID loop that can utilize the second analog input

and modulate one of the analog outputs to maintain setpoint of an independent process (ie. valves, dampers, etc.). All setpoints, process variables, etc. to be accessible from the serial communication network. The setpoints shall be set in Engineering units and not require a percentage of the transducer input.

3. Two (2) programmable analog inputs shall accept current or voltage signals.
4. Two (2) programmable analog outputs (0-20ma or 4-20 ma). The outputs may be programmed to output proportional to Frequency, Motor Speed, Output Voltage, Output Current, Motor Torque, Motor Power (kW), DC Bus voltage, Active Reference, and other data.
5. Six (6) programmable digital inputs for maximum flexibility in interfacing with external devices, typically programmed as follows:

    a. There shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad, input contact closure, time-clock control, or serial communications) the VFD shall provide a dry contact closure that will signal the damper to open (VFD motor does not operate). When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to an VFD digital input and allows VFD motor operation. Two separate safety interlock inputs shall be provided. When either safety is opened, the motor shall be commanded to coast to stop, and the damper shall be commanded to close. The keypad shall display "start enable 1 (or 2) missing". The safety status shall also be transmitted over the serial communications bus. All digital inputs shall be programmable to initiate upon an application or removal of 24VDC.

6. Three (3) programmable digital Form-C relay outputs. The relays shall include programmable on and off delay times and adjustable hysteresis. Default settings shall be for run, not faulted (fail safe), and run permissive. The relays shall be rated for maximum switching current 8 amps at 24 VDC and 0.4 A at 250 VAC; Maximum voltage 300 VDC and 250 VAC; continuous current rating 2 amps RMS. Outputs shall be true form C type contacts; open collector outputs are not acceptable.
7. Seven (7) programmable preset speeds.
8. Two independently adjustable accel and decel ramps with 1 – 1800 seconds adjustable time ramps.
9. The VFD shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and audible motor noise.
10. The VFD shall include a carrier frequency control circuit that reduces the carrier frequency based on actual VFD temperature that allows the highest carrier frequency without derating the VFD or operating at high carrier frequency only at low speeds.
11. The VFD shall include password protection against parameter changes.

D. The Keypad shall include a backlit LCD display. The display shall be in complete English words for programming and fault diagnostics (alpha-numeric codes are not acceptable). The keypad shall utilize the following assistants:

1. Start-up assistants.
2. Parameter assistants
3. Maintenance assistant
4. Troubleshooting assistant

E. All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of three operating values from the list below shall be capable of being displayed at all times. The display shall be in complete English words (alpha-numeric codes are not acceptable):

1. Output Frequency
2. Motor Speed (RPM, %, or Engineering units)
3. Motor Current
4. Calculated Motor Torque
5. Calculated Motor Power (kW)
6. DC Bus Voltage
7. Output Voltage

F. The VFD shall include a fireman's override input. Upon receipt of a contact closure from the fireman's control station, the VFD shall operate at an adjustable preset speed. The mode shall override all other inputs (analog/digital, serial communication, and all keypad commands) and force the motor to run at the adjustable, preset speed. "Override Mode" shall be displayed on the keypad. Upon removal of the override signal, the VFD shall resume normal operation.

G. Serial Communications

1. The VFD shall have an RS-485 port as standard. The standard protocols shall be Modbus, Johnson Controls N2 bus, and Siemens Building Technologies FLN. Optional protocols for LonWorks, BACnet, Profibus, Ethernet, and DeviceNet shall be available. Each individual drive shall have the protocol in the base VFD. The use of third-party gateways and multiplexers is not acceptable. All protocols shall be "certified" by the governing authority. Use of non-certified protocols is not allowed.
2. The BACnet connection shall be PS485, MSTP interface operating at 9.6, 19.2, 38.4 or 76.8 Kbps. The connection shall be tested by the BACnet Testing L (BTL) and be BTL listed. The BACnet interface shall conform to the BACnet standard device type of an Applications Specific Controller (B-ASC). The interface shall support all BIBB's defined by the BACnet standard protocols for a B-ASC including, but not limited to:

    a. Data Sharing – Read Property – B.
    b. Data Sharing – Write Property – B.
    c. Device Management – Dynamic Device Binding (Who-Is; I-AM).
    d. Device Management – Dynamic Object Binding (Who-Has; I-Have).
    e. Device Management – Communication Control – B.

3. Serial communication capabilities shall include but not be limited to; run-stop control, speed set adjustment, proportional/integral/derivative PID control adjustments, current limit, accel/decel time adjustments, and lock and unlock the keypad. The drive shall have the capability of allowing the DDC to monitor feedback such as process variable feedback, output speed / frequency, current (in amps), % torque, power (kW), kilowatt hours (resettable), operating hours (resettable), and drive temperature. The DDC shall also be capable of monitoring the VFD relay output status, digital input status, and all analog input and analog output values. All diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote VFD fault reset shall be possible. The following additional status indications and settings shall be transmitted

over the serial communications bus – keypad "Hand" or "Auto" selected, bypass selected, the ability to change the PID setpoint, and the ability to force the unit to bypass (if bypass is specified). The DDC system shall also be able to monitor if the motor is running in the VFD mode or bypass mode (if bypass is specified) over serial communications. A minimum of 15 field parameters shall be capable of being monitored.

4. The VFD shall allow the DDC to control the drive's digital and analog outputs via the serial interface. This control shall be independent of any VFD function. For example, the analog outputs may be used for modulating chilled water valves or cooling tower bypass valves. The drive's digital (relay) outputs may be used to actuate a damper, open a valve or control any other device that requires a maintained contact for operation. In addition, all of the drive's digital and analog inputs shall be capable of being monitored by the DDC system.
5. The VFD shall include an independent PID loop for customer use. The independent PID loop may be used for cooling tower bypass value control, chilled water value control, etc. Both the VFD control PID loop and the independent PID loop shall continue functioning even if the serial communications connection is lost. The VFD shall keep the last good set-point command and last good DO & AO commands in memory in the event the serial communications connection is lost.

H. EMI / RFI filters. All VFD's shall include EMI/RFI filters. The onboard filters shall allow the VFD assemble to be CE Marked and the AFD shall meet product standard EN 61800-3 for the First Environment restricted level.

I. All VFD's through 50HP shall be protected from input and output power mis-wiring. The VFD shall sense this condition and display an alarm on the keypad.

J. OPTIONAL FEATURES – Optional features to be furnished and mounted by the drive manufacturer. All optional features shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.

1. A complete factory wired and tested bypass system consisting of an output contactor and bypass contactor. Overload protection and shall be provided in both drive and bypass modes.
2. Door interlocked, padlockable circuit breaker that will disconnect all input power from the drive and all internally mounted options.
3. Fused VFD only disconnect (service switch). Fast acting fuses exclusive to the VFD – fast acting fuses allow the VFD to disconnect from the line prior to clearing upstream branch circuit protection, maintaining bypass capability. Bypass designs, which have no such fuses, or that incorporate fuses common to both the VFD and the bypass will not be accepted. Three contactor bypass schemes are not acceptable.
4. The drive / bypass shall provide single-phase motor protection in both the VFD and bypass modes.
5. The following operators shall be provided:

    a. Bypass Hand-Off-Auto
    b. Drive mode selector
    c. Bypass mode selector
    d. Bypass fault reset

6. The following indicating lights (LED type) shall be provided. A test mode or push to test feature shall be provided.

    a. Power-on (Ready)
    b. Run enable (safeties) open
    c. Drive mode select damper opening
    d. Bypass mode selected
    e. Drive running
    f. Bypass running
    g. Drive fault
    h. Bypass fault
    i. Bypass H-O-A mode
    j. Automatic transfer to bypass selected
    k. Safety open
    l. Damper opening
    m. Damper end-switch made

7. The following relay (form C) outputs from the bypass shall be provided:

    a. System started
    b. System running
    c. Bypass override enabled
    d. Drive fault
    e. Bypass fault (motor overload or underload (broken belt))
    f. Bypass H-O-A position

8. The digital inputs for the system shall accept 24V or 115 VAC (selectable). The bypass shall incorporate internally sourced power supply and not require an external control power source.
9. Customer Interlock Terminal Strip – provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external safety interlocks shall remain fully functional whether the system is in Hand, Auto, or Bypass modes (not functional in Fireman's Override 2). The remote start/stop contact shall operate in VFD and bypass modes.
10. Dedicated digital input that will transfer motor from VFD mode to bypass mode upon dry contact closure for fireman's override. Two modes of operation are required.

    a. One mode forces the motor to bypass operation and overrides both the VFD and bypass H-O-A switches and forces the motor to operate across the line (test mode). The system will only respond to the digital inputs and motor protections.
    b. The second fireman's override mode remains as above, but will also defeat the overload and single-phase protection for bypass and ignore all keypad and digital inputs to the system (run until destruction).

11. The VFD shall include a "run permissive circuit" that will provide a normally open contact whenever a run command is provided (local or remote start command in VFD or bypass mode). The VFD system (VFD or bypass) shall not operate the motor until it receives a dry contact closure from a damper or valve end-switch. When the VFD system safety interlock (fire detector, freezestat, high static pressure switch, etc.) opens, the

motor shall coast to a stop and the run permissive contact shall open, closing the damper or valve.

12. Class 20 or 30 (selectable) electronic motor overload protection shall be included.
13. There shall be an internal switch to select manual or automatic bypass.
14. There shall be an adjustable current sensing circuit for the bypass to provide loss of load indication (broken belt) when in the bypass mode.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine areas and conditions under which the variable frequency controls are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner a manner acceptable to installer.

3.2 INSTALLATION OF VARIABLE FREQUENCY DRIVE

A. General: Install variable frequency drive where indicated, in accordance with equipment manufacturer's published installation instructions, and with recognized industry practices, to ensure that units comply with requirements and serve intended purposes.

B. Coordination: Coordinate with other work as necessary to interface installation of variable frequency drive with other work.

C. Access: Provide access space around variable frequency drive for service as indicated.

D. Support: Install floor-mounted variable frequency drives on 4" high reinforced concrete pad, 4" larger on each side than unit base. Provide a unistrut frame.

E. Mounting: Mount variable speed drive in accordance with manufacturer's instructions.

F. Electrical Wiring: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to electrical installer.

1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements, and local codes. Do not proceed with equipment start-up until wiring installation is acceptable to equipment manufacturer.

G. Installation shall be the responsibility of the mechanical contractor. The contractor shall install the drive in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

H. Power wiring shall be completed by the electrical contractor. The contractor shall complete all wiring in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

I. Ground Motor Shafts.

3.3 START-UP

A. Certified factory start-up shall be provided for each drive by a factory authorized service center. A certified start-up form shall be filled out for each drive with a copy provided to the owner, and a copy kept on file at the manufacturer.

B. A computer based training CD or 8-hour professionally generated video (VCR format) shall be provided to the Owner at the time of project closeout. The training shall include installation, programming and operation of the VFD, bypass and serial communication.

3.4 PRODUCT SUPPORT

A. Factory trained application engineering and service personnel that are thoroughly familiar with the VFD products offered shall be locally available at both the specifying and installation locations. A 24/365 technical support line shall be available on a toll-free line.

3.5 FIELD QUALITY CONTROL

A. Testing: Upon completion of installation of variable frequency drive, manufacturer shall start up and operate equipment to demonstrate capability and compliance with requirements. Field correct malfunctioning units, then retest to demonstrate compliance.

B. Instruct Owner's personnel on operation of variable frequency drive motor control system.

END OF SECTION 23 09 72

SECTION 23 09 93 - SEQUENCE OF OPERATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Division 23: Direct Digital Control

C. Division 23: Basic Mechanical Requirements

1.2 SUMMARY

A. This Section includes control sequences for HVAC systems and terminal units.

B. Related Section: Division 23 – Direct Digital Control contains requirements that relate to this Section.

C. See attached point list for monitoring points to be provided at the graphical operator workstation.

1.3 EQUIPMENT SEQUENCE OF OPERATION

A. Rooftop Unit (Graphics, Admin, RTU-10 & RTU-11):

1. Heating Cycle (RTU Graphics and Admin) (Morning Warm-up): Unit will be indexed to the warm-up cycle as instructed by the unit controller when room temperature is below the occupied heating temperature set point upon a sequence change from unoccupied to occupied cycle. The unit shall be indexed to its heating CFM. Outside damper shall be closed and return air damper open, exhaust fan shall be off, the heating shall modulate to maintain space temperature. When the room temperature is at the occupied set point, then the morning warm-up cycle will be switched over to the occupied cycle.
2. Morning Cool-down Cycle (RTU Graphics and Admin): Unit will be indexed to the cool-down cycle as instructed by the unit controller when room temperature is above the occupied cooling temperature setpoint upon a sequence change from unoccupied to occupied cycle. The unit shall be indexed to its full cooling CFM. Outside air damper shall be closed and return air damper open, exhaust fan shall be off, and the mechanical cooling shall energize. The cooling stages shall operate to maintain the cooling setpoint 75°F (adj.) when the room temperature is at the occupied setpoint, then the morning cool-down cycle shall be switched over to the occupied cooling cycle.
3. The new UV’s will be draw-through arrangement with face and bypass dampers, 1 hot water coil, and 1 chilled water coil.

4. The new HW valves will be 3-way since the existing pumps have no VFD's. This matches the existing set-up.
5. The new CHW valves will be 2-way since the new chillers have circulating pumps with VFD's and 35% propylene glycol. To meet minimum flow on air cooled chiller with glycol, provide a differential pressure controlled bypass near the chiller on the roof. Provide an outdoor ONICON flow meter on the bypass for the TAB contractor's use.
6. UV sequence of operation shall include a minimum amount that the HW valve opens to the coil when OA temperatures drop below 40 F (adj). The heating hot water valve opens to the coil a minimum of 20% (adj.)
7. Program freeze protection to make the HW valve open to a minimum position upon a discharge air temperature below 40 degrees F (adjustable).

B. Rooftop Unit – Variable Air Volume/Hot Water Heat (Admin):

1. The RTU will be controlled by the ATC Contractor (ALC). It will provide all control functions.

    a. The RTU unit shall be provided with a terminal strip to be interfaced with existing BACnet DDC system by ALC.
    b. Head Pressure Control: The condenser head pressure will be monitored by the unit controller to maintain head pressure and the compressor operating envelope at all times to avoid high pressure trips on high load days. Condenser fans with ECM motors shall be provided as well as factory sensors to provide this protection.
    c. Compressor Envelope Control: The unit controller will continually monitor the suction and discharge pressure and temperature conditions during compressor operation. The unit will modulate the compressor, condenser head pressure, and electronic expansion valve to maintain a safe compressor operating conditions to add reliability, and limit unit shut down during fringe operating conditions.
    d. Change over Setpoints: The unit change over source temperature is the variable, Outdoor air temperature (OAT), Return air temperature (RAT), or space temperature (ST), that drives the change of unit states. The unit state will change from cooling, fan only or heating based on the changeover heating or cooling setpoints.

2. Occupied Cycle: Unit supply fan shall run continuously, the outdoor air damper shall open to 100% open position, and the exhaust fan shall run. Upon a fall in supply air temperature below set point, the unit hot water valve shall modulate open to maintain supply air temperature set point. Upon a rise in supply air temperature above the set point hot water heat shall be disabled. As the supply air temperature continues to rise and outdoor air conditions permit, the outdoor air damper shall remain open to provide economizer cooling and maintain mixed air temperature setpoint. On a continued rise in supply air temperature, the DX cooling section shall be staged to maintain supply air temperature set point. The supply fan ECM motor shall be modulated to maintain supply pressure set point 2/3 the way down the duct.
3. Outside Air Damper Control:

    a. Proportional Damper Reset: The unit controller will proportionally modulate the outside air dampers open and closed as the supply fan speed changes to provide a constant volume of fresh outside air.

b. Outdoor Air Monitor: The unit controller will modulate the outside air damper as required to maintain the outside air cfm setpoint as measured by the factory provided flow station (Requires Optional OA Monitor).
c. DCV: A space or duct mounted CO2 sensor will supply a PPM reading to the unit controller. The unit controller will open the OA damper to provide more ventilation air as required by the CO2 PPM reading (Requires Optional CO2 Sensor).
d. External Reset: An external 0-10 VDC or 4-20 mA signal can be wired to the unit controller to control the OA damper position by a third party.

4. Airflow measuring stations in the outside air section shall measure airflow. The DDC shall modulate the outside air damper and return air damper to maintain outside air CFM as scheduled. The DDC system shall have the exhaust fan ECM motor to Maintain O/A to return air CFM. Balancing agency and manufacturer's startup technicians shall work together and be responsible for setting the fan speed based on actual air intake volume throughout the entire OSA airflow range (verified through balancing equipment). The relief air volume shall track the OSA intake volume.
5. Cooling:

a. Discharge Air Control: In the cooling mode, the unit capacity will modulate the variable speed compressor to maintain the unit cooling discharge air set point. The cooling DAT set point will be adjustable at the unit controller. Unit capacity will be modulated by the variable speed compressor operation.
b. Cooling DAT Reset: The cooling DAT setpoint may be reset by the space temp, return temp, OAT or external Voltage/mA signals. A linear relationship between the DAT and the reset variable will be created for the minimum and maximum DAT setpoints. As the reset variable changes the DAT will adjust according to the relationship.

6. Economizer: A comparative enthalpy shall be engaged whenever the outdoor enthalpy or dry bulb is less than the return air enthalpy or dry bulb to utilize outside air for cooling. Outside air and return air dampers shall modulate to maintain supply air temperature set point.
7. Exhaust Fan Control: Exhaust fans shall be provided with direct drive electrically commutated motor(s) (ECM). Powered exhaust control options shall be as follows:

a. Building Pressure Control: A differential pressure transducer shall compare the indoor building pressure to ambient atmospheric pressure. The exhaust fan(s) shall modulate to maintain the building pressure set point.

8. Modulating Hot Gas Reheat:

a. The unit is provided with fully modulating, sub cooling, hot gas reheat coil. The control sequence used for dehumidification in the unit uses two separate points of control.
b. Heating is enabled when the temperature falls one deadband below the Heating Setpoint. Heating is disabled when the temperature raises one deadband above the Heating Setpoint.

c. Unoccupied Heating operation is enabled when the Space Temperature falls below the Heating Mode Enable Setpoint minus the Unoccupied Heating Offset.
d. In the Heating Mode, as the Supply Air Temperature falls below the Supply Air Heating Setpoint, the heating will begin to stage on. Each stage must meet its Minimum Off Time (adj.) before it is allowed to energize, and successive stages are subject to a Heating Stage Up Delay (adj).
e. Heating stages will continue to run until the Supply Air Temperature rises above the Supply Air Temperature Setpoint plus the Heating Stage Control Window at which point the heating will begin to stage off. Each stage must meet its Minimum Run Time (adj.) before it is allowed to stage off, and successive stages are subject to a Heating Stage Down Delay (adj.).
f. Mechanical heating is disabled if the Outdoor Air Temperature (OAT) rises 1° above the Heating Lockout Setpoint and will remain disabled until the OAT falls 1° below the Heating Lockout Setpoint. If the OAT disables mechanical heating while it is currently operating, mechanical heating will stage off as minimum run times and stage down delays are satisfied.

9. Dehumidification Operation with Variable Capacity Compressor(s)

a. Dehumidification is enabled when the Indoor Humidity rises above the Indoor Humidity Enable/Hi Reset Setpoint and is disabled when the Indoor Humidity falls below the Disable/Lo Reset Setpoint and Combination Space Return Air Temperature/Humidity Sensor.
b. Dehumidification shall be selected as a priority mode and active anytime the humidity is above the Setpoint; otherwise, it is only available when heating and cooling demands are satisfied.
c. Once in dehumidification, the unit will modulate and stage compressors based on the unit configuration in order maintain the Evaporator Coil Suction (Saturation) Temperature at the Coil Suction (Saturation) Temperature Setpoint.
d. A coil suction pressure sensor shall be factory installed.
e. Dehumidification Reheat shall be controlled to the appropriate Supply Air Temperature Setpoint which will be dependent on whether in Cooling Dehumidification, Heating Dehumidification, or Vent Dehumidification. During Vent Mode Dehumidification the Supply Air Temperature Setpoint is calculated to be halfway between the HVAC Mode Setpoints.

C. Rooftop Unit – Constant Air Volume/Hot Water Heat (Graphics):

1. The RTU will be controlled by the ATC Contractor (ALC). It will provide all control functions, Building Automation System (BAS) interface: The unit shall be provided with a terminal strip to be interfaced with existing BACnet DDC system by ALC.

a. Compressor Envelope Control: The unit controller will continually monitor the suction and discharge pressure and temperature conditions during compressor operation. The unit will modulate the compressor, condenser head pressure, and electronic expansion valve to maintain a safe compressor operating conditions to add reliability, and limit unit shut down during fringe operating conditions.
b. Change over Setpoints: The unit change over source temperature is the variable, Outdoor air temperature (OAT), Return air temperature (RAT), or space

temperature (ST), that drives the change of unit states. The unit state will change from cooling, fan only or heating based on the changeover heating or cooling setpoints.

2. Occupied Cycle:

   a. Unit supply fan shall run continuously, the outdoor air damper shall open to 100% open position, and the exhaust fan shall run. Upon a fall in supply air temperature below set point, the unit hot water valve shall modulate open to maintain supply air temperature set point. Upon a rise in supply air temperature above the set point hot water heat shall be disabled. As the supply air temperature continues to rise and outdoor air conditions permit, the outdoor air damper shall remain open to provide economizer cooling and maintain mixed air temperature setpoint. On a continued rise in supply air temperature, the DX cooling section shall be staged to maintain supply air temperature set point. The supply fan ECM motor shall be modulated to maintain supply pressure set point 2/3 the way down the duct.
   b. Cooling stages will continue to run until the Supply Air Temperature falls below the Supply Air Temperature Setpoint, minus the Cooling Stage Control Window at which point the cooling will begin to stage off. Each stage shall meet its Minimum Run Time (adj.) before it is allowed to stage off, and successive stages are subject to a Cooling Stage Down Delay (adj.).

3. Unoccupied Mode:

   a. Upon going Unoccupied, the Cooling or Heating will turn off immediately. The Fan will then turn off in 30 to 60 seconds. The Supply Fan and Exhaust Fan will cycle intermittently on a call for Heating, Cooling, or Dehumidification.
   b. If the Unoccupied Setback Offset Setpoints for heating and cooling are left at the default of 30°F, no Unoccupied Setback operation will occur and the unit will be off. The Outdoor Air Damper will be closed except if the unit is in unoccupied Economizer Free Cooling Mode. If there is no call for Heating or Cooling, the unit will be off.

4. Outside Air Damper Control:

   a. Proportional Damper Reset: The unit controller will open the outside air dampers to provide a constant volume of fresh outside air.

5. Airflow measuring stations in the return air duct and supply air duct and outside air section shall measure airflow. The DDC shall modulate the outside air damper and return air damper to maintain outside air CFM as scheduled. The DDC system shall have the exhaust fan ECM motor to Maintain O/A to return air CFM. Balancing agency and manufacturer's startup technicians shall work together and be responsible for setting the fan speed based on actual air intake volume throughout the entire OSA airflow range (verified through balancing equipment). The relief air volume shall track the OSA intake volume.

6. Economizer:

    a. Enthalpy Economizer operation is enabled when the Outdoor Air (OA) dry bulb, wet bulb, or dewpoint temperature falls below the Economizer Enable Setpoint by 1°F.
    b. Economizer operation is disabled when the OA temperature rises 1°F above the Economizer Enable Setpoint.
    c. The Economizer acts as the 1st stage of cooling and controls to the Active Supply Air Cooling Setpoint as programmed into the controller.
    d. During Economizer Operation, the economizer will modulate between the minimum position and 100%.
    e. If the economizer reaches 100% and the Supply Air Temperature is still above setpoint, mechanical cooling is then allowed to stage up while the economizer is held at the full open position. Any time cooling stages are currently running, and the economizer becomes enabled, it will immediately open to 100%.
    f. During Heat and Vent Modes, the Economizer will remain at its minimum position. During Unoccupied Mode, the Economizer will enable night setback free cooling; otherwise, it will remain closed.

7. Exhaust Fan Control: Exhaust fans shall be provided with direct drive electrically commutated motor(s) (ECM). Powered exhaust control options shall be as follows:

    a. Building Pressure Control: A differential pressure transducer shall compare the indoor building pressure to ambient atmospheric pressure. The exhaust fan(s) shall modulate to maintain the building pressure set point.

8. Modulating Hot Gas Reheat:

    a. During the Dehumidification Mode, the VCCX2 activates Cooling to extract moisture from the Supply Air and utilizes Modulating Hot Gas Reheat to reheat the Supply Air.
    b. Reheat is controlled to the Supply Air Setpoint which will be different depending on whether the unit is in Cooling Mode Dehumidification or Vent Mode Dehumidification.
    c. During Cooling Dehumidification, Reheat is controlled to the Cooling Supply Air Setpoint.
    d. During Vent Dehumidification, Reheat is controlled to a calculated setpoint that is halfway between the Heating and Cooling Mode Enable Setpoints.
    e. During Dehumidification, the Modulating Hot Gas Reheat (MHGR-X) will modulate the reheat valve to maintain the Supply Air Temperature at the Supply Air Temperature Setpoint.

9. Dehumidification Operation

    a. Unit dehumidification will utilize a Refrigerant System Module (RSM). The RSM will control the following the compressors and condensers.
    b. The RSMD board is used for digital compressors.

c. In the Dehumidification Mode, the compressor is controlled to maintain the Suction (Saturation) Temperature Setpoint. The RSM will control its compressors to achieve the most efficient dehumidification control.
d. Safety: If the Coil Saturated Temperature drops below 32°F, any cooling remaining on will be forced off.
e. During Dehumidification, the Economizer will be held to its minimum position.
f. Dehumidification controls allow the unit to cool and dehumidify simultaneously or just dehumidify if no cooling is needed.
g. Dehumidification will be activated when the relative humidity in the return duct, space, or outdoor air rises above the dehumidification set point.

10. Dirty Filter Switch (Graphics, Admin, RTU-10 & RTU-11):

a. The unit shall be provided with an internally mounted pressure switch to detect pressure drop across the filters and indicate dirty or clogged filters. Alarm shall be sent to BMS System.

11. Safeties (Graphics, Admin, RTU-10 & RTU-11):

a. Smoke detectors in the supply and return ductwork will close and de-energize the unit and DX cooling upon the detection of products of combustion by automatic mode; indicate fire alarm condition at the DDC panels and fire alarm panels upon such occurrences. Smoke detectors are provided by the Electrical Contractor; fire alarm interlock wiring is provided by the Electrical Contractor.
b. Minimum run time, anti-short cycle timer safety – the DDC system controller shall monitor and sequence the stages of cooling. Each stage of cooling shall have a minimum run time of 5 minutes (adj.) and shall have an anti-short cycle time delay of 2.5 minutes (adj.) a compressor can be turned on again. This must be coordinated with the equipment manufacturer.
c. A pressure sensor shall be provided across the filter to provide dirty filter alarm.

12. Provide system graphic showing layout, including fan system, ductwork, dampers, cooling coils, heating coils, sensors, etc. Provide points as defined on point lists.
13. Unoccupied Cycle (Graphics, Admin, RTU-10 & RTU-11): Fan de-energized, outdoor air damper closed, exhaust fan de-energized, return air damper open. The unit shall run intermittently to maintain night setback temperature. During night set back operation. O/A damper is closed, return damper is open, exhaust fan and heat recoveries are off.

D. VAV Box: VAV Boxes controlled by a DDC controller shipped to factory for factory mounting. Each controlled by controller. Each system shall be interfaced with the existing BAS system.

1. Occupied Cycle: On a call for cooling, the space temperature sensor shall modulate the VAV damper from the cooling minimum to maximum setting to maintain cooling set point (75°F, adj.). On a call for heat, the VAV damper shall be modulated to the cooling minimum position on a further drop in space temperature, the hot water reheat control valve shall modulate open and the VAV box shall modulate to minimum heating CFM to maintain heating set point (72°F, adj.). Supply air temperature after the reheat coil shall be monitored through the DDC system.

2. Upon a call for space heat from the VAV box and boiler plant not in operation, the RTU shall operate to provide heating. The VAV box shall work in reverse to control space temperature.

E. Unit Ventilator:

1. The Unit Ventilator will be provided with a controller provided with a communication card to be interfaced with the existing DDC BACnet system. The system will be controlled by the ATC Contractor for each unit.
2. The unit ventilator will be controlled by the ATC Contractor and provide all control functions. The factory unit controller shall be provided with a communication card to be interfaced with existing BACnet DDC system by Air Temp. Unit Ventilators, and chilled water-cooling controls shall be by the same ATC Contractor.
3. Occupied Cycle: Upon a fall in space temperature below setpoint, the outdoor air damper shall remain at minimum position, the hot water 3-way control valve shall modulate open and the coil face and bypass damper shall modulate to maintain space temperature of (72° F, adj.).
   Upon a fall in outdoor air temperature below 40°F (adj.), the hot water 3-way control valve shall open to a minimum of 20% to the hot water coil.
   Upon a drop in supply air temperature below 40°F (adj.), the hot water 3-way control valve shall open at a minimum of 20%.
   Upon a rise in space temperature the outdoor and return air dampers shall modulate to provide free cooling when the outdoor air temperature permit. The coil face and bypass dampers shall be in the bypass position.
   On a continued rise in space temperature above 75°F (adj.), the chilled water 2-way control valve shall modulate open to maintain 75°F (adj.) space temperature. Space temperature between 70°F and 75°F (adj.), the hot water and chilled water control valves shall modulate closed. Space temperature setpoint shall have A ± 5° adjustable range.
4. Unoccupied Cycle: The space thermostat shall cycle unit fan & the hot water coil face and bypass dampers shall modulate open and the hot water 3-way control valve shall modulate open to maintain night set-back temperature setpoint (68° F heating; adj.). Outdoor air damper shall be closed and return air damper full open. When the outdoor air temperature is below 40° F, the hot water valve shall modulate open to a minimum position to maintain a 45° F plenum temperature (adj.) inside the U.V. to prevent potential heating coil freeze up.

F. Fan Coil Unit (Hot Water Heating):

1. Controls by ATC Contractor. Controls to be interfaced with existing BMS system.
2. ATC Contractor to provide space temperature sensor and install all wiring to units.
3. ATC Contractor shall provide a control valve. Upon a fall in space temperature below set point (72°F, adj.), the space thermostat will cycle the unit fan and modulate open the hot water control valve to maintain space set point.

G. Fan Coil and Condensing Unit:

1. Controls by ATC Contractor. Controls to be interfaced with existing BMS system.
2. ATC Contractor to provide space temperature sensor and install all wiring to units.

3. Upon a rise in space temperature above set point (68°F, adj.), the DX cooling shall energize. Upon a drop below 68°F, (adj.) the unit shall activate heating.

H. Packaged Dehumidification Units: See Drawing OFA M-503 for Sequence

I. Boiler (B-4):

1. Field survey and duplicate/match existing boiler controls. The new boiler is an exact replacement of the existing boiler. The control of the boiler shall be controlled through the boiler manufacturer Smart System Control. See Specification 23 52 24 Condensing Boiler for information regarding Boiler Controls. The existing BACnet BMS shall communicate with the boiler via communication card and software provided by the boiler manufacturer.

J. Energy Recovery Unit (ERV): See Drawing OFR M-521 for Sequence.

K. Chilled Water System Control – Controls by Chiller Manufacturer

1. General:

a. The system will be controlled from a BACnet DDC controller. It will provide all control functions. Unit to be provided with a communication card to be interfaced with existing BACnet BMS system. Refer to FCMS point list for required interface. All points on this list will be viewed/adjusted via the existing BACnet FMCS (facilities and control system).
b. The chilled water system is a primary system.
c. The system consists of:

1) Chiller
2) Two (2) chilled water pumps with VFD's. One pump is for backup purposes.

2. Chiller System Start:

a. Upon rise in leaving water temperature above (45°F adj.) the variable speed scroll compressors shall modulate to maintain leaving water temperature setpoint of (45°F adj.).
b. Proof of minimum flow shall be established before activating chiller. Chilled water pump P-1 (Lead) and P-2 (Lag) shall alternate operation for equal run time.
c. Upon activation of pump P-1, the 2-way bypass valve shall modulate towards open as pressure in piping rises. Upon a drop in piping pressure, the 2-way bypass valve shall modulate towards closed to maintain minimum flow to pumps and to chiller (adj.).

3. Chiller Control:

a. The chiller will start as described in the above chiller system start sequence. Should the chiller fail to start after 60 seconds or if the chiller supply water temperature does not fall to within 5°F of its chiller water temperature setpoint, a chiller alarm will report to the FMCS.

1.4 POINTS LIST (INCLUDING, BUT NOT LIMITED TO):

		POINT TYPE			
System School Bldg.	**Point Description**	**AO**	**AI**	**DO**	**DI**
RTU ADMIN & GRAPHICS	Supply Fan Start/Stop			X	
	Supply Fan Status				X
	Supply Fan Speed	X			
	Exhaust Fan Status				X
	Exhaust Fan Start/Stop			X	
	Exhaust Fan Speed	X			
	OSA Damper	X			
	Compressor #1	X			
	Compressor #2	X			
	OSA Temper (Shared)		X		X
	Return Temp		X		X
	Return Humidity		X		
	Space Temp		X		
	Space RH		X		
	OSA Air Flow CFM		X		
	Supply Air Flow CFM		X		
	Supply Temp		X		
	DX Discharge Temp		X		
	Dirty Filter				X
	Mixed Air Temperature		X		
	DX Cooling (per Stage)			X	
	Exhaust Air CFM		X		
	Return Air CFM		X		
	Supply Duct Static Pressure		X		
	Compressor Anti-Cycle				X
	Combustion Blower			X	
	Smoke Alarm (Qty. of 2)				X
	RT Fault to BMS			X	
	Hot Gas Re-Heat Valve	X			
	Hot Water Control Valve	X			
UNIT VENTILATOR (QTY of 26)	Supply Fan Start/Stop			X	
	Supply Fan Status				X
	Space Temperature		X		
	Supply Air Temp		X		
	Dirty Filter				X
	Hot Water Control Valve	X			
	Outdoor Air Damper	X			
	Indoor Air Damper	X			
	Face-by-Pass Damper	X			
	Chilled Water Control Valve	X			
	Chilled Water Discharge Temp		X		
	Space RH		X		

		POINT TYPE			
System School Bldg.	**Point Description**	**AO**	**AI**	**DO**	**DI**
EXHAUST FAN	Exhaust Fan Status				X
	Exhaust Fan Start/Stop			X	
VAV BOXES	Space Temperature		X		
	VAV Damper Control	X			
	Hot Water Valve Control	X			
	Supply Air Temperature		X		
	CFM		X		
CONDENSING UNIT	CU-1 System Start/Stop			X	
	CU-1 Space Temp		X		
	CU-1 System Status				X
FAN COIL	Space Temperature		X		
	Start/Stop		X		
	Hot Water Valve Control	X			
	System Status				X
PDU-1 DEHUMIDIFICATION UNIT	Supply Fan Start/Stop			X	
	Supply Fan Status				X
	Exhaust Fan Status				X
	Exhaust Fan Start/Stop			X	
	Compressor Exhaust Damper	X			
	Cooling: 2 Stage	X			
	Dehumidification: 2 Stage	X			
	Return Humidity		X		
	Space Temp		X		
	Space RH		X		
	Supply Temp		X		
	Dirty Filter				X
	RT Fault to BMS			X	
	Re-Heat Valve	X			
	Hot Water: 2 Stage	X			
CHILLED WATER SYSTEM	Chiller Enable			X	
	Chiller Status				X
	Chiller Alarm				X
	Outdoor Air Temperature		Shared		
	Outdoor Air Humidity		Shared		
	Chiller Water Supply Temp		X		
	Chiller Water Return Temp		X		
	Chilled Water Pump #1 Start/Stop			X	
	Chilled Water Pump #1 Status				X
	Chilled Water Pump #1 VFD Control	X			
	Chilled Water Pump #2 Start/Stop			X	

		POINT TYPE			
System School Bldg.	**Point Description**	**AO**	**AI**	**DO**	**DI**
	Chilled Water Pump #2 Status				X
	Chilled Water Pump #2 VFD Control	X			
	Condenser Fan Status				X
	Condenser Fan Start/Stop			X	
	Pressure Sensor		X		
	Chilled Water Temp Sensor		X		
	Chilled Water Flow Differential Pressure		X		
	Chilled Water By-Pass Valve	X			
BOILER B-4 (Coordinate w/boiler Communication card points available for display)	Boiler DISCH Water Temp		X		
	Hot Water Supply Temp		X		
	Hot Water Return Temp		X		
	Boiler Start/Stop			X	
	Boiler Status				X
ENERGY RECOVERY (ERV)	Supply Fan Start/Stop			X	
	Supply Fan Status				X
	Return Fan Status				
	Return Fan Start/Stop			X	
	OSA Damper	X			
	Exhaust Air Damper	X			
	OSA Temper		X		X
	Return Temp		X		X
	Exhaust Air Temp		X		
	Supply Air CFM		X		
	Supply Temp		X		
	Exhaust Air CFM		X		
	Outside Air CFM		X		
	Smoke Alarm (Qty of 2)				X
	Unit Fault to BMS			X	
	Supply Air Temp Sensor	X			
	Wheel Enable				X
	Pressure Switch		X		

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION – NOT USED

END OF SECTION 23 09 93

SECTION 23 21 14 - HYDRONIC SPECIALTIES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Expansion tanks

B. Air vents

C. Dirt/Air separators

D. Strainers

E. Pump specialties

F. Pump triple duty valve

G. Glycol specialties

H. Relief valves

I. Pressure gauges

J. Thermometers

K. Coil hookup packages with pressure independent control valves

1.2 RELATED WORK

A. Division 23 – Scope of Work

B. Division 23 – Common Work Results for HVAC

C. Division 23 – Hydronic Piping

D. Division 26 – Electrical Wiring Systems

1.3 REFERENCES

A. ANSI/ASME – Boilers and Pressure Vessels Code

B. ASME B31.9 – Building Services Piping

1.4 REGULATORY REQUIREMENTS

A. Conform to ANSI/ASME Boilers and Pressure Vessels Code Section 8D for manufacture of tanks and air separators.

B. Conform to ASME 31.9 for materials, products and installation.

1.5 QUALITY ASSURANCE

A. Manufacturer: For each product specified, provide components by same manufacturer throughout.

1.6 SUBMITTALS

A. Submit shop drawings and product data under provisions of Division 23 – Common Work Results for HVAC.

B. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description, model and dimensions.

C. Submit shop drawings on the following:

1. Expansion tanks
2. Dirt/Air separators
3. Strainers
4. Pump specialties
5. Triple duty valves
6. Coil hookup packages with pressure independent control valves
7. Relief valves
8. Glycol specialties
9. Pressure gauges
10. Thermometers

1.7 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Division 23 – Common Work Results for HVAC. Submit ASME certification.

B. Include installation instruction, assembly views, lubrication instructions, and replacement parts list.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS – EXPANSION TANKS

A. Bell & Gossett

B. Armstrong

C. Amtrol (Basis of Design)

D. Wheatley

2.2 EXPANSION TANKS

A. Construction: Welded steel, tested and stamped in accordance with Section 8D of ANSI/ASME Code; supplied with National Board Form U-1, rated for working pressure of 125 psig for standard HVAC design. Integral heavy duty Butyl rubber diaphragm or bladder as scheduled.

B. Accessories: Pressure gauge and air-charging fitting, tank drain, pre-charge to 12 psig. Unit shall have integral steel legs or provide saddles for elevated installation. Anchor floor mounted units securely to structure.

2.3 ACCEPTABLE MANUFACTURERS – AIR VENTS

A. Armstrong

B. Bell and Gossett

C. Wheatley

2.4 AIR VENTS

A. Manual Type: Line sized tee with ball valve and U-shaped copper pipe for discharge into hand-held container.

B. Float Type: Cast iron body, stainless steel float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve. Bell and Gossett Model 107A Basis of Design, Metraflex MetraVent MV or reviewed equivalent.

2.5 ACCEPTABLE MANUFACTURERS – DIRT/AIR SEPARATORS

A. Caleffi (Basis of Design)

B. Spirotherm

C. Taco

D. Wessels

E. Armstrong

2.6 DIRT/AIR SEPARATORS

A. Furnish and install as shown on the drawings a Caleffi (Basis of Design) coalescing type air eliminator and dirt separator on the hot and process water systems. All combination units shall be fabricated steel, rated for 150 psig working pressure with entering velocities up to 10 feet per second. Units shall include an internal bundle filling the entire vessel to suppress turbulence and provide high efficiency. The bundle may consist of a copper core tube with continuous wound copper medium permanently affixed to the core. A separate medium is to be wound completely around and permanently affixed to the internal element. Each eliminator shall have a separate venting chamber to prevent system contaminates from harming the float and venting valve operation. At the top of the venting chamber shall be an integral full port float actuated brass venting mechanism. Units shall include a valved side tap to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill. Separator shall have the vessel extended below the pipe connections an equal distance for dirt separation. Air eliminators shall be capable of removing 100% of the free air, 100% of the entrained air, and up to 99.5% of the dissolved air in the system fluid. Dirt separation shall be at least 80% of all particles 30 micron and larger within 100 passes.

2.7 ACCEPTABLE MANUFACTURERS – STRAINERS

A. Armstrong

B. Wheatley

C. Keckley (Basis of Design)

2.8 STRAINERS

A. Size 2 ½ inch TO 8 inch: ASTM A126 Class B Cast Iron Body, 200 psi WOG at 150°F, Class 125, Y pattern, bolted screen retainer, off center blow down fitted with gate valve and plug. Provide stainless steel perforated screen for liquid service. Keckley Style A as Basis of Design.

B. Size 2 inch and Under: Cast Bronze Body, 200 psi at 150°F, Class 125, Y pattern, screwed screen retainer, blow down fitted with gate vane and plug, threaded or screwed ends. Provide stainless steel perforated screen for liquid service. Keckley F-150 (screwed) and E-150 (solder joint) as Basis of Design.

C. Well Water Basket Strainers: Flanged carbon steel (ASTM A216, Grade WCB) body rated for 200 psig working pressure, basket pattern with 1/8 stainless steel perforation screen and 80 mesh stainless steel screen, thumbwheel cover. Keckley SGFV-K as Basis of Design.

D. 5 inch and larger Basket Strainers: Flanged carbon steel (ASTM A216, Grade WCB) body rated for 200 psig working pressure, basket pattern with stainless steel perforation screen for liquid service, thumbwheel cover. Keckley SGFV-K as Basis of Design.

2.9 ACCEPTABLE MANUFACTURERS – PUMP SPECIALTIES

A. Metraflex (Basis of Design)

2.10 PUMP SUCTION SPECIALTY

A. Combination reducing elbow, flex connector and rotational vanes. Constructed of steel reducing elbow, ANSI Class 150 flanges and Type 304 stainless steel, close pitch corrugated hose with Type 304 stainless steel outer braided covering. Provide CRV vane that imparts a rotational motion as the fluid enters the elbow and counteract elbow inducted turbulence enabling the fluid to turn uniformly and exit with a flat velocity profile. Rated for 190 psi at 70° F and 175 psi at 200° F. Metraflex CRV Flex as Basis of Design.

2.11 PUMP DISCHARGE SPECIALTY

A. Combination increaser, flex connector and straightening vanes. Construct of steel increaser, ANSI Class 150 flanges and Type 304 stainless steel, close pitched corrugated hose with Type 304 stainless steel outer braided covering. Provide carbon steel straightening vane that reduces turbulence equal to 5-10 pipe diameters of straight pipe while allowing full movement of the connector. Rated for 190 psi at 70° F and 175 psi at 200° F. Provide carbon steel reducing elbow where required. Metraflex Vane Flex as Basis of Design.

2.12 ACCEPTABLE MANUFACTURERS – TRIPLE DUTY VALVES

A. Bell and Gossett

B. Paco (Basis of Design)

C. Armstrong

D. Weinman

2.13 PUMP TRIPLE DUTY VALVE

A. Valves: Straight or angle pattern, flanged cast-iron valve body bolt-on bonnet for 175 psig operating pressure, non-slam check valve with spring-loaded bronze disc and seat, stainless steel stem, and calibrated adjustment permitting flow regulation, repacking under line pressure.

2.14 ACCEPTABLE MANUFACTURERS – RELIEF VALVES

A. Bell and Gossett

B. Kunkle (Basis of Design)

C. Watts

2.15 RELIEF VALVES

A. Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labeled.

2.16 GLYCOL SYSTEM

A. Mixing Tank: 50 gallon polyethylene tank, 1/3 hp gear pump (120V-1 phase) with strainer, NEMA 4X control panel (120V-1 phase) with power switch and light, HOA switch for pump, low level light and 15A fuse. Provide PVC tubing and fittings, PVC ball valve and cast iron Y-strainer on the suction assembly; and Schedule 80 PVC pipe and fittings, PVC ball valve, PVC check valve, pressure gauge and ASME rated brass body pressure relief valve with tubing return to tank on the discharge assembly of each unit. For feeders supplying glycol solutions to heating systems; then the piping and fittings shall be Type S, Schedule 40 steel or Type L copper; provide dielectric fittings between dissimilar metal interfaces and between discharge assembly and system connection. Manufacturer: JL Wingert GL-50E1, or reviewed equivalent.

B. Glycol Solution: Inhibited propylene glycol and water solution mixed 25% by volume. Amrep AmTerm 9030, or reviewed equivalent.

2.17 ACCEPTABLE MANUFACTURERS – PRESSURE GAUGES

A. Ashcroft 1009 (Basis of Design)

B. Trerice 600CB

C. Miljoco P4598L

D. Weksler EA14

E. Weiss 4CTS-1

2.18 PRESSURE GAUGES

A. Gauges shall be ASME B40-100, 4-1/2" diameter, stainless steel case, bronze bourbon tube, brass socket, acrylic/glass window, white dial with black pointer and numbers, liquid filled, 1% of full span accuracy, provide pressure, snubber, union and shut-off.

B. For liquid fill, verify liquid and gauge compatibility for the operating temperature of the measured medium. Provide appropriate liquid fill: Glycerin for temperatures from 30 - 150°F, silicone for temperatures -30 to 240°F.

C. Range: Comply with the following

1. Vacuum: 30 inches Hg of vacuum to 15 psig pressure.
2. Fluids under Pressure: Two times operating pressure.

2.19 ACCEPTABLE MANUFACTURERS – THERMOMETERS

A. Trerice BX (Basis of Design)

B. Miljoco SX935

C. Weksler AA5H-9

D. Weiss 9VU

2.20 THERMOMETERS

A. ASTM E1, industrial type, glass tubing, red reading, 9" long, cast aluminum with chrome front double strength glass, adjustable angle, organic liquid filled with magnifying lens, extended neck to clear insulation. Provide wells and separable sockets and oil or graphite heat transfer liquid.

B. Scale Range:

1. Hot Water: 30 to 240° F with 2° F scale division.
2. Chilled Water: 0 to 100° F with 2° F scale divisions.
3. Geothermal: 0 to 100° F with 2° F scale divisions,
4. Steam and Condensate: 50 to 400° F with 5° F scale divisions.
5. Glycol: (Verify Operating Temperatures of System) Cold Water only: (-) 40 to 110°F, Drycooler water loop with economizer operation: Custom Range (-) 20 to 180°F.

2.21 COIL HOOKUP PACKAGES WITH PRESSURE INDEPENDENT CONTROL VALVES

A. Provide for each coil a combination valving package from one manufacturer throughout.

B. For the supply water line; provide a combination inlet shutoff valve/PT plug/ Y-strainer with blowdown valve and 20 mesh stainless steel screen/union and on the return line; a combination union/PT plug, pressure independent control valve and shutoff valve.

C. Connections shall be sweat 2" and below and flanged 2 1/2" and above.

D. Shutoff valves shall be full port bronze ball type for 2" and below rated at 300 psi at 265° F and butterfly type for 2 1/2" and above rated at 200 psi WP at 250° F. Ball valves shall have extension kit, nylon coated lever handle, Teflon seats and seals, blow-out proof shafts and double shaft seals. Butterfly valves shall be lug pattern, cast iron body, EPDM cartridge seat, one-piece Type 416 stainless steel shaft, lever operator for 6" and below, worm-gear operator for 8" and above.

E. Acceptable Manufacturers: Nexus, FDI, Armstrong, Tour & Anderson or reviewed equivalent

F. Control Valves: Factory fabricated pressure independent with internal differential pressure regulator which automatically adjusts to normal changes in system pressure and provides 100 percent control valve authority at all positions of the valve and maintain proportional/linear

flow coil characteristics and maintain a linear flow characteristic, accurately control the flow from 0-100 percent full rated flow with an operating pressure differential range of 2.3 to 60 psi., FCI 70-2 Class 4 shut-off on all sizes and field serviceable. Control valve shall incorporate control, dynamic system balancing and flow limiting. Hydronic system pressure independent control valve bodies shall meet ASME B16.34 or ASME B16.15 pressure and temperature class ratings based on the design operating temperature and 150 percent of the system design operating pressure and shall have the following characteristics:

1. Valves: Sized for maximum circuit flow rate, generally line sized.

    a. Flow setting of the valves shall be by simple percentage of maximum flow available on the valve.

        1) Valves requiring the use of presetting graphs to determine the percentage of flow to preset on the valve shall not be acceptable.

2. Generally line sized. NPS 2 and Smaller: Class 150 bronze or brass body with union connections, stainless steel trim trim, stainless steel rising stem, stainless steel disc or ball, and screwed ends with backseating capacity repackable under pressure.
3. NPS 2-1/2 and Larger: Class 125 iron or ductile iron body, stainless steel trim, stainless steel rising stem, stainless steel disc or ball, flanged ends with backseating capacity repackable under pressure.
4. Pressure Control Seat: Brass construction with vulcanized EPDM.

    a. Internal components made of Plastics shall NOT be acceptable.

5. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head.

    a. 1/2” thru 1-1/4” shall possess a Close-off rating of at least 130 psi
    b. 1-1/2” thru 10” shall possess a Close-off rating of at least 260 psi

6. Valves shall be manufactured by one manufacturer throughout the project.
7. Valves requiring removal of the Differential Pressure Regulation Cartridge prior to Flushing or initial system cleaning and re-installation after flushing shall not be acceptable.

G. Electronic Actuators: Direct-mounted self-calibrating type designed for minimum 60,000 full-stroke cycles at rated force and shall be from the same manufacturer as the pressure independent control valve; branded or 3rd party actuators must be submitted and approved prior to bid. The actuator shall provide visible position indication. Fail positions on power failure shall include in-place, open or closed as noted in the ATC / BAS controls specifications.

1. Coordinate first subparagraph and list below with Part 2 "Manufacturers" Article. Retain "Available" for nonproprietary and delete for semi-proprietary specifications. If list does not include manufacturers of systems that make or market this equipment under their own name, those manufacturers' names may be added. List can be deleted if it is not important that specific manufacturers be named for this product.
2. Overload Protection: Electronic overload or digital rotation-sensing circuitry.

3. Fail-Safe Operation: Shall be Mechanical, spring-return mechanism; or Capacitance Driven. Power Requirements (Two-Position Spring Return): 24-V ac.
4. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
5. Proportional Signal: 0 to 10Vdc or 2 to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
6. Actuator force shall be capable of providing the valve close-off rating.

    a. 1/2" thru 1-1/4" shall possess a Close-off rating of at least 130psi
    b. 1-1/2" thru 10" shall possess a Close-off rating of at least 260 psi

7. Temperature Rating: -36° to 140° F.

H. 3rd Party Test Results: The manufacturer shall submit in his submittal documentation package a set of 3rd Party test reports from a recognized testing agency verifying the accuracy and operation of the submitted valves and associated actuators. Separate reports for valves and actuators will not be acceptable.

I. Acceptable Manufacturers:

1. Danfoss.
2. Flow Control Industries, Inc.
3. Tour & Anderson
4. Reviewed Equivalent

PART 3 - EXECUTION

3.1 INSTALLATION AND APPLICATION

A. Install specialties in accordance with manufacturer's instructions to permit intended performance.

B. Provide manual air vents at system high points, at end of mains, at terminal return runouts and wherever are needed to purge entrained air Provide automatic air vents where indicated.

C. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.

D. Provide dirt/air separator on suction side of system circulation pump and connect to expansion tank, where indicated on the drawings.

E. Provide pump specialties for centrifugal pumps.

F. Provide pump triple valve on discharge side of constant speed base mounted centrifugal pumps. For VFD driven pumps, substitute a silent check valve and isolation valve.

G. Support pump suction specialty with floor (base) mounted pipe and flange supports.

H. Provide coil hookup packages with pressure independent control valves for each terminal unit, rooftop unit coils, rooftop unit condensers, heat pumps (chilled, hot geothermal) and where temperature or pressure control is necessary for satisfactory system operation, thermal comfort and control.

I. Provide pressure relief valves on pressure vessels (including but not limited to) expansion tanks, buffer tanks, heat exchangers, and boilers.

J. Select system pressure relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment pressure relief valve capacity to exceed rating of connected equipment.

K. Pipe pressure relief valve outlet to nearest floor drain or trench drain. Piping shall be supported so that no stress is induced on the pressure relief valve.

L. Provide isolation valves and balance valves at return line locations where branches tap off mains and sub-branches or as required for proper system isolation and balance and for future isolation and balancing ease due to building renovations. Provide isolation valves and balance valve at taps from risers at each floor.

M. Locate specialties at accessible locations.

N. Provide pressure gauges at the suction and discharge of each pump, at heat pumps, heat exchangers, filters, coils, etc. and where else required to monitor, troubleshoot and measure system water pressures; where indicated on the plans (or not) and control drawings. Provide additional snubber, as required to steady gauge readings. Locate gauges where dials can be easily read; provide pressure gauge cabinet where required for ease of reading.

O. Provide thermometers and pressure gauges at all water source heat pumps, boilers, at heat exchanger supply and return, where pipes enter and exit mechanical rooms and where else required to monitor, troubleshoot and measure system water temperatures and pressures and where indicated on the plans (or not) and control drawings. Locate thermometers and pressure gauges where temperatures can be easily read. Locate thermometers where temperatures can be easily read.

P. Provide thermometers at all main air handling unit coil runouts, at chiller, boiler and heat exchanger supply and return (both sides), at mixing valve locations, at mains entering or leaving mechanical rooms and where else required to monitor and measure system water temperatures and where indicated on the plans (or not) and control drawings. Locate thermometers where temperatures can be easily read. Locate thermometers where temperatures can be easily read.

Q. Provide strainers at inlet of pumps, chillers, condensers, control valves, on main lines, incoming water service (PRV) and where needed and not indicated on the diagrammatic plans. Provide a blowdown valve with capped chain and hose bibb at each strainer.

R. Provide expansion tanks on each water system. Install per manufacturer’s instructions. Charge to final pressure with nitrogen when system is at operating design conditions. Schedules indicate approximate calculated pressures, provide shutoff valve for tank isolation and pressure relief valve between valve and tank, pipe to floor at non-scalding location.

S. Provide specialties in accordance with details on the drawing and as required per manufacturer's recommendations and code regulations.

END OF SECTION 23 21 14

SECTION 23 21 16 - HYDRONIC PIPING AND VALVES (ABOVE GRADE)

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Pipe and pipe fittings

B. Valves

C. Heating water piping system

D. Chilled water piping system

E. Glycol piping system

1.2 RELATED WORK

A. Division 23 – Scope of Work

B. Division 23 – Common Work Results for HVAC

C. Division 23 – Hydronic Specialties

D. Division 23 – Expansion Compensation

E. Division 23 – Hangers and Supports for HVAC Piping and Equipment

F. Division 23 – Piping Insulation

G. Division 23 – Chemical Water Treatment

1.3 REFERENCES

A. ANSI/ASME – Boiler and Pressure Vessel Code

B. ANSI/ASME Sec 9 – Welding and Bracing Qualifications

C. ANSI/ASME B16.3 – Malleable Iron Threaded Fittings Class 150 and 300

D. ANSI/ASME B31.9 – Building Services Piping

E. ANSI/AWS A5.8 – Brazing Filler Metal

F. ANSI/AWS D10.9 - Specifications for Qualification of Welding Procedures and Welders for Piping and Tubing.

G. ASTM A53 – Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless

H. ASTM A234 – Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures

I. ASTM B32 – Solder Metal

J. ASTM B88 – Seamless Copper Water Tube

1.4 REGULATORY REQUIREMENTS

A. Conform to ANSI/ASME B31.9.

1.5 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body.

B. Welding Materials and Procedures: Conform to ANSI/ASME Sec. 9.

C. Welders Certification: In accordance with ANSI/ASME Sec. 9.

1.6 SUBMITTALS

A. Submit product data under provisions of Division 23 – Common Work Results for HVAC.

B. Include data on pipe materials, pipe fittings, valves, and accessories.

C. Include welder's certification of compliance with ANSI/ASME Sec. 9.

1.7 DELIVERY, STORAGE, PROTECTION AND HANDLING

A. Deliver, store, protect and handle products under provisions of Division 23.

B. Protect piping and specialties from contamination by leaving in shipping containers with all caps/plugs in place until time of immediate installation.

PART 2 - PRODUCTS

2.1 HEATING WATER, CHILLED WATER, GLYCOL PIPING ABOVE GRADE

A. Steel Pipe: ASTM A53, Type ERW, Grade B, Schedule 40 for 10" and below, Standard (.375" wall) for 12" and above (both for welded joints). Use ASTM A53 or 120, Type S, Grade B, Schedule 40 for screwed joints.

1. Fittings: ANSI/ASTM B16.3, malleable iron Class 150 or ASTM A234, wrought steel welding type fittings, Schedule 40.
2. Joints: Up to 2 inch, screwed; 2-1/2 inch and up, welded. Utilize fittings as specified above.

B. Copper Tubing: ASTM B88, Type L, hard drawn, 2-1/2" and below.

1. Fittings: ANSI/ASME B16.23 cast brass or ANSI/ASME B16.29 solder wrought copper.
2. Joints: ASTM B32, solder, Grade 95TA. Utilize fittings as specified above.

2.2 EQUIPMENT DRAINS AND OVERFLOWS

A. PVC cannot be used in plenum areas.

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

1. Fittings: Galvanized cast iron, or ANSI/ASTM B16.3 malleable iron.
2. Joints: Screwed, or grooved mechanical couplings, drainage pattern.

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

1. Fittings: ANSI/ASME B16.23 cast brass, or ANSI/ASME B16.29 solder wrought copper, drainage pattern.
2. Joints: ASTM B32, solder, Grade 95TA.

2.3 FLANGES AND UNIONS

A. Unions (non-dielectric)

1. 2" and Smaller – Standard weight, all brass, ground joint, sweat ends for use in copper and brass lines. Standard weight, malleable iron, ASME B16.39, ground type with brass seat ring, pressure rating per pipe fittings and application; threaded ends for use in steel lines.
2. 2 1/2" and Larger – Standard weight, all brass, flanged pattern, gasket type, with brass bolts and nuts, sweat ends for use in copper and brass lines. Standard weight, black steel, flanged pattern, gasket type, with steel bolts and nuts, pressure rating per pipe fittings and application, threaded ends for use in steel lines.
3. All unions shall conform to the requirements set forth per ASME B31.1 and B31.9.

B. Flanges – Faced true, flat face or raised face type as indicated, welding type for welded lines, screwed type for threaded lines, pressure rating as required by service per ASME B16.5, B31.1 and B31.9. Flanges shall be flat or raised face type to match and be compatible with flange construction at equipment and valves.

1. Threaded lines – ASME B16.1 with ASME B1.20.1 threads, face and pressure rating per service per ASME requirements, screwed ends.
2. Welded lines – ASME B16.5, face and pressure rating per service per ASME requirements, forged steel, slip-on welding (front and back) type. Utilize ASME B16.5, forged steel, welding neck type for high pressure steam (above 99 psig) and high temperature hot water service; both with pressure rating per service per ASME requirements.
3. Flange hardware – ASTM B18.2.1 carbon steel, threaded bolts and nuts, per ASME requirements.

2.4 WELDED FITTINGS (STEEL PIPING SYSTEMS)

A. Service class specified herein, beveled end, butt welding type, long radius type elbows, full size (straight) or reducing outlet type welding tees, concentric reducers, return bends, caps.

2.5 PIPE NIPPLES

A. Non-dielectric type – Extra heavy pipe of same material of adjacent installed pipe.

B. Dielectric type – Electroplated steel pipe with thermoplastic lining, threaded ends, rated for minimum 300 psig and 225 service.

2.6 DIELECTRIC UNIONS

A. Provide at copper (non-ferrous) to ferrous metal interface locations. Temperature and pressure rating of union shall equal or exceed the maximum temperature and pressure in which the union is installed. Dielectric unions shall be screwed for use in threaded lines, sweat for use in soldered lines or welded neck flanged ends for use in welded lines and shall withstand 600V on a dry line without flash-over. Central Plastic, EPCO Sales, Watts or reviewed equivalent.

2.7 GASKETS

A. Ring type – ASME B16.21, 1/16" thick, factory cut, compressed, heat resistant for intended service, pressure rating per the intended service. All gaskets for flanges shall conform to the requirements set forth per ASME 31.1 and 31.9. Garlock or reviewed equivalent.

2.8 MECHANICAL WALL SEALS

A. Provide mechanical wall seals at pipe penetrating exterior walls below grade or at pipe penetrating slabs in contact with grade. Seals shall be modular synthetic rubber type (low or

high temp depending upon the pipe application) with interlocking links and mechanical compression via Type 316 stainless steel hardware. Thunderline "Link-Seal", Metraflex "MetraSeal" or reviewed equivalent by Wayne or Michigan.

B. Pipe sleeves – ASTM A53, standard weight steel pipe, hot dipped galvanized finish.

C. Escutcheon plates – 1 piece or split hinge plates, steel for unfinished locations. Polished stainless steel or chrome plated copper plates, 1 piece or split hinge for exposed locations.

2.9 ACCEPTABLE MANUFACTURERS – GATE VALVES

A. Crane

B. Nibco

C. Stockham

D. Powell

2.10 GATE VALVES

A. 2" and Smaller: Class 125, 200 CWP or Class 150, 300 psi CWP, ASTM B62 cast bronze body and bonnet, rising stem, union bonnet, solid wedge disc, asbestos-free packing, malleable iron handwheel, MSS-SP-80. Non-rising stem valves can be used only where there is insufficient room for a rising stem valve.

1. Class 125 – Stockham B-100 (threaded), B-108 (solder), rising stem
   B-103 (threaded), B-104 (solder), non-rising stem

2. Class 150 – Stockham B-120 (threaded), B-125 (solder), rising stem
   B-128 (threaded), non-rising stem

B. 2 1/2" and Larger: Class 125, 200 psi CWP, ASTM A126B cast iron body and bonnet, rising stem, flanged ends, outside screw and yoke, solid wedge disc, bronze trim, packing and gasket shall be asbestos free, malleable iron handwheel, MSS-SP-70. Non-rising stem valves can be used only where there is insufficient room for a rising stem valve.

1. Stockham G-623 and Stockham G-612.

2.11 ACCEPTABLE MANUFACTURERS – GLOBE VALVES

A. Crane

B. Nibco

C. Stockham

D. Powell

2.12 GLOBE VALVES

A. 2" and Smaller: Class 125, 200 psi CWP, or Class 150, 300 psi CWP, ASTM B62 cast bronze body and bonnet, rising stem, renewable seat and disc, bronze stem, PTFE disc, asbestos free packing, malleable iron handwheel, MSS-SP-80.

1. Class 125 – Stockham B-13T (threaded) or BT-14T (solder)
2. Class 150 – Stockham B-22T (threaded) or BT-20T (solder)

B. 2 1/2" and Larger: Class 125, 200 psi CWP, ASTM A-126B cast iron body and bolted bonnet, rising stem, bronze trim, renewable seat and disc, outside screw and yoke, flanged ends, asbestos free packing and gasket material, malleable iron handwheel, MSS-SP-85.

1. Stockham G-512 (straight pattern)
2. Stockham G-515 (angle pattern)

2.13 ACCEPTABLE MANUFACTURERS – BALL VALVES

A. Conbraco

B. Nibco

C. Jamesbury

2.14 BALL VALVES

A. 3" and Smaller: 150 psig WSP, 600 psig CWP, ASTM B584 bronze body, 2 piece design, full port, Type 316 stainless steel vented ball and stem, PTFE seats, extended lever handle with vinyl cover, MSS-SP-110.

1. Nibco S-585-70-66 (solder)
2. Nibco T-585-70-66 (threaded)

2.15 ACCEPTABLE MANUFACTURERS – BUTTERFLY VALVES

A. Nibco

B. Centerline

C. Stockham

D. DeZurik

2.16 BUTTERFLY VALVES

A. 2" and Larger: 200 psig WOG, bubble tight shutoff, ASTM A126 cast iron full lug body, 4" and below, ASTM A536 grade 65-45-12 ductile iron full lug body 5" and above, nickel-plated ductile iron disc, extended neck, Type 416 stainless steel stem, lubricated bronze stem bushings (3), phemolic reinforced EPDM seat, Bung-N shaft seal, 10 position lever handle for valves 6" and smaller, manual gear operator and handwheel for valves 8" and up, MSS-SP-67. Butterfly valves used for motorized isolation shall have a motorized actuator (with full close-off pressure to act against pump head) and manual override handwheel.

1. Stockham LG-712-BS3-E-M (lever handle), 4" and below
2. Stockham LD-712 (lever handle for 5" and 6")
3. Stockham LD-722 (gear operator, 8" and above)

2.17 ACCEPTABLE MANUFACTURERS – SWING CHECK VALVES

A. Crane

B. Stockham

C. Nibco

D. Powell

2.18 SWING CHECK VALVES

A. 2" and Smaller: Class 125, 200 psi CWP or Class 150, 300 psi CWP Y-pattern horizontal flow, ASTM B62 bronze body, regrinding type, replaceable disc, MSS-SP-80.

1. Class 125 – Stockham B-320TY (threaded), B-309Y (solder)
2. Class 150 – Stockham B-321 (threaded)

B. 2 1/2" and Larger: Class 125, 200 psig CWP, ASTM A126 gray iron body and bolted bonnet, regrinding type, flanged ends, clear or full waterway, bronze trim, asbestos free gasket, MSS-SP-71.

1. Stockham G-931

2.19 ACCEPTABLE MANUFACTURERS - SPRING LOADED CHECK VALVES

A. Metraflex (Basis of Design)

B. Reviewed equivalent

2.20 SPRING LOADED CHECK VALVES

A. General: Valves shall be globe style. Valves shall have a cracking pressure of 1/4 to 1/2 psi, and fully open at a flow velocity of 4 FPS. Valve operation shall not be affected by installation position. Valve shall be capable of fully closing prior to reversal of flow and shall eliminate water hammer.

B. 2" and Smaller: ASTM B-145-5A, bronze body, brass stem, beryllium copper spring, Teflon disc, stainless steel seat screw, 250 psig non-shock WOG, 250° F max temperature, threaded ends.

1. Metraflex Style BSN (Basis of Design)
2. Reviewed equivalent

C. 2 1/2" and Larger: Class 125, ASTM A48 cast iron body, bronze seat and disc, stainless steel spring, flanged ends, Buna-N shaft seal, 190 psig non-shock WOG at 200° F.

1. Metraflex Style 900 (Basis of Design)
2. Reviewed equivalent

PART 3 - EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe. Use emery cloth to remove oxidation at joint locations on copper tubing and fittings.

B. Remove scale and dirt on inside and outside before assembly.

C. After completion, flush, clean, rinse, clean strainers, and refill system.

3.2 INSTALLATION

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

B. Water piping shall be tapped off the bottom of the pipe; provide all valves, tees, piping insulation, elbows and swing joints as required for hookup to coils or branches required by this work whether they are indicated on the drawings or not.

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

D. Group piping whenever practical at common elevations.

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

F. Provide clearance for installation of insulation, and access to valves and fittings.

G. Provide access where valves and fittings are not exposed.

H. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.

I. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

J. Do not run piping through transformer vaults or other electrical or electronic equipment spaces and enclosures. Maintain 42" clearance from switchboards, panelboards and motor control centers.

K. Mount all control valves, sensors, flow meters and devices under other sections.

L. Connect to equipment and rooftop units.

M. Connect glycol piping to chiller oil cooler and condenser purge sections. Side tap glycol main, see detail on drawings.

N. Connect chemical treatment to system. Refer to Division 23 and details.

3.3 PIPE CLEANING

A. Add cleaner to closed systems at concentration as recommended by manufacturer.

B. Hot Water Heating Systems: Apply heat while circulating, slowly raising temperature to 160° F and maintain for 12 hours minimum. Remove heat and circulate to 100° F or less; drain systems as quickly as possible and refill with clean water. Circulate for 6 hours at design temperatures, then drain. Refill with water and repeat until system cleaner is removed.

C. Chilled Water Systems: Circulate for 48 hours, and then drain systems as quickly as possible. Refill with clean water, circulate for 24 hours, then drain. Refill with clean water and repeat until system cleaner is removed.

D. Remove, clean and replace strainer screens.

E. Systems Cleaner - Materials

1. Degreaser: Concentrated liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products; sodium tripoly phosphate and molybdate such as AmSolv 9350 or approved equal.
2. Algaecide: chlorine release agents such as sodium hypochlorite or calcium hypochlorite, or michrobiocides such as quaternary ammonia compounds, tributyl tin oxide, methylene bis thiocyanate, or isothiazolones.

F. Provide all additional valves, piping, hoses etc. required to clean and flush the system.

3.4 APPLICATION

A. Install unions or flanges downstream of valves and at equipment or apparatus connections.

B. Provide 3/4 inch gate or ball drain valves at, low points of piping, bases of vertical riser, and at equipment drain locations.

C. Provide chain operators on all valves mounted above 7'-0" in equipment rooms.

D. Use gate or ball valves for isolation and shut off service on heating water systems.

E. Use gate, butterfly or ball valves for isolation and shut off service on chilled water and glycol systems.

F. Use steel pipe for heating, chilled water and glycol systems. Copper pipe may be used for runouts to equipment 1 inch and smaller and main loop piping less than three (3) inches in diameter or less.

G. Provide isolation valves on equipment requiring isolation for service and/or removal use application as specified in parts D and E above.

H. Install isolation gate valves for shut off and to isolate equipment, part of systems or vertical risers. Provide isolation valves at piping mains and changes of direction, at branches, sub-branches, where pipes enter or leave mechanical rooms, where isolation is required or needed; all this whether or not they are shown on the plans.

I. Provide manual air vents on all system high points and at individual runouts to terminal equipment and coils. Provide on return piping runouts only and equip with U-tube to discharge into drain can while piping system. Provide as required to purge air entrapment from system.

3.5 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water after all cleaning procedures are finished, then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following 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 and maximum 200 psig. 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 "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
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.

C. 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.

3.6 HEAT TRACING

A. Heat trace all piping exposed to ambient. Refer to Div. 23 requirements. Contractor to groove insulation as needed to properly install and seal insulation with tight joints and finish with aluminum jacket.

END OF SECTION 23 21 16

SECTION 23 21 23 - HVAC PUMPS

PART 1 - GENERAL

1.1 STIPULATIONS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Sections, apply to this Section.

1.2 WORK INCLUDED

A. Pumps.

B. Factory headers with valves and accessories.

1.3 RELATED WORK

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

B. Division 23 – Scope of Work

C. Division 23 – Common Work Results for HVAC

D. Division 23 – Vibration Isolation

E. Division 23 – Variable Frequency Drives

F. Division 23 – Common motor Requirements for HVAC Equipment

G. Division 23 – Facilities Management and Control System

H. Division 23 – Hydronic Specialties

1.4 REFERENCES

A. ANSI – American National Standards Institute

B. ASTM – American Society for Testing and Materials

C. ANSI/UL 778 – Motor Operated Water Pumps

D. Hydraulics Institute

E. NEMA – National Electrical Manufacturer's Association

F. OSHA – Occupational Safety and Health Administration

G. UL – Underwriters Laboratories, Inc.

1.5 SUBMITTALS

A. Submit shop drawings and product data under provisions of Division 23.

B. Submit certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable. Pumps/motors are selected for additional friction head from scheduled; pumps shall meet Engineer's requirements. All pump motors shall be non-overloading within the entire range of the plotted pump curve and selected per the discretion of the Engineer. Submit multiple curves for parallel pumping arrangement with one, two or more system components in the loop (multiple system head curves plotted with the pump curve) and also submit variable speed curves. The Engineer has the final say if it is determined that substitute manufacturers do not meet proper system requirement nor have the proper characteristics for optimum performance of the hydronic systems. Failure to meet these requirements, then the Contractor shall submit the basis of design pumps.

C. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

D. Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.

E. Submit Wiring Diagrams: Power, signal, and control wiring.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Division 23.

B. Include installation instruction, assembly views, lubrication instructions, and replacement parts list.

1.7 QUALITY ASSURANCE

A. Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of hydronic pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.8 DELIVERY, STORAGE AND HANDLING

A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

B. Store pumps in dry location.

C. Retain protective covers for flanges and protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. Comply with pump manufacturer's written rigging instructions.

1.9 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.10 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Mechanical Seals: One mechanical seal for each pump.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Manufacturers are listed for a quality assurance level only. Although a manufacturer is listed does not constitute compliance with the specification size, weight, functionality, capacity, noise, or performance levels. It is this contractor's responsibility to assure the proposed manufacturer has complete compliance with the Contract Documents, **prior to bidding**.

1. Bell and Gossett
2. Armstrong
3. Taco
4. Aurora

2.2 GENERAL REQUIREMENTS

A. Quiet operation, 1150, 1750 or 3500 RPM as scheduled, single stage, end suction, close or, flexible coupled as selected, serviceable without disturbing piping connections, factory tested, cleaned and inspected. Rate pumps for 175 psig minimum working pressure and 225 degrees F continuous water temperature.

B. Select pumps at 80% of maximum impeller diameter in casing.

C. All motors shall be non-overloading within the entire range of the plotted pump curve. Pumps/motors are selected for additional friction head from scheduled; pumps shall meet Engineer's requirements.

2.3 COMPONMENTS

A. The pumps shall be long coupled, base mounted, single stage, end suction, vertical split case design, in cast iron stainless steel fitted, designed for quiet operation. Working pressures shall not be de-rated at temperatures up to 250F. The pump internals shall be capable of being services without disturbing piping connections, electrical motor connections or pump to motor alignment.

B. The pumps shall be composed of three separable components a motor, bearing assembly, and pump end (wet end). The motor shaft shall be connected to the pump shaft via a replaceable flexible coupling.

C. A bearing assembly shall support the shaft via two heavy-duty regreaseable ball bearings. Bearing assembly shall be replaceable without disturbing the system piping and shall have foot support at the coupling end. Pump bearings shall be regreaseable without removal of the bearings from the bearing assembly. Thermal expansion of the shaft toward the impeller shall be prevented via an inboard thrust bearing.

D. The bearing assembly shall have a solid SAE1144 steel shaft. A stainless-steel shaft sleeve shall be employed to completely cover the wetted area under the seal.

E. Pump shall be equipped with an internally-flushed mechanical seal assembly installed in an enlarged tapered seal chamber. Application of an internally flushed mechanical seal shall be adequate for seal flushing without requiring external flushing lines. Seal assembly shall have Buna bellows and seat gasket, stainless steel spring, and be of a carbon ceramic design with the carbon face rotating against a stationary ceramic face.

F. Bearing assembly shaft shall connect to a stainless-steel impeller. Impeller shall be both hydraulically and dynamically balanced to ANSI/HI 9.6.4-2016, balance grade G6.3 and secured by a stainless-steel locking cap screw or nut.

G. Pump should be designed to allow for true back pull-out allowing access to the pump’s working components, without disturbing motor or piping, for ease of maintenance.

H. A center drop-out type coupling, capable of absorbing torsional vibration, shall be employed between the pump and motor. Pumps for variable speed application shall be provided with a suitable coupling sleeve. Coupling shall allow for removal of pump's wetted end without disturbing pump volute or movement of the pump's motor and electrical connections. On variable speed applications the coupling sleeve should be constructed of an neoprene material to maximize performance life.

I. An ANSI and OSHA rated coupling guard shall shield the coupling during operation. Coupling guard shall be dual rated ANSI B15.1 and OSHA 1910.219 compliant coupling guard and contain viewing windows for inspection of the coupling. No more than .25 inches of either rotating assembly shall be visible beyond the coupling guard.

J. Pump volute shall be of a cast iron design for heating systems with integrally cast pedestal volute support, rated for 175 PSIG with integral cast iron flanges drilled for 125# ANSI companion flanges. (Optional 250 PSIG working pressures are available and are 250# flange drilled.) Volute shall include gauge ports at nozzles, and vent and drain ports.

K. Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Pump and motors shall be factory aligned, and shall be realigned after installation by the manufacturer's representative. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications and conform to standards outlined in EISA 2007.

L. Base plate shall be of structural steel or fabricated steel channel configuration fully enclosed at sides and ends, with securely welded cross members and fully open grouting area (for field grouting). The minimum base plate stiffness shall conform to ANSI/HI 1.3.8.2.1-2019 for grouted Horizontal Baseplate Design standards.

M. Pump shall be of a maintainable design and, for ease of maintenance, should use machine fit parts and not press fit components.

N. The pump(s) vibration limits shall conform to Hydraulic Institute ANSI/HI 9.6.4-2016 for recommended acceptable unfiltered field vibration limits (as measured per ANSI/HI 9.6.4-2016 Figure 9.6.4.2.3.1) for pumps with rolling contact bearings.

O. Pump manufacturer shall be ISO-9001 certified.

P. Each pump shall be hydrostatically tested 1.5 times the maximum rated working pressure and name-plated before shipment.

Q. Pump shall conform to ANSI/HI 9.6.3.1-2012 standard for Preferred Operating Region (POR) unless otherwise approved by the engineer.

2.4 END SUCTION PUMPS

A. The contractor shall furnish and install as shown in the plans and descried in these specifications, a end suction, long coupled base mounted pump designed to deliver the scheduled flow rate at the specified total dynamic head (in feet).

B. Casing – Pump casing shall be close grain cast iron fitted with a replaceable lead-free bronze case wear ring. Pumps with a specific speed greater than 1600 shall have double volute casings with suction splitter to reduce radial loading and shaft deflection. All pumps shall be of the back pull out design so that the rotating element can be removed from the casing without disconnecting the suction or discharge piping.

C. Impeller – Pump impeller shall be of the enclosed type of cast lead free bronze and shall be statically and dynamically balanced. Impeller diameter shall be trimmed for the specific design conditions.

D. Shaft Sealing – Pump shaft shall be fitted with (a leakless mechanical seal) suitable for the temperatures and pressures indicated.

E. Motor – Premium efficient motor shall be of the horsepower and speed shown in the pump schedule. Pumps requiring larger horsepower shall not be acceptable. Pump shall be (flexible, close) coupled to a (horizontal, vertical), ODP motor with 1.15 service factor. 40°C ambient. Motors that are VFD driven shall have shaft grounding.

F. Bearing Frame – Pump shall be mounted on a heavy duty cast in one-piece cast-iron bearing frame. Shaft shall be of (carbon steel, stainless steel). Pump bearings shall be permanently sealed (below 50 hp), regreaseable, (50 hp and above).

G. Base, Coupling and Guard – Pump and motor shall be mounted on a channel steel base, adequately reinforced against deflection. Pump shall be connected to the drive motor by a flexible coupling capable of withstanding all torsional, radial and axial loads. Coupling and exposed rotating components of the pump and motor shall be protected by an OSHA approved guard.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONCRETE BASES

A. Install concrete bases of dimensions indicated for pumps and controllers. Refer to Division 23 requirements.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Cast-in-place concrete materials and placement requirements are specified in Division 03.

3.3 INSTALLATION

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

B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Suspend vertically mounted, in-line centrifugal pumps independent of piping. Install pumps with motor and pump shafts vertical. Use continuous-thread hanger rods and spring hangers of sufficient size to support pump weight.

E. Set base-mounted pumps on concrete foundation. Disconnect coupling before setting. Do not reconnect couplings until alignment procedure is complete.

1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches between pump base and foundation for grouting.
2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.

F. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.

G. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-over loading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

H. Mount pumps on vibration isolation inertia bases/seismic restraints. Refer to Division 23.

I. Ground Motor Shafts for VFD driven pumps.

J. Fill all pumps and/or prime prior the “bump test” (verification of correct rotation). Coordinate with the electrical contractor. Do not energize pump motor without pump being full of fluid.

3.4 ALIGNMENT

A. Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.

B. Comply with pump and coupling manufacturers' written instructions.

C. Adjust pump and motor shafts for angular and offset alignment by methods specified in HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation HI 2.1-2.5, "Vertical Pumps for Nomenclature, Definitions, Application and Operation."

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with non-shrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.5 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For end suction pumps, provide supports under suction diffuser.

F. Provide line sized gate or ball valve, strainer with blowdown valve, increase/reducer, pressure gauge, Metraflex CRV flex connector and long radius elbow on the suction line and a pressure gauge, increaser/reducer, Metraflex Vane Flex connector and a triple duty valve on the discharge line of all constant speed pumps. Substitute butterfly for gate valve on chilled and condenser water systems. Substitute isolation valve and silent check valve for triple duty valve for pumps that are VFD driven. Locate strainer with blowdown valve on discharge side of pump for pumps within open condenser water systems.

G. Install Metraflex pump flexible connectors on suction and discharge sides of base-mounted pumps; install between pump casing and valves. Refer to 23 05 16.2.2 for further specification on Metraflex products.

H. Install pressure gages on pump suction and discharge, at integral pressure-gage tapping, or install single gage with multiple input selector valve.

I. Install check valve and gate or ball valve on each condensate pump unit discharge.

J. Install electrical connections for power, controls, and devices.

K. Ground equipment according to Division 26 Section "Grounding and Bonding."

L. Connect wiring according to Division 26 Section "Conductors and Cables."

M. Provide air cock and drain connection on pump casings.

N. Provide drains for bases and seals, piped to and discharging into floor drains.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Perform the following startup checks for each pump before starting:

    a. Verify bearing lubrication.
    b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    c. Verify that pump is rotating in the correct direction.

5. Prime pump by opening suction valves and closing drains and prepare pump for operation.
6. Start motor.
7. Open discharge valve slowly.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION 23 21 23

SECTION 23 23 00 - REFRIGERATION PIPING AND SPECIALTIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Piping

B. Refrigerant

C. Moisture and liquid indicators

D. Valves

E. Pressure relief valves

F. Filter-driers

G. Solenoid valves

H. Expansion valves

I. Flexible connections

1.2 RELATED SECTIONS

A. Division 23 – Scope of Work

B. Division 23 – Common Work Results for HVAC

1.3 REFERENCES

A. ANSI/ARI 710 – Liquid Line Dryers

B. ANSI/ASHRAE 15 – Safety Code for Mechanical Refrigeration

C. ANSI/ASHRAE 34 – Number Designation of Refrigerants

D. ANSI/ASME SEC 9 – Boilers and Pressure Vessels Code, Welding and Brazing Qualifications

E. ANSI/ASME B16.22 – Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

F. ANSI/ASME B31.5 – Refrigeration Piping

G. ANSI/ASME B31.9 – Building Services Piping

H. ANSI/AWS A5.8 – Brazing Filler Metal

I. ANSI/UL 429 – Electrically Operated Valves

J. ARI 750 – Thermostatic Refrigerant Expansion Valves

K. ARI 760 - Solenoid Valves for Use With Volatile Refrigerants

L. ASTM B280 – Seamless Copper Tube for Air Conditioning and Refrigeration Field Service

M. MIL-I-631C – (Construction at Solenoid Valve Coils)

N. MIL-V-23450C – Valves, Expansion, Thermostatic, Refrigerant 22

1.4 SUBMITTALS

A. Submit shop drawings under provisions of Division 01 and 23.

B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.

1. Shop Drawing Scale: 1/4 inch equals 1 foot.
2. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

C. Submit product data indicating general assembly of specialties, including manufacturer's catalogue information.

D. Submit welder certification of compliance.

E. Submit test reports indicating results of leak test, acid test.

F. LEED Submittals:

1. Credit EA 4" Manufacturers' product data for refrigerants, including printed statement that refrigerants are free of HCFCs.

1.5 PROJECT RECORD DOCUMENTS

A. Submit documents under provisions of Division 23.

B. Accurately record exact locations of equipment and refrigeration accessories on record drawings.

1.6 REGULATORY REQUIREMENTS

A. Conform to ANSI/ASME B31.9.

B. Welding Materials and Procedures: Conform to ANSI/ASME SEC 9 and applicable state labor regulations.

C. Welders Certification: In accordance with ANSI/ASME SEC 9.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store and protect products under provisions of Division 23.

B. Deliver and store piping and specialties in shipping containers with labeling in place. Protect containers.

C. Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.

PART 2 - PRODUCTS

2.1 PIPING

A. Copper Tubing: ASTM B280, Type ACR hard drawn.

1. Fittings: ANSI/ASME B16.22 wrought copper.
2. Joints: ANSI/AWS A5.8 B Cup silver braze.

2.2 REFRIGERANT

A. Refrigerant: ANSI/ASHRAE 34; R-22: Monochlorodiflouromethane.

B. Refrigerant: ANSI/ASHRAE 34; R410A.

2.3 MANUFACTURERS

A. Henry

B. Mueller

C. Sporlan

D. Approved equivalent

2.4 MOISTURE AND LIQUID INDICATORS

A. Indicators: Single port type, UL listed, with copper or brass body, braze ends, sight glass, color coded paper moisture indicator with removable element cartridge and plastic cap; for maximum working pressure of 500 psi, and maximum temperature of 200° F.

2.5 VALVES

A. Diaphragm Packless Valves: UL listed, globe or angle pattern, forged brass body and bonnet, phosphor bronze and stainless steel diaphragms, rising stem and handwheel, stainless steel spring, nylon seat disc, braze ends, with positive backseating; for maximum working pressure of 500 psi and maximum temperature of 275° F.

B. Packed Angle Valves: Forged brass, forged brass seal caps with copper gasket, rising stem and seat with backseating, molded stem packing, braze ends; for maximum working pressure of 500 psi and maximum temperature of 275° F.

C. Packed Ball Valves: Two piece forged brass body with teflon ball seals and copper tube extensions with braze ends, brass seal cap, chrome plated ball, stem with neoprene ring stem seals; for maximum working pressure of 500 psi and maximum temperature of 300° F.

2.6 PRESSURE RELIEF VALVES

A. Straight Thru or Angle Type: Brass body and disc, neoprene seat, factory sealed and stamped with ASME UV and National Board Certification NB; for standard 400 psi setting; selected to ANSI/ASHRAE 15.

2.7 FILTER-DRIERS

A. Replaceable Cartridge Angle Type: ANSI/ARI 710, UL listed, brass shell and bronze cap, perforated brass shell and molded desiccant filter core; for maximum working pressure of 350 psi.

B. Permanent Straight Thru Type: ANSI/ARI 710, UL listed, steel shell with molded desiccant filter core, for maximum working pressure of 400 psi. Use only where replaceable cartridge is not available for line sizes.

2.8 SOLENOID VALVES

A. Valve: ARI 760, pilot operated, copper or brass body and internal parts, synthetic seat, stainless steel stem and plunger assembly, with braze ends; for maximum working pressure of 500 psi. Stem shall permit manual operation in case of coil failure.

B. Coils Assembly: UL Listed, replaceable with molded electromagnetic coil, moisture and fungus proof, with surge protector and color coded lead wires, integral junction box with pilot light.

2.9 EXPANSION VALVES

A. Angle or Straight Thru Type: ARI 750; design suitable for refrigerant, brass body, internal or external equalizer, bleed hole, adjustable superheat setting, replaceable inlet strainer, with replaceable capillary tube and remote sensing bulb. Braze ends.

B. Selection: Evaluate refrigerant pressure drop through system to determine available pressure drop across valve. Select valve for maximum load at design operating pressure and minimum 10° F superheat. Select to avoid being undersized at full load and excessively oversized at part load.

2.10 FLEXIBLE CONNECTORS

A. Corrugated bronze hose with single layer of exterior braiding, minimum 9" long with copper tube braze ends; rated in excess of maximum working pressure of system.

PART 3 - EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Use emery cloth to remove oxidation at joint locations on copper tubing and fittings.

B. Removable scale and dirt on inside and outside before assembly.

C. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

3.2 INSTALLATION

A. Install refrigeration specialties in accordance with manufacturer's instructions.

B. Route piping in orderly manner, with plumbing 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 and locations. Slope piping one percent in direction of oil return.

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

F. Provide clearance for installation of insulation and access to valves and fittings.

G. Provide access to concealed valves and fittings. Coordinate size and location of building access panels.

H. Where pipe support members are welded to structural building frame, brush clean, and apply one coat of zinc rich primer to welding.

I. Prepare pipe, fittings, supports, and accessories not prefinished, ready for finish painting.

J. Insulate suction and hot gas piping; refer to Division 23.

K. Locate expansion valve sensing bulb immediately downstream or evaporator on suction line; locate 45 degrees below horizontal.

L. Provide external equalizer piping on expansion valves with refrigerant distributor connected to evaporator.

M. Install flexible connectors at right angles to axial movement or compressor.

N. Fully charge completed system with refrigerant after testing and dehydration.

O. Provide electrical connection to solenoid valves.

P. All connections and joints shall be brazed. Remove all flared joints.

Q. Install refrigerant piping according to ASHRAE 15.

R. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

S. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

T. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

U. Install piping adjacent to machines to allow service and maintenance.

V. Install piping free of sags and bends.

W. Install fittings for changes in direction and branch connections.

X. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

Y. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels if valves or equipment requiring maintenance is concealed behind finished surfaces.

Z. Install refrigerant piping in protective conduit where installed belowground.

AA. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

BB. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

CC. Install pipe sleeves at penetrations in exterior walls and floor assemblies.

DD. Seal penetrations through fire and smoke barriers.

EE. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

FF. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

GG. Seal pipe penetrations through exterior walls.

HH. Identify refrigerant piping and valves.

II. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

JJ. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
2. Use Type Bag, cadmium-free silver alloy for joining copper with bronze or steel.

3.3 APPLICATION

A. Provide line size liquid indicators in main liquid line leaving condenser, or if receiver is provided, in liquid line leaving receiver.

B. Provide permanent filter-driers in low temperature systems and systems utilizing hermetic compressors; only where replaceable core is not available in line size.

C. Provide replaceable cartridge filter-driers vertically in liquid line adjacent to receivers with three valve bypass assembly to permit isolation of driers for servicing.

D. Provide replaceable cartridge filter-driers, with three-valve bypass assembly on liquid lines.

E. Provide solenoid valves in liquid line of systems operating with single pump-out or pump-down compressor control, in liquid line of single or multiple evaporator systems, and in oil breeder lines from flooded evaporators to stop flow of oil and refrigerant into the suction line when system shuts down.

F. Provide refrigerant charging valve connections in liquid line between receiver shut-off valve and expansion valve.

G. Utilize flexible connectors at or near compressors/equipment where within piping configuration does not absorb vibration.

H. Use refrigerant ball valves whenever possible.

3.4 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Division 01.

B. Test refrigeration system in accordance with ANSI/ASME B31.5.

C. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.

    a. Fill system with nitrogen to the required test pressure.
    b. System shall maintain test pressure at the manifold gage throughout duration of test.
    c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    d. Remake leaking joints using new materials and retest until satisfactory results are achieved.

3.5 TEST PRESSURES

A. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig.
2. Suction Lines for Heat-Pump Applications: 535 psig.
3. Hot-Gas and Liquid Lines: 535 psig.

3.6 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.7 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valve.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 23 23 00

SECTION 23 31 13 - DUCTWORK

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Low pressure ductwork

B. Medium and high-pressure ductwork

C. Double wall ductwork

D. Kitchen hood ductwork

E. Fiberglass ductwork

F. Casing for garage fans

1.2 RELATED WORK

A. Division 23 – Scope of Work

B. Division 23 – Common Work Results for HVAC

C. Division 23 – Supports and Anchors: Sleeves

D. Division 23 – Duct Insulation

E. Division 23 – Ductwork Accessories

1.3 REFERENCES

A. ASHRAE – Handbook 1989 Fundamentals; Chapter 33 – Duct Design

B. ASHRAE – Handbook 1988 Equipment; Chapter 1 – Duct Construction

C. ASTM A 90 – Weight of coating of Zinc-Coated (Galvanized) Iron or Steel Articles

D. ASTM A 167 – Stainless and Heat Resisting Chromium Nickel Steel Plate, Sheet, and Strip

E. ASTM A 525 – General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process

F. ASTM A 527 – Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality

G. ASTM B209 – Aluminum and Aluminum Alloy Sheet and Plate

H. NFPA 90A – Installation of Air Conditioning and Ventilating Systems

I. NFPA 90B – Installation of Warm Air Heating and Air Conditioning Systems

J. NFPA 96 – Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors from Commercial Cooling Equipment

K. SMACNA – Duct Construction Standards

L. UL 181 – Factory-Made Air Ducts and Connectors

1.4 DEFINITIONS

A. Duct Sizes: Inside clear dimensions. For lined ducts, main sizes inside lining.

B. Low Pressure: Three pressure classifications: 1/2 inch WG positive or negative static pressure and velocities less than 2,000 fpm; 1 inch WG positive or negative static pressure and velocities less than 2,500 fpm and 2 inch WG positive or negative static pressure and velocities less than 2,500 fpm.

C. Medium Pressure: Three pressure classification: 3 inch WG positive or negative static pressure and velocities less than 4,000 fpm, 4 inch WG positive static pressure and velocities greater than 2,000 fpm, 6 inch WG positive static pressure and velocities greater than 2,000 fpm.

1.5 REGULATORY REQUIREMENTS

A. Construct ductwork to NFPA 90A and NFPA 96 standards.

1.6 SUBMITTALS

A. Submit shop drawings under provisions of Division 01 and 23.

B. Indicate duct fittings, particulars such as gages, sizes, welds, and configuration prior to start of work. Provide detailed layout drawings showing each duct fitting. The minimum acceptable scale is 1/4 inch equals 1 foot.

C. Provide mockups of ductwork indicating construction, sealing methods, reinforcement and methods, longitudinal and traverse joint methods, elbows with turning vanes, fittings, volume/smoke/fire/combination fire/smoke dampers installation and appurtenances. Mockups may be actual ductwork segments utilized for the project. Mockups are subject to analysis by the Engineer for conformance to these specifications and details on the contract documents.

D. Structural steel fabricator and installer shall be responsible for the coordination of all framed openings in roof with approved equipment manufacturers. (Openings such as, but not limited to mechanical units, exhaust fans, curb mounted equipment, roof drains, skylights, stair openings,

roof hatches, smoke hatches, duct through roof penetrations, expansion joints, etc.) Exact sizes and exact locations of all openings are to be verified with the approved shop drawings issued for the installation. The exact sizes shall be coordinated prior to any fabrication and installation by any/all trades. Sizes and locations indicated on Contract Drawings are diagrammatic and for information only. Any fabrication and/or installation which has not been properly coordinated with approved equipment manufacturer and must be repaired, relocated, altered, replaced, reinstalled or modified in any manner will be done to the satisfaction of the Owner with no additional cost to the Owner or design professional.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Non-combustible or conforming to requirements for Class 1 air duct materials, or UL 181.

B. Actual gauge sheetmetal shall be utilized for ductwork. Sheetmetal that is out of tolerance shall not be used on the project.

C. Steel Ducts: ASTM A 527 galvanized steel sheet, lock-forming quality, having zinc coating of .90 oz. per sq. ft. for each side in conformance with ASTM A90. Ductwork that is exposed for painting shall be galvannealed.

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

E. Insulated Flexible Ducts: Flexible duct wrapped with flexible glass fiber insulation, enclosed by seamless aluminum pigmented plastic vapor barrier jacket; maximum 0.23 K value at 75 degrees F, R-8. 10 year parts and labor warranty against blow-out. Thermaflex G-KM. Provide insulated Thermaflex FlexFlow elbows at diffuser locations.

F. Insulated Flexible Ducts for MRI Areas: All non-metallic construction flexible duct with engineered polymer wire helix, wrapped with flexible glass fiber insulation, enclosed by seamless polyester scrim reinforced polyester film vapor barrier jacket; maximum 0.23 K value at 75 degrees F, R-8. 10 year parts and labor warranty against blow-out. Thermaflex PHD.

G. Stainless Steel Ducts: ASTM A167, Type 304 #4 finish for exposed ductwork, 2D finish for concealed ductwork.

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

I. Sealant: Non-hardening, water resistant, fire resistive, compatible with mating materials; heavy mastic, water-based, less than 50/25 smoke developed/flame spread per ASTM E84. Ductmate Pro Seal.

J. Hanger Rod: Steel, galvanized; threaded both ends, threaded one end, or continuously threaded.

K. Seal all ducts in accordance with SMACNA Duct Construction Standards. All joints, longitudinal and transverse seams and connections in ductwork, shall be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded fabric systems, or tapes. Tapes and mastics used to seal ductwork shall be listed and labeled in accordance with UL 181A or UL 181B. Duct connections to flanges of air distribution system equipment shall be sealed and mechanically fastened. Unlisted duct tape shall not be permitted as a sealant on any metal ducts. Utilize Pittsburg lock longitudinal seams for rectangular ducts and fittings through 18 gauge material. Utilize welded seams for rectangular ducts 16 gauge and up.

L. Duct hangers and supports shall be in accordance with the SMACNA HVAC DUCT CONSTRUCTION STANDARDS - METAL AND FLEXIBLE. Ducts shall be supported with approved hangers at intervals not exceeding 10 feet or by any other approved hangers systems designed in accordance with the International Building Code. Flexible and other factory made ducts shall be supported in accordance with the manufacturer's installation instructions.

M. Duct fittings and transitions shall be constructed using the minimum requirements as per SMACNA standards. Slope all transitions between 8° to 14° degrees from horizontal. Transitions required to be greater than 14 degrees shall utilize radius corners to promote airflow at minimum pressure drop. Maximum slope shall be 20° from horizontal.

N. Provide custom fabricated duct transitions from air handling unit and/or fan inlets/outlets. Transitions shall be full size of the connection and slope gradually to duct size as indicated on the plans and/or per SMACNA guidelines for the velocity and pressure class of the designated system. Minimum duct length shall be 4 feet long. Extend transition length as necessary to be less than the maximum slope requirements.

2.2 LOW PRESSURE DUCTWORK

A. Fabricate and support in accordance with SMACNA Duct Construction Standards and ASHRAE handbooks, except as indicated. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated herein. Utilize heavier duct gauges with no stiffeners required whenever possible, in compliance with SMACNA Duct Construction Standards. Use of lighter duct gauges with stiffeners shall not be used unless approved by the Engineer prior to installation.

B. Size round and oval ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular, oval and round ducts. No variation of duct configuration or sizes permitted except by written permission.

C. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on the inside radius. Where not possible and where rectangular elbows are used, provide Aero Dyne HEP turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.

D. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible. Divergence upstream of equipment shall not exceed 30 degrees; convergence downstream shall not exceed 45 degrees.

E. Provide easements where low pressure ductwork conflicts with piping and structure. Where easements exceed 10 percent duct area, split into two duct maintaining original duct area.

F. Connect flexible ducts to metal ducts with draw bands.

G. Use double nuts and lock washers on threaded rod supports.

H. All longitudinal joints shall be of the Pittsburgh lock type. Provide an additional application of sealant on the airstream side of the joint of all ducts.

I. Use Buckley ATMD fittings on taps to diffusers. Fittings to have adhesive neoprene gasket, integral volume damper and extended neck/quadrant lock. Secure with multiple sheetmetal screws.

2.3 MEDIUM PRESSURE DUCTS

A. Fabricate and support in accordance with SMACNA Duct Construction Standards and ASHRAE handbooks, except as indicated. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated herein. Utilize heavier duct gauges with no stiffeners required whenever possible, in compliance with SMACNA Duct Construction Standards. Use of lighter duct gauges with stiffeners shall not be used unless approved by the Engineer prior to installation.

B. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows are used, provide (airfoil) turning vanes; refer to Div 23 Ductwork Accessories for turning vane specifications.

C. Transform duct sizes gradually, not exceeding 15 degrees divergence and 30 degrees convergence.

D. Duct mate joints shall be used on supply, return and exhaust. Apply sealant to inside and outside of flange joint/duct joint.

E. Provide standard 90 degree lateral wye takeoffs with 45 degree inlet edge. Conical tee connections may be used.

F. Round and oval ductwork may be used in lieu of rectangular. Air velocity may not be increased. Acceptable manufacturer is United McGill. Clearances must be verified and considered where conflicts occur.

G. Use double nuts and lock washers on threaded rod supports.

H. All longitudinal joints shall be of the Pittsburgh lock type, with appropriate sealant applied to the joint during assembly. Apply another application of sealant on the airstream side of the joint.

I. Use Buckley M-BM fittings on taps to CV or VAV boxes. Fittings to have neoprene gasket and mini-bellmouth tap configuration. Secure to duct with multiple sheetmetal screws.

2.4 DUCT CONSTRUCTION STANDARDS

A. Pressure Class: 1" WG Pos. or Neg.

Material: Galvanized, G90 grade

Standard Joint: 55 ¾" (18 gauge – 24 gauge)

Seams: Longitudinal Pittsburgh seams for all ducts and fittings
All longitudinal seams sealed.

Joint Types: 8" Duct dimension or less: S-Lock and Drive
Greater than 8" dimension: TDF flange and gasket.
No additional reinforcement unless noted.

Duct Reinforcing: ¾" EMT conduit & Condu-Lock,
Max spacing 30" on center.

DUCT GAUGE/REINFORCEMENT					
Duct Dimension	Duct Length				
	49" – 60"	37" – 48"	31" – 36"	25" – 30"	24" - Down
30" – Down	24	24	24	24	24
31" – 36"	24	24	24	24	24
37" – 42"	24	24	24	24	24
43" – 48"	A	24	24	24	24
49" – 54"	A	A	24	24	24
55" – 60"	A	A	22	24	24
61" – 72"	B	B	22	22	22
73" – 84"	J	J	C	C	C
85" – 96"	F	J	E	E	C
97" – Up	\\\\\	H	G	G	G

TABLE KEY:

1. A - 24 ga with tie-rods in center
2. B - 22 ga with tie-rods in center
3. C - 22 ga with tie-rods in ends
4. D - 22 ga with tie-rods in center and ends

5. E - 20 ga with tie-rods in ends
6. F - 20 ga with tie-rods in center and ends
7. G - 18 ga with tie-rods in ends
8. H - 18 ga with tie-rods in center and ends
9. J - 18 ga with no reinforcement or 22 ga with tie-rods in center and ends
10. \\\\\ - Not Designed

B. Pressure Class: 2" WG Pos. or Neg.

Material: Galvanized, G90 grade

Standard Joint: 55 ¾" (18 gauge – 24 gauge)

Seams: Longitudinal Pittsburgh seams for all ducts and fittings
All longitudinal seams sealed.

Joint Types: 8" Duct dimension or less: S-Lock and Drive
Greater than 8" dimension: TDF flange and gasket.
No additional reinforcement unless noted.

Duct Reinforcing: ¾" EMT conduit & Condu-Lock,
Max spacing 30" on center.

DUCT GAUGE/REINFORCEMENT					
Duct Dimension	Duct Length				
	49" – 60"	37" – 48"	31" – 36"	25" – 30"	24" - Down
26" – Down	24	24	24	24	24
27" – 28"	24	24	24	24	24
29" – 30"	24	24	24	24	24
31" – 36"	22	24	24	24	24
37" – 42"	20	22	24	24	24
43" – 48"	18	20	22	22	24
49" – 54"	J	J	20	22	22
55" – 60"	D	J	20	20	22
61" – 72"	H	D	J	J	18
73" – 84"	\\\\\	D	E	C	C
85" – 96"	\\\\\	G	G	E	E

97" – Up	\\\\\	\\\\\	G	G	G

TABLE KEY:

1. A - 24 ga with tie-rods in center
2. B - 22 ga with tie-rods in center
3. C - 22 ga with tie-rods in ends
4. D - 22 ga with tie-rods in center and ends
5. E - 20 ga with tie-rods in ends
6. F - 20 ga with tie-rods in center and ends
7. G - 18 ga with tie-rods in ends
8. H - 18 ga with tie-rods in center and ends
9. J - 18 ga with no reinforcement or 22 ga with tie-rods in center and ends
10. \\\\\ - Not Designed

C. Pressure Class: 4" WG Pos. or Neg.

Material: Galvanized, G90 grade

Standard Joint: 55 ¾" (18 gauge – 24 gauge)

Seams: Longitudinal Pittsburgh seams for all ducts and fittings
All longitudinal seams sealed.

Joint Types: TDF flange and gasket.
No additional reinforcement unless noted.

Duct Reinforcing: ¾" EMT conduit & Condu-Lock,
Max spacing 30" on center.

DUCT GAUGE/REINFORCEMENT					
Duct Dimension	Duct Length				
	49" – 60"	37" – 48"	31" – 36"	25" – 30"	24" - Down
12" – Down	24	24	24	24	24
13" – 18"	24	24	24	24	24
19" – 22"	24	24	24	24	24
23" – 28"	22	24	24	24	24
29" – 30"	C	22	24	24	24
31" – 36"	E	C	22	22	24

37” – 42”	D	D	C	C	22
43” – 48”	D	D	C	C	C
49” – 54”	D	D	E	C	C
55” – 60”	D	D	E	C	C
61” – 72”	F	D	G	E	C
73” – 84”	\\\\\	F	G	E	E
85” – 96”	\\\\\	F	\\\\\	G	E
97” – Up	\\\\\	\\\\\	\\\\\	G	G

TABLE KEY:

1. A - 24 ga with tie-rods in center
2. B - 22 ga with tie-rods in center
3. C - 22 ga with tie-rods in ends
4. D - 22 ga with tie-rods in center and ends
5. E - 20 ga with tie-rods in ends
6. F - 20 ga with tie-rods in center and ends
7. G - 18 ga with tie-rods in ends
8. H - 18 ga with tie-rods in center and ends
9. J - 18 ga with no reinforcement or 22 ga with tie-rods in center and ends
10. \\\\\ - Not Designed

2.5 DOUBLE WALL DUCTWORK

A. Double Wall (Insulated) Ductwork: Fabricate double-wall (insulated) ductwork with an inner and outer shell and a 2" liner between. Dimensions indicated on internally insulated ducts are inside dimensions.

1. Thermal Conductivity (k-Value): 0.26 at 75 deg. F means temperature.
2. Outer Shell: Base outer-shell metal thickness is 18 gauge metal. Use the same metal thicknesses for uninsulated fittings as outer duct.
3. Insulation: 2" thick fibrous-glass insulation, (duct liner) unless otherwise indicated. Terminate insulation where internally insulate duct connects to single-wall duct or uninsulated components. Terminate insulation and reduce outer duct dimension to nominal single-wall size.
4. Perforated Inner Liner: Base inner shell metal thickness is 22 (standard), 20 (custom) gauge metal.
5. This ductwork shall be installed on the first 20'-0" on all ducts connected to the air handler unit or more as indicated on the contract documents. Construct to medium pressure requirements as outlined herein.
6. Perforated Liner shall consist of 5/32 perforations spaced to provide 25% free area.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The Contractor shall include allowances for structural, piping, and conduit interferences not evident during the bid phase or indicated on the drawings. Interferences are to be worked out during the shop drawing phase.

B. Contractor to take special care of shipping, handling and assembly of ductwork.

C. Provide offsets at interference locations and/or where changes in ceiling heights require such offsets; offsets shall be smooth as possible and without the need for hard elbows; offsets shall minimize the elbow/offset angle required which shall result in minimal static pressure gradients into the system.

D. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

E. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

F. All ductwork openings shall be covered, protected and sealed against contaminant migration into the airstream and shall be covered by plastic. Plastic to be removed upon continuation of work. Maintain integrity of protection as the work progresses.

G. Use 24 inch minimum length, straight sheet metal duct directly adjacent to inlets at terminal boxes.

H. Provide a Type 304 stainless steel ductwork section for duct mounted humidifiers located in the supply airstream. Refer to plans for size, length and location. Fabricate of all welded construction and with the bottom sloped in 2 directions to a common drain stub on one side of the section. Provide a stainless steel access door on the side of the section and directly adjacent to the steam grid; access door shall be sized for access thereto and for cleaning the interior surfaces of the section. Provide a P-trap of adequate depth to prevent blow thru or backup conditions. Extend condensate line as indicated on the plans and/or to the nearest drain.

I. Connect diffusers and grilles (exhaust and return) to low pressure ducts with 8 feet maximum length of straight run insulated flexible duct. Hold in place with strap or clamp. Flex duct shall be supported such that the installation is in kink-free manner. Use Thermaflex FlexFlow elbows at all air inlet and outlet connection to flex ducts.

J. Provide residue traps in kitchen hood exhaust ducts at base of vertical risers with provisions for cleanout. Provide cleanouts at 15’ horizontal intervals or per code jurisdiction.

K. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

L. Install Buckley fittings per manufacturer's instructions. Secure with sheet metal screws.

M. Where ductwork is exposed to weather, provide .060" thick EPDM membrane adhered to the ductwork.

N. All ductwork located within 20' of the discharge and return air opening around air handling equipment shall be solid double wall with 20 gauge perforated, 18-gauge outer shell and 2" thick acoustic duct liner between the liner and shell. The inner duct shall be the pressure duct where the inner duct is solid wall.

3.2 DUCTWORK MATERIAL SCHEDULE

AIR SYSTEM	MATERIAL
Supply, Return, Relief and Intake	G90 Steel
General Exhaust	G90 Steel
Humidifier	Stainless Steel; welded liquid tight
First 20' of ductwork of discharge and return air opening around each air handling unit	G90, Double wall, (22) (20) gauge inner, 18 gauge outer (see execution)

3.3 DUCTWORK CLEANING

A. The (Insert locations here) ductwork shall be internally cleaned. Follow NADCA specifications for Commercial Duct Cleaning. Use powered nylon brushes and HEPA filtered exhaust units. Provide duct access doors as required for cleaning in order to gain access to ductwork internal surface. Provide scaffolding as required to perform work; follow all OSHA rules and regulations. All cleaned ductwork shall be visually clean. Provide reports with actual pictures verifying work has been satisfactorily performed; include recommendations where ductwork is visually corroded or where excessive contaminants warrant ductwork replacement.

3.4 DUCTWORK PRESSURE CLASSIFICATION

SYSTEM	**CLASSIFICATION**
Ductwork: Within equipment room	Medium Pressure; 4 inch; Seal Class A
Ductwork: Main return	Medium Pressure; 4 inch; Seal Class A
Ductwork: Equipment room wall to terminal unit	Medium Pressure; 4 inch; Seal Class A
Ductwork: Terminal unit to air outlet	Low Pressure; 1 inch
Ductwork: Branch return and general exhaust	Low Pressure; 2 inch, Seal Class A
Ductwork: General Exhaust <1"	Low Pressure, 1 inch

3.5 KITCHEN FACTORY BUILT DUCTWORK, INSTALLATION

A. The inner pipe joints shall be sealed by use of V-bands and with high temperature joint cement. The kitchen exhaust/ductwork shall comply with National Safety Standards and Building Codes when installed according to be manufacturer's installation instructions. Kitchen exhaust ductwork extended above the roof must terminate as required by local code, or as required in NFPA 96.

B. The kitchen exhaust ductwork manufacturer shall warrant the complete system against functional failure due to defects in material and workmanship for 10 years form date of delivery. The system manufacturer shall be responsible for checking the sizing, design, and installation of the system. If any component fails to perform its intended function of exhausting grease laden kitchen exhaust from the hood for any reason, within 10 years of shipment, the system supplier shall, at no expense to the Owner, provide a replacement part or parts, FOB jobsite.

3.6 DUCTWORK LEAKAGE TESTING

A. The Contractor shall not insulate the systems until leakage tests have been performed and results accepted.

B. The Contractor shall, at the beginning of the work, construct, erect and leak test a representative sample of the duct construction to be used which is designed to operate at static pressures 3" wg and above. The sample specification shall be at least 25% of the entire system which shall include at least five transverse joints, two typical seams, an access door, typical branch connections, at least one elbow and two fire or fire/smoke dampers. All shafts/risers shall be leak tested prior to insulating and enclosing.

C. The pressure testing shall be performed in accordance with the SMACNA HVAC Air Duct Leakage Test Manual, latest edition.

D. The leakage amount shall not exceed the allotted amount for the pressure class or the allotted amount for that portion of this system, whichever is applicable.

DUCT CONSTRUCTION CLASS	RATE OF AIR LEAKAGE (C_L)
10" wg	3
6" wg	6
4" wg	6
3" wg	6

The Rate of Air Leakage (C_L) of the sample specimen shall be determined by the formula (C_L) = $F/P^{.65}$ where F is the measured leakage rate in cfm/100 sq. ft. duct area and P is the static pressure of the test.

E. If the sample specimen fails to meet the allotted rate of air leakage (C_L), the Contractor shall modify to bring it into compliance and shall retest it until the acceptable leakage level is demonstrated. Excessive buttering with duct sealant is prohibited.

F. Tests and necessary repair shall be completed prior to the installation of insulation and concealment of ductwork.

END OF SECTION 23 31 13

SECTION 23 31 15 - FABRIC DUCTWORK

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Extent of fabric ductwork is indicated on drawings and by requirements of this section.

1.2 RELATED WORK

A. Division 23 – Common Work Results for HVAC

B. Division 23 - Ductwork

1.3 QUALITY ASSURANCE

A. Quality Assurance:

1. Manufacturer must be a UL Registered Firm.
2. Any production facility used by manufacturer must be ISO 9001 registered.
3. Fabrics used must be produced in an environmentally friendly factory. The actual production site for each individual fabric must be Oeko-Tex certified by Oeko-Tex International - Association for the Assessment of Environmentally Friendly Textiles.

B. Codes and Standards:

1. Where fire retardant fabrics are required, products must be classified in accordance with the 25/50 smoke/flame spread development requirements of UL723 -"Standard for Test for Surface Burning Characteristics of Building Materials" as required by UL2518 - "Outline of Investigation for Air Dispersion System Materials".
2. If antimicrobial treated duct is specified, product must be treated with an EPA approved and listed antimicrobial agent.

1.4 SUBMITTALS

A. Submit copy of UL/ULC Registered Firm certificate and ISO 9001 certificate from production facility.

B. Submit UL file number under which product is Classified by Underwriter's Laboratories to UL2518 (as required by NFPA 90A) or ULC-S102.2 for Canada.

C. If Antimicrobial treated duct is specified, submit documentation for EPA registration.

D. Submit manufacturer's drawings indicating size and placement of dispersion units, and installation instructions.

E. Submit manufacturer's technical product data for fabric dispersion units.

F. Submit manufacturer's performance data for each fabric duct system including airflow rate, design static pressure, inlet velocity, and isothermal throw.

G. Submit manufacturer's maintenance data.

1.5 WARRANTY

A. Manufacturer must provide a 10 Year Product Warranty for products supplied from Date of Final Acceptance.

B. Contractor warranty shall be 1 year on parts and labor from Date of Final Acceptance

1.6 DELIVERY, STORAGE, PROTECTION AND HANDLING

A. Deliver, store, protect and handle products under Division 23 requirements and per the manufacturer’s instructions.

B. Protect fabric air ductwork systems from damage during shipping, storage and handling.

C. Store products inside and protect from weather. Prevent dirt and moisture from entering packaging.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Fabric Air, Inc. (Basis of Design)

B. Ductsox

C. Reviewed equivalent

2.2 FABRIC AIR DISPERSION SYSTEM

A. Round fabric air dispersion system shall be constructed of FabricAir Combi 70 fabric. The fabric is a woven fire retardant and permeable fabric complying with the following characteristics:

1. Duct Shape: Round
2. Fabric: 100% Flame Retardant Polyester

3. Weight: 8.50 oz./yd² per ASTM D3776
4. Shrinkage: Max. 0.5% per EN ISO 5077
5. Color: STANDARD
6. Temperature Range: -40°F and +284°F
7. Base Permeability @ 0.5" WG: 2 CFM/SQFT per ASTM D737, shall be verified by the Frazier Permeability Test
8. Fire Retardancy: Shall meet the requirements of NFPA 90-A, ICC AC167 and UL 2518
9. Manufacturer shall provide a 10-year non-prorated warranty. Prorated warranties will not be accepted.

B. System Fabrication Requirements

1. The system is made with sewn in, but still removable, aluminum hoops. The rods support the shape of the fabric system by 180° (8”-48”), 120° (49”-60”), 90° (61”-68”) and 60° (69”-80”). Hoops must be pre-installed from factory, no installation at sight. Diameter of hoops and distance between as specified by manufacturer.
2. Elbows of 70° or more to have 2 hoops sewn in order to maintain shape.
3. Air dispersion shall be accomplished with linear or polar arrays of laser cut orifices. Size of laser cut orifices shall be from 0.56" to 4.92" diameter. Due to exact throw requirements and NC requirements alternative flow models are not acceptable.
4. Number, spacing, and size of orifices shall be determined by the manufacturer.
5. Fabric system shall include continuous flexible slider to attach to suspension system listed below.
6. Provide system in sections optimized for maintenance, connected by zippers. Zippers shall provide closure completely around the circumference to prevent leakage. Required number of zippers shall be specified by the manufacturer.
7. Each section to have a unique tag including information about manufacturers order number, position, diameter of section, length of section, maintenance instruction, code compliance and contact details for spare parts.

C. Design Parameters

1. Use fabric air diffusers only for positive pressure air distribution.
2. Do not use fabric air diffusers in concealed locations.
3. Fabric diffusers shall be designed to a maximum of 3" water gauge, with 0.5" being the standard.
4. Design temperatures shall be between -40°F and +284°F
5. Manufacturer shall approve all technical design parameters.

D. Hangers And Supports

1. Type 8: One row H-rail/cable system located 2" above 12 o'clock of FabricAir system. Hardware to include H-rail connector, vertical cable supports, endcap H-rail, tie down strap and H-rail as required. FabricAir system shall be attached to H-Rail using RapidSlider, a flexible linear slider located 12 o'clock along the entire length of the system. Each system shall be provided with insertion device to allow single-worker duct installation. Due to aesthetic concerns and installation efficiency requirements, intermediate connection point systems are not acceptable.

a. Hardware

1) Anodized Aluminum H-Rails - With PVC coated stainless steel suspension cables, cable eyes, cable locks for H-rail, rail connectors and endcaps. Suspension cables, locks, connectors, and all other factory supplied metal components shall be stainless steel.

2.3 AIR HANDLER REQUIREMENTS

A. Provide adequate pre-filtering prior to the fabric duct system, all according to manufacturer's specifications.

B. Air handler filters shall be changed per unit manufacturer's requirements. Failure to maintain clean filters may result in a voided warranty.

C. Provide fans capable of delivering the specified air volume at the specified static pressure.

PART 3 - INSTALLATION

3.1 INSTALLATION OF FABRIC AIR SYSTEM

A. Examine area and conditions under which the FabricAir systems are to be installed. Do not continue any installation until unsatisfactory conditions have been corrected.

B. Install chosen suspension system in accordance with the requirements of the manufacturer. Installation instructions shall be provided by the manufacturer with product.

C. Coordinate layout with suspended ceiling, lighting layouts, and all other trades that may interfere with the installation of FabricAir systems.

3.2 CLEANING

A. Clean air handling unit and other ductwork prior to the FabricAir system as it is installed. Ensure that all construction debris, including dust, is removed from the air handling unit and other ductwork before connecting the FabricAir system.

B. If the FabricAir system becomes soiled during the installation, it should be removed and cleaned following the manufacturers’ cleaning instructions.

END OF SECTION 23 31 15

SECTION 23 33 10 - DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 WORK INCLUDED

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

B. Volume control and shut off dampers

C. Fire dampers

D. Air turning vanes

E. Flexible duct connections

F. Duct access doors

G. Duct test holes

H. Combination Fire and Smoke Dampers

I. Airflow Stations

1.2 RELATED WORK

A. Division 23 – HVAC Scope of Work

B. Division 23 – Common Work Results for HVAC

C. Division 23 – Ductwork

D. Division 23 Section "Fire Alarm" for duct-mounting fire and smoke detectors

E. Division 23 Section "HVAC Instrumentation and Controls" for electric and pneumatic damper actuators.

1.3 REFERENCES - (LATEST EDITION)

A. AMCA 500-D – Laboratory Methods for Testing Dampers for Ratings

B. AMCA 511 – Certified Ratings Program for Air Control Devices

C. IBC – International Building Code

D. NFPA 90A – Installation of Air Conditioning and Ventilating Systems

E. NFPA 92A – Smoke Control Systems

F. NFPA 92B – Smoke Control Systems in Atria, Covered Malls and Large Areas

G. NFPA 101 – Life Safety Code

H. SMACNA – Duct Construction Standards

I. UL 33 – Heat Responsive Links for Fire-Protection Service

J. UL 555 – Standard for Safety: Fire Dampers

K. UL 555S – Standard for safety leakage characteristics for dampers in engineered smoke control systems

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Division 01 and 23, Common Work Results for HVAC.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. Include rated capacities, outlet velocities, furnished specialties, and accessories for each type of product indicated and include the following:

1. Motor ratings and electrical characteristics, plus motor and electrical accessories.
2. Material thickness and finishes, including color charts
3. Dampers, including housings, linkages, and operators.
4. Controllers and other controls.
5. Special fittings
6. Manual-volume damper installations
7. Motorized-control damper installations
8. Fire-damper, smoke-damper, and combination fire and smoke damper installations, including sleeves and duct-mounting access doors.
9. Wiring Diagrams: Power, signal, and control wiring.
10. Copies of UL Installation Instructions.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

D. Wiring Diagrams: Power, signal, and control wiring.

E. Design Calculation: Calculate requirements for seismic restraints.

F. All fan motors shall be non-overloading and selected per the discretion of the Engineer.

G. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved.

H. Field quality-control test reports.

I. Operation and Maintenance Data: To include in emergency, operation, and maintenance manuals.

J. Structural steel fabrication and installer shall be responsible for the coordination of all framed openings in roof with approved equipment manufacturers. (Openings such as, but not limited to mechanical units, exhaust fans, curb mounted equipment, roof drains, skylights, stair openings, roof hatches, duct through roof penetrations, expansion joints, etc.) Exact sizes and exact locations of openings are to be verified with the approved shop drawings issued for the installation. The exact sizes shall be coordinated prior to any fabrication and installation by any/all trades. Sizes and locations indicated on Contract Drawings are diagrammatic and for information only. Any fabrication and/or installation which has not been properly coordinated with approved equipment manufacturer and must be repaired, relocated, altered, replaced, re-installed or modified in any manner will be done to the satisfaction of the Owner with no additional cost to the Owner or design professional.

K. Submit the Installation, Operation and Maintenance Manual (IOM) and install thereto.

L. Provide shop drawings for the following:

1. Fire dampers
2. Air turning vanes
3. Volume dampers
4. Flexible duct connections
5. Duct access doors
6. Duct test holes
7. Combination Fire and Smoke Dampers

1.5 COORDINATION

A. Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinating penetrations and ceiling-mounting items. Show ceiling-mounting access panels and access doors required for access to duct accessories.

B. Coordinate size and location of structural-steel support members.

C. Coordinate installation of ductwork accessories with actual location.

1.6 QUALITY ASSURANCE

A. Comply with NFPA 90A, 92A, 92B and 101 and all applicable building codes.

1.7 DELIVERY, STORAGE, PROTECTION AND HANDLING

A. Deliver Store, store, protect and handle fans and accessories according to Div. 01 and 23 requirements, comply with manufacturer's instructions.

B. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly indicating manufacturer, material, products included, and location of installation

C. Storage: Store materials in a dry area indoor, protected from damage, and in accordance with manufacturer's instructions. For long term storage follow manufacturer's Installation, Operations, and Maintenance Manual

D. Handling: Handle and lift ductwork accessories in accordance with the manufacturer's instructions. Protect materials and finishes during handling and installation to prevent damage. Follow all safety warnings posted by the manufacturer.

E. Protect motors, shafts, and bearings from weather and construction dust. Provide sealed housings to prevent debris from entering assembly. Store units off-site until surfaces are ready for immediate installation.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10% of amount installed.

1.9 WARRANTY

A. One year warranty on parts and labor from date of final acceptance.

1.10 MAINTENANCE MANUALS

A. Submit and refer to Manufacturer's Installation, Operation and Maintenance Manual (IOM), to find maintenance procedures.

PART 2 - PRODUCTS

2.1 Manufacturers are listed for a quality assurance level only. Although a manufacturer is listed does not constitute compliance with the specification size, weight, functionality, capacity, noise, or performance levels. It is this contractor's responsibility to assure the proposed manufacturer has complete compliance with the Contract Documents, **prior to bidding**.

2.2 ACCEPTABLE MANUFACTURERS – VOLUME CONTROL AND SHUT OFF DAMPERS

A. Ruskin

B. Louvers and Dampers

C. Greenheck

2.3 VOLUME CONTROL AND SHUT OFF DAMPERS

A. Control Dampers: AMCA Standard 500-D tested and rated. Provide dampers with parallel blades for 2-position control or opposed blades for modulating control. Construct blades of 16-gauge steel; provide heavy-duty molded self-lubricating nylon bearings, 1/2-inch hex steel axles spaced on 9" centers. Construct frame of 5-inch x 1 inch x 16-gauge steel channel with linkage concealed within the jamb. Finish is to be galvanized. For dampers located in ductwork with air velocities greater than 1500 FPM, dampers shall have airfoil blades. Provide frames to accept Ductmate joints where applicable transverse joints are provided. Provide a 2" standoff bracket and locking quadrant manual operator. Dampers for moisture laden airstreams or corrosive environments shall be type 304 stainless steel construction including bearings. Provide sleeve and security bars where required.

B. Provide positive-locking air volume damper. Provide quadrant (damper handle) which has a spring-loaded locking mechanism which ensures that the handle's position remains locked where it is set. A wingnut lockdown is not acceptable. Field assembled damper hardware into duct and fittings. Snap-In Bearings into 3-inch holes on each side of the duct or fitting, holding the round continuous-rod damper blade in position and passing the rod through the pre-stamped channel in the blade and the bearings. Dampers handle on the outside of the fitting or duct. Damper adjustments can be made by hand—without the need for any tool. The Positive-Locking Air Volume Damper consists of a locking damper handle (or quadrant), two 3-inch bearings, a rod and a round damper blade. All the components shall adhere to the relevant UL requirements, Plenum ratings and SMACNA standards for manual dampers; and are in compliance with NFPA 90A & 90B Standard for the Installation of Air-Conditioning and Ventilating Systems. All non-metallic components are made of flame-retardant polymer with a free rating of 5VA as specified in UL 1995 Standards Code for Heating & Cooling. The positive locking damper handle consists of a bracket, a handle, a thumb trigger, a spring and a retaining ring. The bracket is made of cold rolled steel in conformance with ASTM A1008, 18-gauge nominal thickness 0.0478, tolerance range 0.0438–0.0518. The Handle & Thumb Trigger is made of Polyamide 66 (PA66), flame retardant, glass-reinforced polymer in conformance with CSA-C22.2 No. 238 UL 1995. Stainless steel 302-OP 0.25 wire Compression Spring, 0.026 free length; 7 inch; ten coils, closed, not ground. Carbon Spring Steel with Zink Bright Plating Retaining Ring, C-SCALE Rockwell Hardness 47–51, Country of origin: USA. Snap-in Bearings (11 inch) (B Long) for use with inside-insulated, (lined), duct and fittings. B-Longs are recommended for all pressure class applications. B-Snaps are recommended for low or medium pressure systems. Clip-on Bearings snap into a 3-inch hole with an E-Clip securing the bearing from the opposite side. Continuous Rod Damper Blades - Galvanized ASTM A553 LFO G90, 20 and 22 gauge; designed with additional radial reinforcement throughout the disc which effectively equals the strength of 18-gauge material.

Available in 4–16-inch diameter. A 3-inch full length bar fits through the formed channel in the center of each damper blade. Basis of Design: Rossi Positive-Locking Air Volume Damper.

C. Intake and Relief Air Dampers: Provide dampers with opposed blade except gravity relief air dampers shall be parallel blade. Frames and blades shall be of aluminum construction. Blades shall be of the airfoil design. Axle shall be 1/2-inch hex and fitted into nylon bearings. Provide ball bearings on gravity relief dampers. Blades shall be provided with neoprene end and jamb seals for a tight shut off. Construct frame of 5-inch x 1 inch x .125 minimum wall thickness. Provide frames to accept Ductmate joints where applicable transverse joints are provided.

2.4 ACCEPTABLE MANUFACTURERS – FIRE DAMPERS

A. Ruskin

B. Greenheck (Basis of Design)

C. Reviewed equivalent.

2.5 FIRE DAMPERS

A. General: UL Listed per UL Standard 555, dynamic type, 1-1/2 hour rated for assembles less than 3-hour rating, 3 hour rated for assemblies 3 hour or greater rating, refer to contract documents for wall type, rating and construction.

B. Type: Use Type C curtain damper for low pressure duct system sizes for maximum single assembly of 31" x 31" rectangular, 31" diameter round and 46" x 31" oval. For duct sizes larger, use multi-blade type fire dampers. Use multi-blade type for medium pressure duct systems (upstream of VAV/CV boxes and Phoenix valves).

C. Fire Closure Temperature: Each fire damper shall be equipped with a fusible link rated to close the damper when temperature at the damper reaches 165° F.

D. Differential Pressure: Dampers shall have a minimum UL 555 differential pressure of 4" wg.

E. Velocity: Curtain dampers and low-pressure multi-blade dampers have minimum UL velocity rating of 2000 fpm. Medium pressure system multi-blade dampers shall have minimum UL velocity rating of 3000 fpm.

1. Curtain Fire Damper Construction: Galvanized steel in gauges required by manufacturer's UL Listing. Provide frame, sleeve, retaining angles, blades, links and duct transition connection (Type C, Type CO, Type CR) for each damper. Dampers for moisture laden airstreams or corrosive environments shall be type 304 stainless steel construction.

F. Multi-blade Damper Construction

1. Frame: Galvanized steel formed into 5" x 1" structural hat channel. Top and bottom frame members on dampers less than 17" high shall be low profile design to maximize free area. Frame to be 4-piece construction with minimum 1-1/2" integral overlapping

gusset reinforcement in each corner to assure square corners and provide maximum resistance to racking.

2. Blades: 16-gauge galvanized steel with 1" each deep-vee grooves along the blade with each blade being symmetrical. Provide airfoil blades for medium pressure systems.
3. Blade Stops: Maximum 1/2" around the damper openings.
4. Jamb Seals: Flexible stainless steel compression type.
5. Linkage: Concealed in jamb.
6. Axles: Minimum 1/2" diameter plated steel.
7. Bearings: Bronze sleeve type polished extruded holes.
8. Dampers for moisture laden airstreams or corrosive environments shall be type 304 stainless steel construction including bearings.
9. Provide sealed sleeves with breakaway Ductmate flanges, retaining angles, links and duct transitions for each damper.

G. Provide security bars where required, refer to contract documents. Provide manual quadrant actuator where required for balancing, consult with Engineer.

H. The minimum size damper shall be 12" x 12", provide transitions for duct sizes smaller than 144 square inches.

I. Application (Basis of Design)

1. Low pressure 1-1/2 hour rated: Greenheck DFD-150
2. Low pressure 3 hour rated: Greenheck DFD-350
3. Medium pressure 1-1/2 hour rated: Greenheck DFD-210 (with volume damper accessory) and Greenheck DFDTF-210.

2.6 COMBINATION FIRE/SMOKE DAMPERS

A. General: UL Listed per UL Standard 555 and 555S, dynamic type, 1-1/2-hour fire rated for assemblies less than 3 hours, 3 hour fire rated for assemblies 3 hour or greater rating, refer to Contract Documents for wall type, rating and construction. UL Listed as Class 1 per UL Standard 555S, dynamic.

B. Fire Closure Temperature: Factory installed heat responsive device rated to close the damper when 165° F is reached.

C. Elevated Operation Temperature: 350° F per UL 555S.

D. Differential Pressure: 4" wg per UL 555S.

E. Velocity: Low pressure systems shall have a UL 555S rating of 2000 fpm; medium pressure systems shall have a UL 555S rating of 3000 fpm. Medium pressure systems are defined as ductwork upstream of VAV/CV boxes and Phoenix valves.

F. Frame: 16-gauge galvanized steel formed into 5" x 1" structural hat channel, low profile design, 4 piece construction with minimum 1-1/2" integral overlapping gusset reinforcements in each corner to assure square corners and maximum resistance to racking.

G. Blades: 16-gauge galvanized steel, variable symmetrical, 3-vee with 1" deep grooves for low pressure systems, double skin airfoil for medium pressure systems.

H. Blade Stops: Maximum 1/2" to maximize available free area.

I. Blade Seals: Silicone rubber permanently bonded to the blade.

J. Jamb Seals: Flexible stainless steel compression type.

K. Linkage: Concealed in jamb.

L. Axles: Minimum 1/2" diameter plated steel.

M. Bearings: Sintered bronze type rotating in polished extruded holes in the frame.

N. Provide sealed sleeves with breakaway Ductmate flanges and retaining angles sized per UL Listing.

O. Actuator: Electric, 24 VAC, 2 position; coordinate with electrical documents. Coordinate with contractor regarding internal or external mounting of actuator with accessibility and maintenance requirements. Fail Closed.

P. Accessories: For each damper provide the following:

1. Greenheck RRL/OCI 165° F link and open/close indicating DPDT switch.
2. Security Bars: Where required, refer to plans.
3. Greenheck GTS-3 test panel with momentary test switch with closed and open indicating LED's.
4. Access door.
5. Sleeve Joints: Ductmate type

Q. The minimum damper size shall be 12" x 12", provide transitions for duct sizes smaller than 144 square inches.

R. Application (Basis of Design)

1. Low pressure, 1-1/2 hour rated: Greenheck FSD-211
2. Low pressure, 3 hour rated: Greenheck FSD-231
3. Medium pressure, 1-1/2 hour rated: Greenheck FSD-311
4. Medium pressure, 3 hour rated: Greenheck FSD-331

2.7 SMOKE DAMPERS

A. General: UL listed per UL Standard 555S, Class 1 leakage rate.

B. Elevated operational temperature: 350° F

C. Differential pressure = 4" wg per UL 555 S.

D. Velocity: Low pressure systems shall have a UL 555S rating of 2000 fpm; medium pressure shall have a UL 555S rating of 3000 fpm. Medium pressure systems are defined as ductwork upstream of VAV/CV boxes and Phoenix valves.

E. Frame: 16-gauge galvanized steel formed into 5" x 1" structural hat channel, low profile design, 4 piece construction with minimum 1-1/2" integral overlapping gusset reinforcements in each corner to assure square corners and maximum resistance to racking.

F. Blades: 16-gauge galvanized steel, variable symmetrical, 3-vee blades for low pressure systems, double skin airfoil for medium pressure systems.

G. Blade Stops: Maximum 1/2" to maximize available free area.

H. Blade Seals: Extruded silicone rubber permanently bonded to the blade.

I. Jamb Seals: Flexible stainless steel compression type.

J. Linkage: Concealed in jamb.

K. Axles: Minimum 1/2" diameter plated steel.

L. Bearings: Sintered bronze type rotating in polished extruded holes in the frame.

M. Provide sealed sleeves with breakaway Ductmate flanges and retaining angles sized per UL Listing.

N. Actuator: Electric, 24 VAC – 1 phase, modulating; coordinate with electrical documents. Coordinate with contractor regarding internal or external mounting of actuator with accessibility and maintenance requirements. Fail closed.

O. Accessories: For each damper, provide the following:

1. Greenheck OCI – open/closed indicating DPDT switch.
2. Transitions to round and oval ductwork as required.
3. Fail closed.
4. Greenheck GTS-3 test panel with momentary test switch with closed and open indicating LED’s.
5. Sleeve Joints: Where required shall be Ductmate type, else use slip and drive; coordinate as required.
6. Access door.
7. Security Bars: Where required, refer to plans.
8. Sleeve Joints: Ductmate type

P. The minimum damper size shall be 12" x 12", provide transitions for duct sizes smaller than 144 square inches.

Q. Application (Basis of Design):

1. Low Pressure: Greenheck SMD-201
2. Medium Pressure: Greenheck SMD-301

2.8 ACCEPTABLE MANUFACTURERS – AIR TURNING VANES

A. Aero Dyne HEP as Basis of Design

2.9 AIR TURNING VANES

A. Multi-blade device with 3" radius blades aligned on 2.4" centers; steel or aluminum construction with set and lockable blades, mounting straps. Performance shall be 0.027" wg pressure drop at 1000 FPM air velocity; 0.105" wg static pressure drop at 2000 FPM air velocity and 0.24" wg static pressure drop at maximum air velocity of 3000 FPM.

2.10 ACCEPTABLE MANUFACTURERS – FLEXIBLE DUCT CONNECTIONS

A. Ventfabrics (Basis of Design)

2.11 FLEXIBLE DUCT CONNECTIONS

A. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

B. Metal-Edged Connectors: Factory fabricated with a fabric strip 6" wide attached to two strips of 3" wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch-thick aluminum or stainless-steel sheets. Select metal compatible with ducts.

C. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene. Model Ventglas.

1. Minimum Weight: 30 oz./sq. yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 20 to plus 200 degrees F.
4. Service Pressure: Rated to +/- 10" wg.

D. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and Ozone. Model Ventlon.

1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus to plus 275 degrees F.
4. Service Pressure: Rated to +/- 10" wg.

E. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber. Model Ventsil.

1. Minimum Weight: 16 oz./sq. yd.
2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
3. Service Temperature: Minus 25 to plus 500 degrees F.
4. Service Pressure: Rated to +/- 8" wg.

F. High-Corrosive Environment System, Flexible Connectors: Glass fabric with chemical resistant coating. Model Ventel.

1. Minimum Weight: 14 oz./sq. yd.
2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 degrees F.
4. Service Pressure: Rated to +/- 8" wg.

2.12 ACCEPTABLE MANUFACTURERS – DUCT ACCESS DOORS

A. Duro Dyne

B. Ruskin

C. Ductmate

D. Air Balance

2.13 DUCT ACCESS DOORS

A. Fabricate in accordance with SMACNA Duct Construction Standards and as indicated.

B. Review locations prior to fabrication.

C. Fabricate rigid and close-fitting doors of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, install minimum one-inch-thick insulation with sheet metal cover.

D. Access doors smaller than 12 inches square may be secured with sash locks.

E. Provide two hinges and two sash locks for sizes up to 18 inches square, three hinges and two compression latches with outside and inside handles for sizes up to 24 x 48 inches. Provide an additional hinge for larger sizes.

F. Access doors with sheet metal screw fasteners are not acceptable.

G. The access openings shall not reduce the fire-resistance rating of the assembly. Access points shall be permanently identified on the exterior by a label having letters not less than 0.5 inch in height reading: SMOKE DAMPER or FIRE DAMPER.

2.14 DUCT TEST HOLES

A. Permanent test holes shall be factory fabricated, airtight flanged fittings with screw cap. Provide extended neck fittings with screw cap. Provide extended neck fittings to clear 2" insulation thickness.

B. Manufacturer – Ventlok 699-2

2.15 AIRFLOW STATIONS

A. Basis of Design is Paragon with equivalent by Ebtron.

B. Provide airflow stations at the main supply, and outside air sections from air handling equipment and where indicated on the plans and where required.

C. The airflow stations shall be tested to AMCA Standard 611-95 and qualified to bear the AMCA Rating Seal for Airflow Measurement performance.

D. Duct-Mounted Airflow Stations (Paragon)

1. Probes shall be mounted in an eight-inch deep, 16-gauge galvanized steel casing with 90-degree undrilled flanges, fabricated to the duct size, and shall contain multiple airflow traverse elements interconnected as previously described.
2. Each element shall be of a dual integral chambered design. Airflow measuring element shall contain multiple total and static pressure sensing ports placed along the leading edge of the cylinder. The static pressure chamber shall incorporate dual offset static taps on opposing sides of the averaging chamber, so as to be insensitive to flow angle variations of as much as +1- 20 degrees in the approaching air stream.
3. The airflow traverse elements shall be capable of producing steady, non-pulsating signals of true total and static pressure, with an accuracy of 2 percent of actual flow for operating velocities as low as 180 feet per minute. Signal amplifying sensors requiring flow correction (K factors), or field calibration are not acceptable.
4. The airflow traverse elements shall not induce a pressure drop greater than .18 inches of water column at 4,000 feet per minute. The units shall have a self-generated sound rating of less than NC40 and the sound level within the duct shall not be amplified, nor shall additional sound be generated.

E. Fan Inlet Mounted Airflow Measuring Stations (Paragon)

1. Where mounted into controllable pitch axial inlet bells, or inlet cones of centrifugal fans, provide traverse probe assemblies with all necessary end mounting plates and master takeoff fittings. Eight mounting bolts, lock washers and nuts; interconnecting tubing and compression fittings to be provided by the installing contractor.
2. Primary flow elements shall not be used on fan inlet applications where the narrowest diameter of the inlet cone is under ten inches without prior approval. Fan inlet sensors shall not be used on fans having inlet guide vanes. The use of only one static element and one total pressure element on fan inlets is prohibited. Fan primary elements shall not exceed .562 inches in diameter on fans having inlet cone diameters less than 30 inches.

F. Duct static pressure sensing elements shall be equal to Paragon Controls model PE-5000.

1. Each system static pressure sensing element shall be built in accordance with the airflow measurement stations above, except that only static pressure sensing element shall be provided. Individual single point pitot tubes are not acceptable.

G. Space (room) pressure sensing elements shall be equal to Paragon Controls model PE-7000.

1. Provide space static pressure sensors suitable for flush mounting. Each sensor is to be complete with multiple sensing ports, pressure impulse suppression, and field connection fitting. The sensing unit shall be constructed of 11-gauge stainless steel, with a brushed finish on exposed surfaces.
2. These elements shall be capable of sensing the static pressure in the proximity of the sensor to within percent of the actual space pressure value.

H. Shielded outdoor (atmospheric) pressure sensing elements shall be equal to Paragon Controls model PE-8000.

1. Provide shielded static pressure sensors, suitable for exterior mounting, to be utilized as the reference value for space static pressure indication and control. Each sensor is to be complete with multiple sensing ports, pressure impulse suppression, airflow velocity shielding, and a 2-1/2-inch diameter female pipe thread connection for field mounting and signal transmitting. These sensors are to be constructed of 11-gauge stainless steel.
2. The outdoor air probe shall be capable of sensing the outside atmospheric air pressure to within 2 percent of the actual value when subjected to a radial wind velocity up to 80 miles per hour with approach angles up to 30 degrees to the horizontal.

I. Provide Paragon individual differential static pressure and airflow transducers, selected for the required range of each of the above primary elements, and in accordance with the following:

1. The transducer(s) shall be solid state electronic type, with infinite output resolution, capable of performing dedicated static pressure and air volume control functions. Microprocessor based transducers with time sharing of multiple square root extractors and/or controllers are not acceptable.
2. Each transducer's output shall not be affected by direction of mounting (attitude) or external vibrations and shall be furnished with a factory calibrated range that matches the application.
3. Airflow transducers shall be provided with an integral dual scale indicating meter operating independent of all other control devices. The top scale shall indicate the measured air volume in units of cubic feet per minute (CFM), and the bottom scale shall indicate the air velocity in units of fee per minute (FPM). The meter shall be a differential pressure type that is diaphragm actuated and is to be flush mounted on the enclosure door. The meter shall be calibrated to an accuracy of +2 percent of span.
4. Transducer performance shall be equal to or better than the following:

    a. Accuracy: +/- 0.5% F.S. (Terminal Point); +/- 0.35% F.S. (BFSL)
    b. Temperature Effects: <0.03% F.S./$_0$ Fahrenheit
    c. Over-Pressure: 5 psig Proof/10 psig Burst
    d. Response: < 0.25 seconds for full scale input
    e. Noise Filtration: Low Pass Filter, factory set at 3.2 Hz

J. Each Paragon transducer shall be selected for its respective duty. Supply, exhaust and/or return airflow transducers shall provide analog output signal lnear to air volume that are factory set for a full-scale value equal to 110 percent of the maximum design capacity of the flow measuring

element served for variable air volume applications, or 200 percent of the design operating value for constant volume applications.

K. Paragon Airflow transducers for operating velocities below 1266 feet per minute shall provide the following features:

1. Local electronic indication of the measure airflow rate. The indicating meter shall be one-half inch high, three- and one-half digit light emitting diode (LED) type. The LED shall indicate the measured air volume in engineering units of cubic feet per minute (CFM).
2. Automatic zeroing circuit that shall be capable of maintaining the transducer output to within 0.1 percent of value and shall be field configurable for frequency of activation between one and seventy-two hours. The transducer output shall be locked and maintained at the last given output value during the automatic zeroing period so as not to interrupt the automatic control process. The meter shall be auto calibrated to an accuracy of _/- count.
3. Transducer accuracy shall be +/- 0.25 percent F.S. (Terminal Point); +/- 0.15 percent F.S. (BFSL).

L. The Ebtron airflow stations shall be "Gold Series" Model GTA116-P or GTN116-P duct or plenum probes, GTA116-F and GTA116-B or GTN116-B dynamic pressure sensors, with associated transmitters.

1. Airflow/Temperature Measurement

a. The airflow/temperature measurement station shall be capable of monitoring airflow and temperature rates at each measurement location. Sensors shall use thermal dispersion technology with two "bead in glass", hermetically sealed thermistor probes at each measurement point. The system shall be factory tested prior to shipment and not require calibration or adjustment over the life of the equipment when installed in accordance to manufacturer's guidelines. Each sensor probe shall be provided with a UL plenum-rated connecting cable with circular terminal connectors and gold-plated contacts. Connecting cable shall be a minimum of 10 feet in length or up to 50 feet as required for each probe. Sensor probes shall be "plug and play" design and do not have to be matched to a specific transmitter. All sensor calibration data shall be stored in the sensor probe. No additional devices or transducers shall be required to interface with the host controls.

b. Sensors shall be factory-calibrated at 16 airflow rates and 3 temperatures to NIST – traceable standards for both airflow and temperature. Each sensing point shall independently measure airflow and temperature prior to averaging. Installed accuracy shall be percent of reading and demonstrated at both maximum and minimum airflow rates for each measurement location.

2. Transmitter and Electronics Enclosure

a. The transmitter shall be microprocessor-based and capable of processing up to 16 independent sensing points per location. All connectors and interconnects shall have gold plated contacts. The transmitter shall operate on 24 VAC and be

internally fused and protected. The transmitter shall have a 16-character alphanumeric LCD display for airflow, temperature, and system diagnostics. Analog output signals shall be field selectable (0-10 VDC or 4-20 mA). When required on the plans, a serial RS-485 interface will be made available with field selectable network protocols (N2 or ModBus RTU). All inputs and outputs shall be fused, protected, and internally isolated from the 24 VAC power supply. The transmitter shall have a digital adjustment for output signal offset/gain and an adjustable digital filter for airflow output. The transmitter shall be capable of being field configured to display either I.P. or S.I. units. The transmitter shall accept a user-defined area for CFM or LPS display. The transmitter shall be capable of continuously performing sensor and transmitter diagnostics and perform a full system check on power-up. A sensor detection system shall ignore any malfunctioning sensors and set a visual alarm on the LCD display. The transmitter shall be capable of indicating individual sensor airflow and temperature readings on the LCD display.

b. The enclosure shall be a aluminum alloy for indoor use and capable of operating over a temperature range of +30° F to +120° F.

3. Duct & Plenum Mounted Sensor Probes

a. Sensor probes shall be constructed of gold anodized aluminum alloy tube with 303 stainless steel mounting brackets. Probes shall be constructed as insertion, internal, or standoff mounting, depending on the installation requirements.

1) Probe Performance Requirements

The sensor accuracy for airflow shall be at least ± 2% of reading over the sensor probe operating ranges. The installed total accuracy for airflow shall be better than ± 3% of reading over then sensor probe operating ranges when installed in accordance with manufacturers' guidelines. The sensor accuracy for temperature shall be better than ± 0.15° F over the entire operating range.

2) Probe Sensor Density

The number of independent sensing points shall be as indicated below.

Area (ft^2)	**Area** (m^2)	**Sensors**
<= 1	<= 0.093	2
>1 to <4	>0.093 to <0.372	4
4 to <8	0.372 to <0.743	6
8 to <12	0.743 to <1.115	8
12 to <16	1.115 to <1.486	12
>=16	>=1.486	16

3) Probe Operating Ranges:

Airflow: 0 to 5,000 FPM
Temperature: -20° F to +160° =

Relative Humidity: 0 to 99% (non-condensing)

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Inspect areas to receive dampers. Notify the Engineer of conditions that would adversely affect the installation or subsequent utilization of the dampers. Do not proceed with installation until unsatisfactory conditions are corrected.

C. Provide balancing dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts and branch ducts and as required for air balancing; whether indicated on the contract drawings or not.

D. Provide fire dampers, combination fire/smoke at locations required whether indicated on the contract drawings or not, where ducts and outlets pass through fire, smoke and fire/smoke rated components. Include locations as required by code authorities to isolate the air handling equipment. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings, and hinges. Install per UL and NFPA requirements.

E. Locate normal/alarm remote test indicating panels on adjacent walls for duct smoke detectors; mount 48" AFF level with light switches.

F. For fire dampers, combination fire/smoke; install PVC cleats on the Ductmate type joints; do not install the corner clip bolts. Use slip joints for dampers provided without Ductmate joints. For round and oval ductwork connecting to fire dampers, use galvanized slip joints.

G. Install fire dampers, combination fire/smoke per the manufacturer's UL approved installation instructions. Provide a frame system in the wall to support the sleeve; construct according to the manufacturer’s installation instructions and per code requirements. Installations shall be approved by the local code bodies having jurisdiction. Install dampers square and free from racking with blades running horizontally. Do not compress or stretch damper frame into duct or opening. Handle damper using sleeve or frame. Do not lift damper using blades, actuator, or jackshaft. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Install bracing as needed.

H. All fire dampers and ceiling dampers shall be operated and tested by Contractor prior to occupancy of a building to determine that they function properly in accordance with NFPA 90A. Provide a compliance report to Engineer and Owner for approval a minimum of 14 days prior to final project closeout.

I. Provide minimum 3 equivalent straight duct diameters upstream and downstream of smoke and combination fire/smoke dampers. If more space is available, then use the maximum allowable straight duct lengths.

J. Provide flexible connections immediately adjacent to equipment in ducts associated with fans and motorized equipment.

K. Provide duct access doors for inspection and cleaning at filters, coils, fans, automatic dampers, fire dampers, combination fire/smoke dampers, smoke dampers, duct smoke detectors and elsewhere as indicated. Provide minimum 18 x 18-inch size unless duct size will not allow; else use maximum available size. Provide duct access doors for steam grid humidifiers.

L. Provide duct test holes in the supply and return main ducts in straight sections near air handling units before branch take-offs. In addition, provide test holes in exhaust ducts at exhaust fans. Use judgement in locating test holes to improve CFM readings. Locate test holes a maximum of 9 inches on center. Indicate locations on ductwork shop drawings. Test holes shall clear insulation.

M. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

N. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

O. Install volume dampers in ducts with liner; avoid damage to and erosion of duct liner.

P. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:

1. On both sides of duct coils.
2. Downstream from volume dampers[, **turning vanes**,] and equipment.
3. Adjacent to fire or smoke dampers, providing access to reset or reinstall fusible links.
4. To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot spacing.
5. On sides of ducts where adequate clearance is available.

Q. Install the following sizes for duct-mounting, rectangular access doors:

1. One-Hand or Inspection Access: 8 by 5 inches
2. Two-Hand Access: 12 by 6 inches
3. Head and Hand Access: 18 by 10 inches
4. Head and Shoulders Access: 21 by 14 inches
5. Body Access: 25 by 14 inches
6. Body Plus Ladder Access: 25 by 17 inches

R. Install the following sizes for duct-mounting, round access doors:

1. One-Hand or Inspection Access: 8 inches in diameter
2. Two-Hand Access: 10 inches in diameter
3. Head and Hand Access: 12 inches in diameter
4. Head and Shoulders Access: 18 inches in diameter
5. Body Access: 24 inches in diameter

S. Install the following sizes for duct-mounting, pressure relief access doors:

1. One-Hand or Inspection Access: 7 inches in diameter
2. Two-Hand Access: 10 inches in diameter
3. Head and Hand Access: 13 inches in diameter
4. Head and Shoulders Access: 19 inches in diameter

T. Label access doors according to Division 23 Section "Identification for HVAC."

U. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.

V. Dampers must be accessible to allow inspection, adjustment, and replacement of components. The sheet metal contractor shall furnish any access doors in ductwork or plenums required to provide this access. The general contractor shall furnish any access doors required in walls, ceilings or other general building construction.

W. Install dampers square and free from racking.

X. The installing contractor shall provide and install bracing for multiple section assemblies to support assembly weight and to hold against system pressure.

Y. Do not compress or stretch the damper frame into the duct or opening.

Z. Attach multiple damper section assemblies together in accordance with manufacturer's instructions. Install support mullions as reinforcement between assemblies as required.

AA. Handle dampers using the frame or sleeve. Do not lift or move dampers using blades, actuator or jackshaft.

BB. Install connections to electric actuators as specified in Division 23.

CC. Attach multiple damper section assemblies together in accordance with manufacturer's instructions. Install support mullions as reinforcement between assemblies as required.

DD. Primary elements shall be installed in strict accordance with the manufacturer’s published requirements, and with ASME guidelines effecting non-standard approach condition. These elements serve as the primary signals for the airflow systems; therefore; it shall be the responsibility of the Contractor to verify and install, to assure that accurate primary signals are obtained.

EE. Coordinate with other work, including ductwork, electrical, mechanical, and automatic temperature controls, as necessary to interface the installation of the airflow control systems with other work.

FF. Provide an identification label to be placed on each unit casing listing model number, size, area, and specified airflow capacity.

GG. Provide an identification label to be placed on each primary flow element showing airflow direction and listing the model number, system served, size and identifying tag number.

HH. Provide an identification label to be placed on each airflow indicating transducer listing the model number flow elements served, full scale value, and identifying tag number.

3.2 START UP SERVICE AND GUARANTEE

A. Provide Factory Authorized startup service. A factory certified representative shall visit the job site after the successful contractor completes installation. The startup service will require inspection of each device; placement location, wiring and operation. A written report of the findings from the start up service shall be provided to the mechanical engineer for review and approval.

B. Upon approval by the mechanical engineer, each device shall be provided with a 12 month "on-site" warranty for defective equipment and shall also be provided with a standard limited parts warranty for total 36-month coverage from date of shipment.

3.3 FIELD QUALITY CONTROL

A. Provide factory authorized personnel to field quality control. The factory personnel shall assist the Commissioning Agent in the Commissioning process in his work for this equipment.

B. Perform the following field tests and inspections and prepare test reports:

1. Verify that the installation complies with the manufacturer's instruction and provides a workable system for the owner, installed per the design intent and that is code compliant to authorities having jurisdiction.
2. Verify that unit is secure on mountings and supporting devices and that connection to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Adjust damper linkages for proper damper operation.
5. Verify lubrication for bearings and other moving parts.
6. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
7. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
8. Shut unit down and reconnect automatic temperature-control operators.
9. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Provide factory authorized personnel to provide adjustment. The factory personnel shall assist the Commissioning Agent in the Commissioning process in his work for this equipment.

E. Adjust damper linkages for proper damper operation.

F. Adjust belt tension.

G. Refer to Division 23 Section "Testing, Adjusting, and Balance for HVAC" for testing, adjusting, and balancing procedures.

H. Replace fan and motor pulleys as required to achieve design airflow.

I. Lubricate bearings.

3.4 MANUFACTURERS' FIELD SERVICES

A. Provide factory authorized personnel to initial start-up, check out and shutdown. The factory personnel shall assist the Commissioning Agent in the Commissioning process in his work for this equipment.

B. Prior to startup, engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections and complete pre-startup checklists. Report results in writing.

1. Operational Test: After electrical circuitry has been energized, engage a factory-authorized service representative to start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. The FMCS vendor shall provide programming of the unit for optimum start/stop, morning cool-down cycle, morning warm- up cycle, timed override, date (daily, weekly, monthly, holiday, etc) occupied and unoccupied periods as well as all programming required for the sequence of operation.

3.5 TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate and maintain rooftop units.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 01 and Division 23.

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

END OF SECTION 23 33 10

SECTION 23 34 23 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Roof exhausters

B. Ceiling and cabinet exhaust fans

1.2 RELATED WORK

A. Division 23 – Scope of Work

B. Division 23 – Common Work Results for HVAC

C. Division 23 – Common Motor Requirements for HVAC Equipment

D. Division 23 – Ductwork Accessories

E. Division 23 – Variable Frequency Drives

F. Division 23 – Vibration Isolation

G. Division 23 – Vibration Isolation and Seismic Restraints

H. Division 23 – Sequence of Operation

I. Division 23 – Facilities Management and Control System

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on actual project site elevations.

B. Operating Limits: Classify according to AMCA 99.

1.4 REFERENCES

A. Air Movement and Control Association Inc. (AMCA):

1. 99 - Standards Handbook
2. 200 - Publication, Air Systems
3. 201-90 - Publication, Fans and Systems
4. 202-88 - Publication, Troubleshooting

5. 203-90 - Publication, Field Performance Measurement of Fan Systems
6. 211-05 - Publication, Certified Ratings Program – Product Rating Manual for Fan Air Performance
7. 300-96 - Standard Reverberant Room Method for Sound Testing of Fans
8. 311-05 - Publication Certified Ratings Program – Product Rating Manual for Fan Sound Performance
9. 99-0401-86 - Classification for Spark Resistant Construction
10. 99-2408-69 - Operating Limits for Centrifugal Fans

B. Air Movement and Control Association Inc. (AMCA), American National Standards Institute (ANSI):

1. 204-05 - Standard Balance Quality and Vibration Levels for Fans
2. 210-99 - Standard Laboratory Methods of Testing Fans for Aerodynamic Performance Rating

C. American National Standards Institute (ANSI):

1. 11-r1999 - Method of Evaluating Load Ratings of Bearings

D. American Society of Civil Engineers (ASCE):

1. 7-02 - Minimum Design Loads for Building and Other Structures

E. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE):

1. Chapter 45 - 2003 Handbook, HVAC Applications
2. Chapter 7 - 2001 Fundamentals handbook, Sound-Vibration
3. Chapter 32 - 2001 Fundamentals handbook, Duct Design
4. Chapter 18 - 1992 HVAC System and Equipment handbook, Fans

F. American Society for Testing and Materials (ASTM):

1. E330-02 - Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylight and Curtain Walls by Uniform Static Air Pressure Difference

G. National Fire Protection Association (NFPA)

1. 70 - National Electrical Code
2. 90A-02 - Standard for the Installation of Air-Conditioning and Ventilating Systems
3. 92A-06 - Recommend Practice for Smoke-Control System
4. 92B-05 - Standard for Smoke Management System in Malls, Atria, and Large Areas
5. 96-04 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations

H. Occupational Safety and Health Administration (OSHA):

1. 1910.212 - General requirements for Machine Guarding
2. 1910.219 - General requirements for guarding safe use of mechanical power transmission apparatus

3. 1926.300 - General requirements for safe operation and maintenance of hand and power tools

I. Underwriters Laboratories (UL):

1. 507 - Electric Fans
2. 555 - Fire Dampers
3. 555S - Smoke Dampers
4. 705 - Standard Power Ventilators
5. 762 - Standard Power Roof Ventilators for Restaurant Exhaust Appliances
6. 793 - Snow Load

1.5 QUALITY ASSURANCE

A. Performance ratings: Conform to AMCA standard 211 and 311. Fans must be tested in accordance with ANSI/AMCA Standard 210-99 and AMCA Standard 300-96 in an AMCA accredited laboratory. Fans shall be certified to bear the AMCA label for air and sound performance seal

B. Classification for Spark Resistant Construction Conform to AMCA 99

C. Each fan shall be given a balancing analysis which is applied to wheels at the outside radius. The maximum allowable static and dynamic imbalance is 0.05 ounces (Balance grade of G6.3)

D. Comply with the National Electrical Manufacturers Association (NEMA), standards for motors and electrical accessories

E. The High Wind models shall be analyzed and stamped by a state license P.E. to the ASCE 7-02 Standard which meets the IBC, Florida and Miami-Dade codes

F. Each High Wind model is subject to be certified by a third party to the ASTM E330 Static Pressure Difference Standard

G. All High Wind models shall be analyzed using Computational Fluid Dynamics (CFD). The CFD simulates the flow of high speed (150MPH) winds over the surface of objects

H. The Finite Element Analysis (FEA) is the results from the CFD and it can accurately predict the stress, strain, and deflection resulting from high wind loads

1.6 SUBMITTALS

A. Submit shop drawings and product data under provisions of Division 01 and 23, Common Work Results for HVAC.

B. Product Data: Include rated capacities, outlet velocities, furnished specialties, and accessories for each type of product indicated and include the following:

1. Certified fan performance curves with system operating conditions indicated.

2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts
5. Dampers, including housings, linkages, and operators.
6. Roof curbs.
7. Fan speed controllers and other controls.

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.
2. Design Calculation: Calculate requirements for selecting vibration isolators and seismic restraints.

D. Provide fan curves with specified operating point clearly plotted. Fans/motors are selected for additional CFM and ESP from scheduled; fans shall meet Engineer's requirements. All fan motors shall be non-overloading and selected per the discretion of the Engineer.

E. Submit sound power levels for both fan inlet and outlet at rated capacity and acoustical treatment as one package.

F. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Roof framing and support members relative to duct penetrations.
2. Ceiling suspension assembly members.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

I. Submit and comply with the Manufacturer’s Installation Manuals.

J. Structural steel fabrication and installer shall be responsible for the coordination of all framed openings in roof with approved equipment manufacturers. (Openings such as, but not limited to mechanical units, exhaust fans, curb mounted equipment, roof drains, skylights, stair openings, roof hatches, duct through roof penetrations, expansion joints, etc.) Exact sizes and exact locations of openings are to be verified with the approved shop drawings issued for the installation. The exact sizes shall be coordinated prior to any fabrication and installation by any/all trades. Sizes and locations indicated on Contract Drawings are diagrammatic and for information only. Any fabrication and/or installation which has not been properly coordinated with approved equipment manufacturer and must be repaired, relocated, altered, replaced, re-installed or modified in any manner will be done to the satisfaction of the Owner with no additional cost to the Owner or design professional.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Division 23 – Common Work Results for HVAC and requirements of Division 01.

B. Include instructions for lubrication, installation, motor and drive replacement, spare parts list and wiring diagrams.

C. Refer to Manufacturer's Installation, Operation and Maintenance Manual (IOM), to find maintenance procedures.

1.8 DELIVERY, STORAGE, PROTECTION AND HANDLING

A. Deliver: Store, protect and handle fans and accessories according to Div. 01 and 23 requirements, comply with manufacturer’s instructions.

B. Delivery: Deliver materials to site in manufacturer’s original, unopened containers and packaging, with labels clearly indicating manufacturer, material, products included, and location of installation

C. Storage: Store materials in a dry area indoor, protected from damage, and in accordance with manufacturer’s instructions. For long term storage follow manufacturer's Installation, Operations, and Maintenance Manual

D. Handling: Handle and lift fans in accordance with the manufacturer’s instructions. Protect materials and finishes during handling and installation to prevent damage. Follow all safety warnings posted by the manufacturer.

E. Protect motors, shafts, and bearings from weather and construction dust. Provide sealed housings to prevent debris from entering assembly. Store units off-site until surfaces are ready for immediate installation.

1.9 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.10 WARRANTY

A. One year warranty on parts and labor from date of final acceptance.

1.11 SOUND CRITERA

A. All fans shall be selected to result in sound power levels (and without and objectionable tone to the occupant) within occupied spaces per ASHRAE sound criteria guidelines and LEED sound

criteria guidelines as to gain the required LEED acoustics point. The Contractor shall work with the vendor prior to bid to accomplish this. Any work required due to the increase of fan size, equipment change from direct drive to belt drive, any sheave changes, any addition of VFD's, any addition of sound attenuators, any increase in motor HP size, any addition of ductwork size, any addition of needed internal acoustic lining, and addition of vibration isolators and seismic restraints, any addition of control sequence changes, software and programming, any increase in duct gauge to lessen breakout noise from the duct, any ductwork configuration or routing changes, any addition of electrical feeder size increase of breaker increases shall be conveyed to the Architect/Engineer prior to bid and prior to the last available date for addendum with a reasonable amount of time for the A/E to prepare the addendum memorandum. At the award of bid, the Contractor shall make good of such as needed to comply with this contract requirement.

1.12 MAINTENANCE

A. Submit and refer to the Manufacturer's Installation, Operation and Maintenance Manual (IOM), to find maintenance procedures.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Penn Barry

B. Loren Cook

C. Greenheck (Basis of Design)

2.2 GENERAL – ALL FANS

A. Fans used shall not decrease motor size, increase noise level, or increase tip speed by more than 10 percent, or increase inlet air velocity by more than 20 percent, from specified criteria. Fans shall be capable of accommodating static pressure variations of plus or minus 10 percent.

B. Base performance on site elevation conditions.

C. Statically and dynamically balance fans to eliminate vibration or noise transmission to occupied areas.

D. Manufacturers are listed for a quality assurance level only. Although a manufacturer is listed does not constitute compliance with the specification size, weight, functionality, capacity, noise levels or performance levels. It is this contractor's responsibility to assure the proposed manufacturer has complete compliance with the Contract Documents, **prior to bidding**.

2.3 ROOF EXHAUST FANS

A. General: Centrifugal fan, V-belt or direct driven as scheduled, with spun aluminum housing; resilient mounted motor; 1/2 inch mesh, 16 gage aluminum birdscreen; square base to suit roof curb with continuous curb gaskets; secured with cadmium plated bolts and screws. Motor shall be NEMA rated, wired and fused as per NEC and premium efficiency type. Motors that are VFD driven shall have shaft grounding.

B. Roof Curb: 18 inch high; double shell galvanized steel with continuously welded seams, built-in raised cant strip, curb bottom; factory installed 2 x 4 inch nailer strip (fireproof); and internal insulation.

C. Disconnect Switch: Factory wired, non-fusible, NEC compliant; mounted in or on fan housing wired to motor. For disconnect switch mounted on fan housing; provide NEMA 3R, lockable type.

D. Motorized Damper: 24 volt motor activated, aluminum multiple blade construction, felt edged, nylon bearings and end switch control to open damper prior to starting fan; fans for kitchen hoods shall not have dampers. Refer to 23 05 00 for control wiring. For ducts to fans that are less than 12" x 12"; damper to be gravity type.

E. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheave selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

F. Roof Mounted Upblast Exhaust Fans: A leakproof fan housing shall be constructed with a one-piece windband with an integral rolled bead for added strength.

2.4 CEILING EXHAUST FANS

A. Direct driven with galvanized steel housing; plastic ceiling grille, resilient mounted motor, gravity backdraft damper in discharge; variable speed motor; and variable speed controller mounted on fan, hanging brackets with rubber isolators, 60 second delay relay to let fan run after lights are turned off, round duct connection. Provide fan/light combinations as indicated on the drawings. Provide wall discharge cap. Provide soffit discharge grille with incoming elbow.

2.5 SQUARE CABINET EXHAUST FANS

A. V-belt or direct driven as scheduled, with galvanized steel housing; lined with 1/2 inch acoustic insulation, removable housing panels, resilient mounted motor, gravity backdraft damper in discharge; variable speed motor; and variable speed controller mounted on fan, hanging brackets with spring/rubber isolators, belt guard and in-line duct connections.

PART 3 - EXECUTION

3.1 GENERAL

A. Installing contractor shall install unit, including field installed components, in accordance with Installation, Operation and Maintenance manual instructions.

B. Any rigging devices (cranes, scaffolds) required shall be provided by the installing (Mechanical) Contractor.

3.2 EXAMINATION

A. Verify that roof, structure and floor is ready to receive work and opening dimensions are as illustrated by the manufacturer.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Secure roof exhausters with corrosion resistant lag screws to roof curb. Kitchen hood exhausters shall be attached to grease duct, see detail on drawings.

C. Install ceiling, cabinet and return fans on vibration isolators, refer to Division 23.

D. Provide frame for suspended installation, complete with all necessary beam clamps and hardware.

E. Coordinate roof openings with General Contractor.

F. Set units on roof-curbs with vibration isolation where not installed on dunnage. Turn over roof curbs to the General Contractor for installation and roofing/flashing.

G. Check unit safeties and interlocks with fire alarm system.

H. Check unit operation for compliance with the sequence of operation.

I. Provide flexible connections on ductwork systems connected to each rooftop unit.

J. Ductwork penetrations through the roof shall be sealed with acoustical fill and acoustical grade caulk in order to eliminate gaps and resulting noise paths.

K. Provide sheave/belt changes as required for final air volume delivery as determined by the testing and balancing firm.

L. Provide two spare belts per fan.

M. Install power ventilators level and plumb.

N. Install units with clearances for service and maintenance.

O. Label units according to requirements specified in Division 23.

P. Do not operate fans for any purpose until ductwork is clean, filters are in place, bearings lubricated, and fans have been test run under observation.

Q. Install fans on isolator base and flexible electrical leads. Refer to Division 23.

R. Install flexible connections specified in Division 23 between fan inlet and discharge ductwork. Ensure metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.

S. Provide sheaves required for final air balance.

T. Provide safety screen where inlet or outlet is exposed.

U. Check and adjust wheel overlap.

V. Check belt alignment and adjust as required.

W. Check belt tension and adjust as required.

X. Locate panels for multipurpose fans where indicated on plans or directed by Engineer. Panel location shall have 36” clearance in front per NEC. Field wire from panel to motor including control voltage to dampers. Run all wiring in conduit.

3.4 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23.

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Division 26 Section "Grounding and Bonding."

D. Connect wiring according to Division 26 Section "Wires and Cables".

3.5 FIELD QUALITY CONTROL

A. Provide factory authorized personnel to field quality control. The factory personnel shall assist the Commissioning Agent in the Commissioning process in his work for this equipment.

B. Perform the following field tests and inspections and prepare test reports:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connection to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.

3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Align sheaves.
7. Adjust damper linkages for proper damper operation.
8. Verify lubrication for bearings and other moving parts.
9. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
10. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
11. Shut unit down and reconnect automatic temperature-control operators.
12. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 ADJUSTING

A. Provide factory authorized personnel to provide adjustment. The factory personnel shall assist the Commissioning Agent in the Commissioning process in his work for this equipment.

B. Adjust damper linkages for proper damper operation.

C. Adjust belt tension.

D. Refer to Division 23 Section "Testing, Adjusting, and Balance for HVAC" for testing, adjusting, and balancing procedures.

E. Replace fan and motor pulleys as required to achieve design airflow.

F. Lubricate bearings.

3.7 MANUFACTURERS' FIELD SERVICES

A. Provide factory authorized personnel to initial start-up, check out and shutdown. The factory personnel shall assist the Commissioning Agent in the Commissioning process in his work for this equipment.

B. Prior to startup, engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections and complete pre-startup checklists. Report results in writing.

1. Operational Test: After electrical circuitry has been energized, engage a factory-authorized service representative to start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. The FMCS vendor shall provide programming of the unit for optimum start/stop, morning cool-down cycle, morning warm- up cycle, timed override, date (daily, weekly, monthly, holiday, etc) occupied and unoccupied periods as well as all programming required for the sequence of operation.

3.8 TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate and maintain rooftop units.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing and maintaining equipment and schedules.
2. Review data in maintenance manuals. Refer to Division 01 and Division 23.

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

END OF SECTION 23 34 23

SECTION 23 36 00 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Constant Volume Terminal Units

B. Variable Volume Terminal Units

C. Fan Powered Terminal Units

D. Bypass Terminal Units

1.2 RELATED WORK

A. Division 23 – Scope of Work

B. Division 23 – Common work Results for HVAC

C. Division 23 - Building Automation System

D. Division 23 – Direct Digital Control Systems for HVAC

E. Division 23 – Sequence of Operation for HVAC

F. Division 26 – Electrical Wiring Systems

1.3 REFERENCES

A. NFPA 90A – Installation of Air Conditioning and Ventilation Systems.

B. UL 181 – Factory-Made Air Ducts and Connectors.

C. ARI 880 – Air Terminals

1.4 SUBMITTALS

A. Submit shop drawings and product data under provision of Division 01 and 23, Common Work Results for HVAC.

B. Submit product data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings which indicate air flow, static pressure, coil performance, air pressure drop, etc. Submit power and control wiring diagrams.

C. Include schedules listing discharge and radiated sound power level for each of second through sixth octave sixth octave bands as inlet static pressures of 0.5 to 4 inch wg. Sound levels shall match those as cataloged by Basis of Design manufacturer as indicated herein.

D. Coil connection and control box location is indicated on the drawings which are diagrammatic in nature. Contractor may move box in shop drawing phase which shall be submitted in his ductwork shop drawings which are to be reviewed by the Engineer. Vendor and Contractor to coordinate both proper hand location of coil and control box location so that both coil connections can be properly made and access to control box is proper for access.

E. Submit shop drawing data on the following:

1. Variable volume terminal units.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Division 23, Basic Mechanical Requirements.

B. Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.

1.6 DELIVERY, STORAGE, PROTECTION AND HANDLING

A. Deliver, store and protect and handle products under provisions of Division 23 and manufacturer’s instructions.

B. Protect units from physical damage by storing off site until roof mounting steel is in place, ready for immediate installation of units.

C. Deliver as factory-assembled units with protective crating and covering as recommended by the manufacturer.

D. Coordinate delivery of units in sufficient time to allow movement onto final locations.

E. Handle to comply with manufacturer's written hoisting and installation instructions for unloading and moving to final location.

1.7 WARRANTY

A. Provide 1 year warranty on parts and labor from date of final acceptance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Trane

B. Enviro-Tec

C. Nailor

2.2 GENERAL

A. Above ceiling mounted variable air volume as scheduled supply air control terminals for connection to medium pressure duct, with DDC volume control.

B. Identify each airflow unit with clearly marked identification label and airflow indicator. Label shall include unit nominal air flow.

C. Each unit performance shall bear the ARI 880 certification seal.

D. Units shall be factory assembled, pressure independent operation, externally powered complete with casing, primary air valve, sound attenuator, airflow sensor volume controller, heating coil, sound attenuator, universal larger hinged control box, unit mounting bracket and accessories. Each box shall have sheet metal transitions with duct access doors to field installed hydronic heating coils.

E. Equip each terminal unit with a calibration chart and wiring diagram.

2.3 CASING

A. Outer Casing: Minimum 20 gauge galvanized steel.

B. Lining: Minimum ½" thick matt-faced dual-density fiberglass insulation, 1.92 min R value at 75 deg F, 4 PCF skin and 1.5 PCF core meeting NFPA 90A requirements and UL 181 erosion requirements. Line attenuator sections with 2 inch thick insulation of same type.

C. Inner Casing: Minimum 22 gauge galvanized steel with no insulation exposed to the airstream for healthcare and laboratory use; else units shall be single wall.

D. Assembly: Air volume damper, and controls in single cabinet.

E. Duct Air Inlets: Round, square or oval stub connections for duct attachment.

F. Plenum Air Outlets: Slip and drive connections. Provide Sound Attenuator adjacent to unit outlet. Attenuator shall be as provided by terminal unit manufacturer.

G. Provide factory installed unit mounting brackets for threaded rod installation hardware.

2.4 PRIMARY AIR VALVE

A. The damper assembly shall consist of a round blade that requires nominal 90-degree rotation from fully opened to fully closed positions on sizes 05 through 16. The damper blade shall be mechanically attached to the die-cast metal damper shaft through the shaft machine-applied rivets. The low leakage damper shall be constructed of a gasket material sandwiched between two 22-gauge zinc coated steel plates. Leakage through the damper shall be less than 1% of the maximum rated airflow at 3" w.g. inlet static pressure. The damper gasket material is securely fastened between the two damper plates using machine applied rivets. The damper assembly shall rotate freely in self-lubricating bearings. Damper position shall be indicated on the end of the shaft on the outside of the casing. Inlet connection and damper on size 24 x 16 shall be rectangular. Warren Zebra sliding plate damper is an acceptable equivalent.

2.5 PRIMARY AIRFLOW SENSOR

A. A multi-point airflow sensor (Velocity Ring) of the center averaging type shall be located in the terminal inlet. The airflow sensor shall be aerodynamically designed to provide low pressure loss, quiet operation and have not less than 20 sensing points on any given size unit. The sensor shall amplify the velocity pressure signal and provide feedback of actual flow to the controller. An identification label with piping/wiring diagram and airflow calibration chart shall be affixed to each unit. Flow taps with caps, separate from the airflow sensor or controller taps shall be provided for flow readjustment.

2.6 THERMOSTAT AND DDC CONTROLLER

A. By ATC vendor

B. Factory or field mount DDC controls provided by controls vendor. Coordinate prior to bid.

2.7 SOUND ATTENUATOR

A. Provide factory mounted sound attenuator that is from terminal unit manufacturer's product line for all units.

2.8 HEATING COILS

A. Hot Water Heating Coil: 1/2 inch or 5/8-inch copper tube mechanically expanded into aluminum plate fins, leak tested performed under water to 450 psig air pressure in the tubes, factory installed and rated for 300 psig working pressure at 200° F.

2.9 BUILDING AUTOMATION SYSTEM CONTROL INTERFACE

A. The ATC Contractor shall provide the following devices for installation at the equipment manufacturer's factory. Coordinate with existing BMS system.

1. Application specific controllers
2. Electronic Operators: Damper operators will be electronically actuated provided by Controls Contractor. Operators shall have spring return for positive return.

B. The equipment manufacturer shall be responsible for installation of the devices into his equipment. The equipment and controls shall be factory run tested and commissioned.

C. DDC Controls shall be provided by ATC Contractor, shipped to unit manufacturer and mounted and wired by VAV box manufacturer.

The VAV box manufacturer shall be responsible for all costs related to the installation. The ATC Contractor shall provide instructions and programming to the HVAC equipment manufacturer.

2.10 WIRING

A. Factory mounted and wired controls. Mount electrical components in control box with removable cover. Incorporate single point electrical connection to power source.

B. Factory mount transformer for control voltage on electric and electronic control units. Provide terminal strip in control box for field wiring of thermostat and power source.

C. Provide non-fused disconnect.

2.11 CONTROL CABINET

A. Factory or field mount controls, Contractor, ATC vendor and Contractor to coordinate prior to bid. All mounting hardware should be provided by the DDC control supplier. It shall be the responsibility of the DDC supplier to coordinate and provide job specific wiring diagrams to the terminal manufacturer.

B. Mount components in universal large control box with hinged cover and camlock.

C. Incorporate single point electrical connection to power source with factory mounted and wired for 24V power with non-fused disconnect switch.

D. Provide terminal strip in control box for field wiring of thermostat and power source.

E. Provide 120V/24V Transformer

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide ceiling access doors for units located above hard ceilings or locate units above easily removable ceiling components.

C. Use factory mounting brackets to support units individually from structure. Do not support from adjacent ductwork.

D. Provide minimum 24" long straight runout duct section directly adjacent to the inlet to box runout. Duct shall be spiral sheetmetal; see schedule for sizes (2" larger than box inlet size with transition immediately at box inlet collar).

E. Install heating coils in accordance with Division 23.

F. Transition from box outlet to reheat coils where indicated on the plans. Follow details.

G. Install fan powered boxes on vibration isolators, see Division 23.

H. Utilize Buckley M-BM fitting from tap of main to inlet of box.

I. Provide coil hook-up packages and pressure independent control valves at hydronic coils. Refer to Division 23 "Hydronic Specialties."

3.2 ADJUSTING

A. Reset volume with damper operator attached to assembly allowing flow range modulation from 100 percent of design flow to minimum heating and cooling setpoints as scheduled or indicated on the drawing.

END OF SECTION 23 36 00

SECTION 23 37 00 - AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Diffusers

B. Registers/grilles

C. Louvers

1.2 RELATED WORK

A. Division 23 – Scope of Work

B. Division 23 – Common Work Results for HVAC

1.3 REFERENCES

A. ADC 1062 – Certification, Rating and Test Manual

B. AMCA 500 – Test Method for Louvers, Dampers and Shutters

C. ANSI/NFPA 90A – Installation of Air Conditioning and Ventilating Systems

D. ARI 650 – Air Outlets and Inlets

E. ASHRAE 70 – Method of Testing for Rating and the Air Flow Performance of Outlets and Inlets.

F. SMACNA –Duct Construction Standards

1.4 QUALITY ASSURANCE

A. Test and rate performance of air outlets and inlets in accordance with ADC Equipment Test Code 1062 and ASHRAE 70.

B. Test and rate performance of louvers in accordance with AMCA 500.

1.5 REGULATORY REQUIREMENTS

A. Conform to ANSI/NFPA 90A.

1.6 SUBMITTALS

A. Submit shop drawings and product data under provisions of Division 01 and 23, Common Work Results for HVAC.

B. Submit dimensional information on roof hoods along with performance data.

C. Submit schedule of outlets and inlets indicating type, size, location, application, and noise level.

D. Review requirements of outlets and inlets as to size, finish, and type of mounting prior to submitting product data and schedules of outlets and inlets.

E. Submit a sample of each diffuser, grille, and register type for approval.

1.7 CEILING COORDINATION

A. Coordinate all ceiling diffuser/grille mounting systems with the ceiling type listed on the architectural drawing. Use drop face diffusers where drop face tiles are used.

1.8 COLOR COORDINATION

A. Coordinate all diffusers/grilles with Architectural and Mechanical Requirements as indicated on the drawings. Where diffusers are field painted, and then provide factory prime finish.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS – CEILING DIFFUSERS

A. Anemostat

B. Titus

C. Tuttle and Bailey

2.2 CEILING DIFFUSERS – LOUVERED FACE TYPE

A. Four (4) way discharge, horizontal air pattern, throw reducing vanes. Refer to schedule for panel size, neck size, CFM, throw, flex duct runout size, etc. Provide insulated plenum with round stub for ductwork attachment.

B. Provide diffuser insulation kit to be applied to the back of the diffuser.

C. Factory fabricated of stamped steel cones with factory baked enamel or powder coated white finish.

D. Anemostat, SDP w/TRV (Basis of Design) or reviewed equivalent by Titus TDC or Tuttle & Bailey RC.

2.3 ACCEPTABLE MANUFACTURERS – GRILLES/REGISTERS

A. Anemostat

B. Titus

C. Tuttle & Bailey

2.4 RETURN, RELIEF AND EXHAUST GRILLES

A. 1/2" x 1/2" x 1/2" aluminum core, aluminum frame, with aluminum opposed blade balancing damper.

B. Fabricate frame with countersunk screw mounting.

C. Anemostat GC5 as Basis of Design

2.5 SUPPLY REGISTERS/GRILLES

A. Streamlined and individually adjustable blades to discharge air along face of grille, two-way deflection (horizontal and vertical), and shaped to conform to duct (E); rectangular (F). Rotacore diffusers shall have fine blades and tight blade spacing.

B. Fabricate 1-1/4 inch margin frame with countersunk screw mounting and gasket.

C. Fabricate units from steel or aluminum extrusions with factory baked enamel white finish or prime finish for field painting, refer to Architectural drawings.

D. Provide integral, air extractor, adjustable from face (E) or opposed blade volume damper (F).

E. Provide insulated supply plenum where grille is installed at a dimension from the supply duct.

F. Anemostat ECO as Basis of Design for types mounted on round ductwork.

G. Anemostat Rotacore XR2/OB (thinline) and Anemostat S25H as Basis of Design.

2.6 EXHAUST AND RETURN REGISTERS/GRILLES

A. Streamlined blades, depth of which exceeds 3/4 inch spacing, with spring or other device to set blades, 45 deg. blades, horizontal face. Rotacore diffusers shall have fine blades and tight blade spacing.

B. Fabricate 1-1/4 inch margin frame with countersunk screw mounting or lay-in type mounting.

C. Fabricate units from steel or aluminum extrusions, with factory baked enamel or powder coated white finish or prime finish for field painting, refer to Architectural drawings.

D. Where not individually connected to exhaust fans, provide integral, gang-operated opposed blade dampers with removable key operator, operable from face.

E. Anemostat S3HO, S3HD and AC3LD as Basis of Design.

2.7 ACCEPTABLE MANUFACTURERS – CEILING SLOT DIFFUSERS

A. Anemostat

B. Titus

C. Tuttle & Bailey

2.8 CEILING SLOT DIFFUSERS

A. Multi-slot with non-adjustable or adjustable vanes for left, right or vertical discharge. Refer to schedule for number of slots, length, CFM, throw, etc.

B. Fabricate steel with factory baked enamel color selected by Architect.

C. Fabricate frame to be compatible with the ceiling system used. Use 1-1/4 inch margin frame for drywall mounting. Use clip type frame for suspension system ceilings compatible with carrier grid.

D. Units shall be factory supplied and mounted with 1-1/2 lb. density glass fiber, internally lined plenum boot with round duct connection. Internal liner shall conform to NFPA 90A and UL 181 regulations. Boot shall have butterfly damper on inlet.

E. Return linear units shall match the supply but shall not be equipped with adjustable vanes.

2.9 ROUND CEILING DIFFUSERS

A. Multi-cone, adjustable cone for horizontal to vertical throw, removable cone assembly via spring lock release by a twist of the inner cones, steel construction, round neck with volume damper, white finish or primed for field painting with color as selected by Architect; refer to Architectural Plans. Provide safety cables to secure cone assembly.

B. Anemostat C-27 as Basis of Design.

2.10 ACCEPTABLE MANUFACTURERS – LOUVERS (4" DEEP)

A. Arrow

B. Ruskin

C. Louvers and Dampers

D. Greenheck

2.11 ACCEPTABLE MANUFACTURERS – LOUVERS (6" DEEP)

A. Ruskin

B. Arrow

C. Louvers and Dampers

D. Greenheck

2.12 ACCEPTABLE MANUFACTURERS – BRICK VENTS

A. Ruskin

B. Arrow

C. Louvers and Dampers

D. Greenheck

2.13 LOUVERS, BRICK VENTS

A. Louvers and brick vents shall be 4 (6) inches deep, 4-3/8 inch blade spacing, 45 degree drainable, stationary blades, head and sill with blades contained within the jamb; constructed of 6063-T52 aluminum alloy with .125 inch thick blades. Intake louvers shall be furnished with 18/16, .011 inch diameter aluminum insect screen, exhaust louvers shall have bird screen. All louvers shall bear the AMCA seal.

B. Furnish with screw holes in jambs for installation. Provide all necessary duct collars, and caulking required for the complete installation of each unit. Provide extended sill below louver and flange frame.

2.14 ACCEPTABLE MANUFACTURERS – ROOF HOODS

A. Cook

B. Greenheck

2.15 ROOF HOODS

A. Fabricate air intake or exhaust hoods in accordance with SMACNA Low Pressure Duct Construction Standards.

B. Mount unit on minimum 12 or 18 inch high curb. The curb assembly shall be double shell; galvanized, insulated, with 2 x 4 inch treated wood nailer.

C. The hood outlet area shall be a minimum of twice the throat area. See schedules for usage (intake or relief).

2.16 GOOSENECKS

A. Fabricate in accordance with SMACNA Low Pressure Duct Construction Standards of minimum 18 gage galvanized steel.

B. Mount on minimum 12 or 18 inch high curb. The curb assembly shall be double shell; galvanized, insulated, with 2 x 4 inch treated wood nailer.

2.17 CORROSION PROTECTION FOR MARINE ENVIRONMENTS

A. Provide a special finish on the interior of the equipment and the exterior, where indicated. Apply coating at the premises of a company specializing in such work.

1. Mild Steel and Factory Primed Surfaces

    a. Synthetic Resin Primer: 36 percent, plus or minus 6 percent, solids content by volume; 1 coat, 3 mils minimum dry film.
    b. Vinyl Copolymer: 23 percent, plus or minus 4 percent, solids content by volume; 2 coats, 1 1/2 mils minimum dry film thickness per coat.

2. Nonferrous Heat Exchanger Fin Coil Surfaces

    a. Vinyl copolymer, 4 coats, 1 1/2 mils minimum dry film thickness per coat.

3. Galvanized Surfaces

    a. Polyamide Epoxy Primer: 48 percent, plus or minus 2 percent, solids content by volume; 1 coat, 2 mils minimum dry film thickness.
    b. Vinyl Copolymer: 23 percent, plus or minus 4 percent, solids content by volume; 2 coats, 1 1/2 mils minimum dry film thickness per coat.

4. Aluminum Surfaces Other than Fin Coil Surfaces

   a. Polyamide Epoxy Primer: 48 percent, plus or minus 2 percent, solid contact by volume; 1 coat, 2 mils minimum dry film thickness.
   b. Vinyl Copolymer: 23 percent, plus or minus 4 percent, solids content by volume; 2 coats, 1 1/2 mils minimum dry film thickness per coat.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install items in accordance with manufacturers' instruction. Coordinate locations with other trades.

B. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.

C. Install diffusers to ductwork with air tight connection.

D. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, regardless of whether dampers are specified as part of the diffuser, or grille and register assembly.

E. Paint ductwork visible behind air outlets and inlets matte black.

F. All air outlets and inlets shall be covered, protected and sealed against contaminant migration into the ductwork at time of installation. Plastic to be removed upon startup. Maintain integrity of protection between the two periods.

G. Coordinate wall and roof openings with General Contractor.

END OF SECTION 23 37 00

SECTION 23 52 24 - CONDENSING CAST IRON BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes gas-fired, condensing boilers for heating hot water.

B. Related Sections include the following:

1. Division 23 – HVAC Scope of Work
2. Division 23 – Common work Results for HVAC
3. Division 23 – Breechings. Chimneys and Stacks
4. Division 23 – Vibration isolation
5. Division 23 – Sequence of Operation
6. Division 23 – Hydronic Piping
7. Division 23 – Hydronic Accessories

1.3 SUBMITTALS

A. Product Data: Include manufacturer's technical data for each model indicated, including rated capacities of selected model clearly indicated; dimensions; required clearances; location and size of field connections; shipping, installed, and operating weights; furnished specialties; and accessories for each model indicated; electrical nameplate data; control and power wiring diagrams; furnished specialties; accessories; and installation and startup instructions.

B. Shop Drawing: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection. Detail mounting, securing, and flashing of roof curb to roof structure.

1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

C. Commissioning Reports: Indicate results of startup and testing commissioning requirements. Submit copies of checklists.

D. For substitutions, submit layout and with factory service clearances indicated.

E. Noise Criteria: Submit certified noise criteria and distance measured at.

F. Warranties: Special warranties specified in this Section.

G. Submit manufacturer's installation instructions under provisions of Divisions 01 and 23.

H. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved.

I. Source Quality Control Tests and Inspection Reports: Indicate and interpret test results for compliance with performance requirements before shipping.

J. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

K. Operation and maintenance Data: Include in the operation and maintenance manuals specified in Division 01 and 23. Include parts list, maintenance guide, and wiring diagrams for each boiler.

1.4 QUALITY ASSURANCE

A. Listing and Labeling: Provide electrically operated components specified in this Section that are listed and labeled.

1. The Boiler shall be certified and listed by C.S.A. International under the latest edition of the harmonized ANSI Z21.13 test standard for the US and Canada. The Boiler shall comply with the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard. The Boiler shall operate at a minimum of 85% thermal efficiency.

1.5 SOURCE QUALITY CONTROL

A. Test and inspect boilers according to the ASME Boiler and Pressure Vessel Code, Section IV. Boilers shall be test fired in the factory with a report attached permanently to the exterior cabinet of the boiler for field reference.

1.6 DELIVERY, STORAGE, PROTECTION AND HANDLING

A. Deliver, store, protect and handle products under provisions of Divisions 01 and 23.

B. Protect units from physical damage by storing off site until floors and housekeeping pads are in place, ready for immediate installation of units.

C. Deliver units as factory-assembled units with protective crating and covering as recommended by the manufacturer.

D. Coordinate delivery of units in sufficient time to allow movement into building.

E. Handle units to comply with manufacturer's written rigging and installation instructions for unloading and moving to final location.

1.7 COORDINATION

A. Coordinate size and location of concrete bases size to accommodate boilers.

1.8 WARRANTY

A. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents. Installing contractor shall provide one year of warranty parts and labor from date of final acceptance.

B. Special Warranty: Submit a written warranty, executed by the contractor for the heat exchanger.

1. The complete heat exchanger assembly shall carry a ten (10) year limited warranty.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Lochinvar CHE is the basis of design. Listed acceptable manufacturers shall be subject to compliance with requirements. Reviewed equivalent boilers shall be by one of the following:

1. Lochinvar CHE
2. Aerco Benchmark

2.2 COMPONENTS

A. The water containing section shall be of a "Fin Tube" design, with straight copper tubes having extruded integral fins spaced seven (7) fins per inch. The tubes shall terminate into a one piece, glass lined, cast-iron header. There shall be no bolts, gaskets or "O" rings in the head configuration. There shall be access to the front header of the heat exchanger for the purposes of inspection, cleaning or repair. The heat exchanger shall be mounted in a stress-free jacket assembly in order to provide a "free floating design" able to withstand the effects of thermal shock. The Boiler shall bear the ASME "H" stamp for 160 psi working pressure and shall be National Board listed. The complete heat exchanger assembly shall carry a ten (10) year limited warranty.

B. The combustion chamber shall be sealed and completely enclosed with "Loch-Heat" ceramic fiberboard insulation. A burner/flame observation port shall be provided at both ends of the boiler. The burners shall be a premix design, constructed of high temperature stainless steel and fire on a horizontal plane. The Boiler shall have a multi-speed combustion air blower to precisely control the fuel/air mixture for maximum efficiency.

C. The Boiler shall be constructed with a heavy gauge galvanized steel jacket assembly, primed and pre-painted on both sides with a minimum dry film thickness of 0.70 mils. The jacket design shall allow single unit venting connection without the use of external draft hood devices.

D. The Boiler shall be certified and listed by C.S.A. International under the latest edition of the harmonized ANSI Z21.13 test standard for the US and Canada. The Boiler shall comply with the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard. The Boiler shall operate at a minimum of 85% thermal efficiency.

E. The Boiler shall be approved for indoor installation. The Boiler shall be approved for Sidewall, DirectAire Vertical, DirectAire Vertical with Sidewall Air Inlet, DirectAire Horizontal, Aire-Lock Direct Vent and conventional venting (See mechanical detail). Venting shall be classified as Category I, negative draft, non-condensing, to use type "B" double wall venting materials. Direct Vent installations require the use of AL29-4C vent materials.

1. The Boiler shall have an independent laboratory rating for Oxides of Nitrogen (NOx) of less than 20 ppm corrected to 3% O_2.

2.3 BOILER CONTROLS

A. The Boiler shall be equipped with an Electronic Integrated Control Module with a microprocessor-based platform incorporating software customized for operation of the Lochinvar Copper-Fin II. All internal safety, operating and ignition controls shall be included in the electronic integrated control module. The electronic integrated control module shall provide on/off control of the gas supply to the burner, operation of the combustion air blower, ignition of the gas-air mixture, flame proving, control of water temperature set points, and monitoring of all safety functions. Modbus protocol (optional).

A. The Boiler shall feature the “Smart System” control with a 2-line, 16-character LCD display, password security, outdoor reset, pump delay with freeze protection, pump exercise and PC port connection. The Boiler shall allow 0-10 VDC input connection for BMS control and have built-in “Cascade” to sequence and rotate while maintaining stage firing of up to eight Boilers without utilization of an external controller. The Copper-Fin II Boiler may be Cascaded to the Lochinvar Crest Boiler for Front End Loading control. Supply voltage shall be 120 volt / 60 hertz / single phase.

1. Local communication, programming and a display of operating and alarm status conditions shall be accessible through the Smart System control panel. The Smart System control panel shall contain an on/off main power switch, a digital display of temperature functions, the operational status of the Boiler, or an active alarm fault. Data points visible in the digital display include inlet water temperature, outlet water temperature, water temperature differential, percent firing rate, setpoint temperatures, setpoint

differential, outdoor air temperature, minimum temperature, maximum temperature and maximum reset temperature. Operational status shall be displayed for Off, Standby, Pre-purge, Ignition, Space Heating, DHW Heating, and Post-purge. Fault status shall be provided for high limit, gas pressure (optional), low water, blocked drain, louver proving, and air pressure switch status.

2. The 991,000 Btu/hr model shall proportional fire with three stages of burner input and the 1,260,000 through 2,070,000 Btu/hr models shall proportional fire with four stages of burner input. The Boiler selected shall provide (3 or 4) individual stages of control. Each stage shall provide for On/Off control of individual valves and increase/decrease control of the combustion air blower to maintain maximum efficiency at all stages of operation.
3. The standard operating control system shall include redundant Proven Pilot Hot Surface Ignition with full flame monitoring capability. The Ignition system shall be able to function independently in the event of a failure in one system. Multiple main gas valves with redundant valve seats and built in low gas pressure regulators shall be supplied as standard. Gas valves will be referenced to the combustion chamber to ensure proper air/gas mixture for efficient combustion.
4. Additional standard controls shall include a flow switch, low air/blocked flue pressure switch for each fan, low voltage transformer for the control circuit, 7-amp circuit breaker and an ASME pressure relief valve. All natural gas models will be equipped with an automatic reset low gas pressure switch. The manufacturer shall verify proper operation of the burners, all controls and the heat exchanger by connection to water and venting for a factory fire test prior to shipping. A quality test report shall be shipped with each unit.
5. A 24 VAC control circuit and components shall be used. All components shall be easily accessed and serviceable. All components shall have multipin, plug in type connectors to ease service, troubleshooting and lower removal and replacement cost. The Boiler must be able to maintain approximately 50% operating capacity in the event of a failure of any one (1) control component, ie: gas valve, combustion air fan, ignition control, igniter or pressure switch.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine area to receive boiler for compliance with requirements for installation tolerances and other conditions affecting boiler performance. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install boilers level and plumb, according to manufacturer's written instructions and referenced standards.

B. Install gas-fired boilers according to NFPA 54.

C. Install electrical devices furnished with boiler, but not specified to be factory mounted.

D. Install a 1" drain valve on the outlet piping prior to the first shut off valve.

E. Provide emergency shutoff buttons for the heating plant and mount one at each room exit and at 48" AFF. When activated, the main fuel solenoid shall close and the boiler/burners shall de-energize.

3.3 CONNECTIONS

A. Connect gas piping full size to boiler gas-train inlet with union.

B. Connect hot-water piping to supply-and-return-boiler tappings with shutoff valve and union or flange at each connection.

C. Install piping from safety-relief valves to nearest floor drain. Install so that no stress is induced on the relief valve.

D. Connect breeching to boiler outlet, full size of outlet. The boiler shall operate under negative (Category II) stock pressure. Vent material must be listed AL29-4C Stainless Double Wall stack for condensing appliances.

E. Electrical: Comply with applicable requirements in Division 26 Sections.

F. Ground equipment:

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

G. Connect condensate drain to condensate neutralizer tube to discharge to floor drain.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to supervise the field assembly of components and installation of boilers, including piping and electrical connections. Report results in writing.

1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Manufacturer's representative shall supply a factory authorized service technician to start up the boilers.

3.5 CLEANING

A. Flush and clean boilers on completion of installation, according to manufacturer's written instructions.

B. After completing boiler installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes including chips, scratches, and abrasions with manufacturer's touchup paint.

3.6 COMMISSIONING

A. Engage a factory-authorized service representative to complete installation checklists, inspect installation and provide startup service and assist the commissioning agent in his work for boilers. Start up to be performed only after complete boiler room operation is field verified to offer a substantial load, and complete system circulation. One year warranty shall be handled by factory authorized tech.

B. Verify that installation is as indicated and specified.

1. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 26 Sections. Do not proceed with boiler startup until wiring installation is acceptable to equipment installer.

C. Complete manufacturer's installation and startup checklist and verify the following:

1. Boiler is level on concrete base.
2. Flue and chimney are installed without visible damage.
3. No damage is visible to boiler jacket, refractory, or combustion chamber.
4. Pressure-reducing valves are checked for correct operation and specified relief pressure. Adjust as required.
5. Clearances have been provided and piping is flanged for easy removal and servicing.
6. Heating circuit pipes have been connected to correct ports.
7. Labels are clearly visible.
8. Boiler, burner, and flue are clean and free of construction debris.
9. Pressure and temperature gages are installed.
10. Control installations are completed.

D. Ensure pumps operate properly.

E. Check operation of pressure-reducing valve on gas train, including venting.

F. Check that fluid-level, flow-switch, and high-temperature interlocks are in place.

G. Start pumps and boilers, and adjust burners to maximum operating efficiency.

1. Fill out startup checklist and attach copy with Contractor Startup Report.
2. Check and record performance of factory-provided boiler protection devices and firing sequences.
3. Check and record performance of boiler fluid-level, flow-switch, and high-temperature interlocks.
4. Run-in boilers as recommended or required by manufacturer.

H. Perform the following tests for each firing rate for high/low burners and for 100, 66, and 33 percent load for modulating burners. Adjust boiler combustion efficiency at each firing rate. Measure and record the following:

1. Gas pressure on manifold.
2. Combustion-air temperature at inlet to burner.
3. Flue-gas temperature at boiler discharge.
4. Flue-gas carbon-dioxide and oxygen concentration.
5. Natural flue draft.

I. Measure and record temperature rise through each boiler.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:

1. Operate boiler, including accessories and controls, to demonstrate compliance with requirements.
2. Train Owner's maintenance personnel on procedure and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
3. Review data in the maintenance manuals. Refer to Division 01 Section "Contract Closeout."
4. Review data in the maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data."
5. Schedule training with Owner with at least 7 days' advance notice.

END OF SECTION 23 52 24

SECTION 23 64 43 - PACKAGED AIR-COOLED SCROLL WATER CHILLERS

PART 1 - GENERAL

1.1 STIPULATIONS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 01 Sections, apply to this Section.

1.2 WORK INCLUDED

A. Chiller package

B. Charge of refrigerant and oil

C. Controls and control connections

D. Electrical power and connections

E. Roofcurb

F. Chilled Liquid Connections G. Manufacturer start-up.

1.3 RELATED WORK

A. Division 23 – Scope of Work

B. Division 23 – Common Work Results for HVAC

C. Division 23 – Common Motor Requirements for HVAC Equipment

D. Division 23 – Vibration Isolation

E. Division 23 – Hydronic Piping

F. Division 23 – Hydronic Accessories

G. Division 23 – Heat tracing for HVAC Piping

H. Division 23 – Sequence of Operation

I. Division 26 – Equipment Wiring Systems

1.4 REFERENCES

A. AHRI 550/590 – Performance Rating of Water Chilling Packages using the Vapor Compression Cycle

B. AHRI 370 – Standard for Sound Rating of Large Outdoor Refrigerating and Air Conditioning Equipment

C. ANSI/ASHRAE 15 – Safety Code for Mechanical Refrigeration

D. ANSI/ASME SEC 8 – Boiler and Pressure Vessel Code

E. UL 1995 – Standard for Heating and Cooling Equipment

F. Energy Conservation Construction Code of New York State, 2020

1.5 SUBMITTALS

A. Submit shop drawings and product data under provisions of Division 01 and 23.

B. Submit shop drawings indicating components, assembly, dimensions, weights, and loadings, required clearances, and location and size of field connections. Indicate valves, strainers and thermostatic valves required for complete system.

C. Submit sound data and acoustic treatment within same submittal. Treatment to be custom tailored to the manufacturer's sound data that may be different from the Basis of Design.

D. Submit product data indicating components, assembly, dimensions, rated capacities, weights and loadings, required clearances, specialties and accessories, electrical requirements and power and control wiring diagrams and location and size of field connections.

E. Submit written certification that components of package not furnished by manufacturer have been selected in accordance with manufacturers requirements.

F. Submit manufacturer's installation instructions under provisions of Division 23.

G. Submit plan of chiller location with recommended clearances for review. Include future chiller (same size as new) location and clearances as our plan indicates.

H. The manufacturer shall include in his bid, an allowance for structural framing revisions including the locations and supports/steps for as required for service platforms at control and power panel locations.

I. Submit certification of satisfactory run test by company officer.

J. Shop Drawings: Complete set of manufacturer's certified prints of water chiller assemblies, control panels, sections, and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.

2. Operating weight and load distribution.
3. Required clearances for maintenance and operation.
4. Size and location of piping and wiring connections.
5. Vibration Isolation Calculations and Details: Signed and sealed by a qualified professional engineer.

    a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
    b. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment.

6. Wiring Diagrams: Power, signal, and control wiring. Differentiate between factory and field installed.

K. Coordination Drawings: Floor plans drawn to scale and coordinated with the following:

1. Structural supports.
2. Piping roughing-in requirements.
3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

L. Certificates: For certification required in "Quality Assurance" Article.

M. Source quality-control test reports.

N. Startup service reports.

O. Operation and Maintenance Data: For each water chiller to include in emergency, operation, and maintenance manuals.

P. Warranties: Special warranties specified in this Section.

Q. Structural steel fabrication and installer shall be responsible for the coordination of all framed openings in roof with approved equipment manufacturers. (Openings such as, but not limited to mechanical units, exhaust fans, curb mounted equipment, roof drains, skylights, stair openings, roof hatches, duct through roof penetrations, expansion joints, etc.) Exact sizes and exact locations of openings are to be verified with the approved shop drawings issued for the installation. The exact sizes shall be coordinated prior to any fabrication and installation by any/all trades. Sizes and locations indicated on Contract Drawings are diagrammatic and for information only. Any fabrication and/or installation which has not been properly coordinated with approved equipment manufacturer and must be repaired, relocated, altered, replaced, re-installed or modified in any manner will be done to the satisfaction of the Owner with no additional cost to the Owner or design professional.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Division 23.

B. Include start-up instructions, installations checklists, maintenance data, descriptive literature, operating instructions, cleaning procedures, replacement parts list, controls and accessories.

1.7 QUALITY ASSURANCE

A. The chillers shall be pressure tested, evacuated and fully charged with HFC-410A refrigerant and oil. A factory functional test shall be performed to verify correct operation by cycling condenser fans closing compressor contacts and reading data points from temperature and pressure sensors.

B. Chiller manufacturer shall have a factory trained and supported service organization that is within a 75 mile radius of the site.

C. Qualifications: Equipment manufacturer must specialize in the manufacture of the products specified and have five years' experience with the equipment and refrigerant offered.

D. Regulatory Requirements: Comply with the codes and standards specified.

E. Chiller must be manufactured in an ISO 9001.

1.8 REGULATORY REQUIREMENTS

A. Fabricate and label refrigeration system to comply with ASHRAE 15.

B. Listing and Labeling: Provide electrically operated components specified in this Section that are listed and labeled.

1. Conform to ANSI/ARI 550/590 code for testing and rating of water chillers.
2. AHRI 370 – Sound Rating of Large Outdoor Refrigerating and Air-Conditioning Equipment.
3. ANSI/ASHRAE 15 – Safety Code for Mechanical Refrigeration
4. ANSI/ASHRAE 34 – Number Designation and Safety Classification of Refrigerants
5. ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings
6. ANSI/NFPA 70 – National Electrical Code (N.E.C.)
7. ASME Boiler and Pressure Vessel Code, Section VIII, Division 1
8. OSHA – Occupational Safety and Health Act
9. Manufactured in facility registered to ISO 9001
10. Conform to Intertek Testing Services for construction of chillers and provide ETL/cETL Listed Mark.

C. Factory Run Test: Chiller shall be pressure-tested, evacuated and fully charged with refrigerant and oil, and shall be factory operational run tested with water flowing through the vessel.

D. Chiller manufacturer shall have a factory trained and supported service organization.

1.9 DELIVERY, STORAGE, PROTECTION, AND HANDLING

A. Deliver, store, protect and handle units under provisions of Divisions 01 and 23, comply with manufacturer's instructions.

B. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

C. Protect units from physical damage by storing off site until concrete pads or platforms are in place and ready for immediate installation of units.

1.10 WARRANTY

A. Provide one year warranty on parts and labor from Date of Final Acceptance.

B. Include five-year extended compressor warranty on parts and labor from date of Final Acceptance.

1.11 MAINTENANCE SERVICE

A. List amount of funds required for a complete service and maintenance agreement on unit for five years from Date of Final Acceptance; should the agreement be accepted.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers are listed for a quality assurance level only. Although a manufacturer is listed does not constitute compliance with the specification size, weight, functionality, capacity, noise, or performance levels. It is this contractor's responsibility to assure the proposed manufacturer has complete compliance with the Contract Documents, **prior to bidding.**

1. Quantech (Basis of Design)
2. Trane
3. Daikin

2.2 CHILLER MATERIALS AND COMPONENTS

A. General: Install and commission, as shown on the schedules and plans, factory assembled, charged, and tested air cooled scroll compressor chiller(s) as specified herein. Chiller shall be designed, selected, and constructed using a refrigerant with Flammability rating of "1", as defined by ANSI/ASHRAE STANDARD 34 Number Designation and Safety Classification of Refrigerants. Chiller shall include not less than two refrigerant circuits above 50 tons (200kW), scroll compressors, direct-expansion type evaporator, air-cooled condenser, refrigerant, lubrication system, interconnecting wiring, safety and operating controls including capacity

controller, control center, motor starting components and special features as specified herin or required for safe, automatic operation.

B. Cabinet: External structural members shall be constructed of heavy guage, galvanized steel coated with baked on powder paint which, when subject to ASTM B117, 1000-hour, 5% salt spray test, yields minimum ASTM 1654 rating of "6".

C. Operating Characteristics: Provide low and high ambient temperature control options as required to ensure unit is capable of operation from 30°F to 115°F ambient temperature. [Optional: -10°F to 125°F ambient.]

D. Service Isolation valves: Discharge (ball type) isolation valves factory installed per refrigerant circuit. Includes a system high-pressure relief valve in compliance with ASHRAE15.

E. Pressure Transducers and Readeout Capability

1. Discharge Pressure Transducers: Permits unit to sense and display discharge pressure.
2. Suction Pressure Transducers: Permits unit to sense and display suction pressure.
3. High Ambient Control: Allows units to operate when the ambient temperature is above 115°F. Includes discharge pressure transducers

2.3 COMPRESSORS

A. Compressors: Shall be hermetic, scroll-type, including:

1. Compliant design for axial and radial sealing.
2. Refrigerant flow through the compressor with 100% suction cooled motor.
3. Large suction side free volume and oil sump to provide liquid handling capability.
4. Compressor crankcase heaters to provide extra liquid migration protection.
5. Annular discharge check valve and reverse vent assembly to provide low-pressure drop, silent shutdown and reverse rotation protection.
6. Initial oil charge.
7. Oil level sight glass.
8. Vibration isolator mouonts for compressors.
9. Brazed-type connections for fully hermetic refrigerant circuits.
10. Compressor Motor overloads capable of monitoring compressor motor current. Provides extra protection against compressor reverse rotation, phase-loss and phase-imbalance.

2.4 REFRIGERANT CIRCUIT COMPONENTS

A. Each refrigerant circuit shall include: a discharge service ball type isolation valve, high side pressure relief, liquid line shutoff valve with charging port, low side pressure relief device, filter-drier, solenoid valve, sight glass with moisture indicator, thermostatic expansion valves, and flexible, closed-cell foam insulated suction line and suction pressure transducer.

2.5 HEAT EXCHANGERS

A. Evaporator:

1. Evaporator shall be brazed-plate stainless steel construction capable of refrigerant working pressure of 650 psig (3103 kPa) and liquid side pressure of 150 psig (1034 kPa) [Option for 300 psig (2068 kPa) available].
2. Constructed, tested, and stamped in accordance with applicable sections of ASME pressure vessel code for minimum 450 psig (31 bar) refrigerant-side design working pressure and150 psig (1034 kPa) water-side design working pressure.
3. Exterior surfaces shall be covered with 3/4" (19mm), flexible, closed cell insulation, thermal conductivity of 0.26k ([BTU/HR-Ft² - °F]/in.) maximum.
4. Water nozzles shall be provided with grooves for field provided ANSI/AWWA C-606 mechanical couplings.
5. Evaporator shall include vent and drain fittings and thermostatically controlled heaters to protect to -20°F (-29°C) ambient in off-cycle.
6. A serviceable wye-strainer and mechanical couplings shall be provided for field installation on evaporator inlet prior to startup.

B. Air-cooled Condenser:

1. Coils: Condenser coils shall be constructed of a single material to avoid galvanic corrosion due to dissimilar metals. Coils and headers are brazed as one piece. Integral sub cooling is included. Coils shall be designed for a design working pressure of 650 PSIG (45 bar). Condenser coil shall be washable with potable water under 100 psi (7 bar) pressure.
2. Low Sound Fans: Shall be dynamically and statically balanced, direct drive, corrosion resistant glass fiber reinforced composite blades molded into a low noise, full-airfoil cross section, providing vertical air discharge and low sound. Each fan shall be provided in an individual compartment to prevent crossflow during fan cycling. Guards of heavy gauge, PVC (poly- vinylchloride) coated or galvanized steel shall be factory installed.
3. Fan Motors: High efficiency, direct drive, 6 pole, 3 phase, insulation class “F”, current protected, Totally Enclosed Air-Over (TEAO) , rigid mounted, with double sealed, permanently lubricated, ball bearings.
4. Low Sound Fans with Variable Speed Drives. All fans shall be powered by VSDs. Fans shall provide vertical air discharge from extended orifices. Fans shall be composed of corrosion resistant aluminum hub and glass-fiber-reinforced polypropylene composite blades molded into a low-noise airfoil section. Fan impeller shall be dynamically balanced for vibration-free operation. Fan guards of heavy gauge, PVC (polyvinyl chloride) coated or galvanized steel.

2.6 CONTROLS

A. General: Automatic start, stop, operating, and protection sequences across the range of scheduled conditions and transients.

B. Power/Control Enclosure: Rain and dust tight NEMA 3R powder painted steel cabinet with hinged, latched, and gasket sealed door.

C. Microprocessor Control Center:

1. Automatic control of compressor start/stop, anti-coincidence and anti-recycle timers, automatic pump down at system shutdown, condenser fans, evaporator pump, evaporator heater, unit alarm contacts, and chiller operation from -10°F to 125°F ambient. Automatic reset to normal chiller operation after power failure.
2. Software stored in non-volatile memory, with programmed setpoints retained in lithium battery backed real-time-clock (RTC) memory for minimum 5 years.
3. Forty character liquid crystal display, descriptions in English (or Spanish, French, Italian, or German), numeric data in English (or Metric) units. Sealed keypad with sections for Setpoints, Display/Print, Entry, Unit Options & clock, and On/Off Switch.
4. Programmable Setpoints (within Manufacturer limits): display language; chilled liquid temperature setpoint and range, remote reset temperature range, daily schedule/holiday for start/stop, manual override for servicing, low and high ambient cutouts, low liquid temperature cutout, low suction pressure cutout, high discharge pressure cutout, anti-recycle timer (compressor start cycle time), and anti-coincident timer (delay compressor starts).
5. Display Data: Return and leaving liquid temperatures, low leaving liquid temperature cutout setting, low ambient temperature cutout setting, outdoor air temperature, English or metric data, suction pressure cutout setting, each system suction pressure, liquid temperature reset via a 4-20milliamp or 0-10 VDC input, anti-recycle timer status for each compressor, anti-coincident system start timer condition, compressor run status, no cooling load condition, day, date and time, daily start/stop times, holiday status, automatic or manual system lead/lag control, lead system definition, compressor starts/operating hours (each), status of hot gas valves, evaporator heater and fan operation, run permissive status, number of compressors running, liquid solenoid valve status, load & unload timer status, water pump status.
6. System Safeties: Shall cause individual compressor systems to perform auto shut down; manual reset required after the third trip in 90 minutes. System Safeties include: high discharge pressure, low suction pressure, high pressure switch, and motor protector. Compressor motor protector shall protect against damage due to high input current or thermal overload of windings.
7. Unit Safeties: Shall be automatic reset and cause compressors to shut down if low ambient, low leaving chilled liquid temperature, under voltage, and flow switch operation.
8. Alarm Contacts: Low ambient, low leaving chilled liquid temperature, low voltage, low battery, and (per compressor circuit): high discharge pressure, and low suction pressure.
9. BAS Communications: BACnet MS/TP, Modbus and N2 communication capabilities are standard.

D. Manufacturer shall provide any controls not listed above, necessary for automatic chiller operation. Mechanical Contractor shall provide field control wiring necessary to interface sensors to the chiller control system.

2.7 POWER CONNECTION AND DISTRIBUTION

A. Power Panels:

1. NEMA 3R/12 rain/dust tight, powder painted steel cabinets with hinged, latched, and gasket sealed outer doors. Provide main power connection(s), control power connections, compressor and fan motor start contactors, current overloads, and factory wiring.
2. Power supply shall enter unit at a single location, be 3 phase of scheduled voltage, and connect to individual terminal blocks per compressor. Separate disconnecting means and/or external branch circuit protection (by Contractor) required per applicable local or national codes.

B. Compressor, control and fan motor power wiring shall be located in an enclosed panel or routed through liquid tight conduit.

2.8 ACCESSORIES AND OPTIONS

A. Some accessories and options supersede standard product features. Your Quantech representative will be pleased to provide assistance.

B. Microprocessor controlled, Factory installed Across-the-Line type compressor motor starters as standard.

C. Low Ambient Control: Permits unit operation to -10°F ambient. Standard unit controls to 30°F ambient.

1. High Ambient Control: Permits unit operation above 115°F ambient.

D. Power Supply Connections:

E. Control Power Transformer: Converts unit power voltage to 120-1-60 (500 VA capacity). Factory-mounting includes primary and secondary wiring between the transformer and the control panel.

F. Protective Chiller Panels (Factory or Field Mounted)

1. Louvered/Wire Panels: Louvered steel panels on external condenser coils painted as per remainder of unit cabinet. Heavy gauge, welded wire-mesh, coated to resist corrosion, around base of machine to restrict unauthorized access.

G. Hot Gas By-Pass: Permits continuous, stable operation at capacities below the minimum step of unloading to as low as 5% capacity (depending on both the unit & operating conditions) by introducing an artificial load on the evaporator. Hot gas by-pass is installed on only one refrigerant circuit.

H. Low Temperature Process Glycol: Leaving chilled liquid setpoint range 10°F to 50°F.

I. Vibration Isolation (Field installed):

1. 2” Deflection Restrained Spring Isolators: Level adjustable, restrained mounts in rugged welded steel housing with vertical and horizontal limit stops. Housings shall be designed to withstand a minimum 1.0g accelerated force in all directions to 2 inches (50.8 mm)

J. Hydronic Kit (Qty of 2 Pumps)

1. Hydronic kit shall be factory installed within the framework of the chiller, lowering additional installation costs and decreasing floor space occupied by mechanical equipment.
2. The hydronic kit shall include features such as:

    a. Factory-installed Y strainer with a drain port.
    b. Factory-installed butterfly shut off valve for servicing pumps.
    c. Factory-installed Armstrong 4392 pump with two drain ports on the lower side of the casing.
    d. ¼" NPT fitting for field provided venting device.
    e. ¼" NPT fitting for factory-installed thermal dispersion flow switch.
    f. Flow Trex Combination Valve, including shut off valve, check valve and balancing capability.

3. The unit with the hydronic kit shall have single point power, reducing installation time and cost.
4. The hydronic kit shall have remote on/off control through the chiller micropanel.
5. Hydronic kit piping and components shall be heated and insulated for freeze protection.
6. Hydronic kit shall use variable speed drive (VSD), which:

    a. Reduces commissioning time needed to balance the system.
    b. Saves energy when used in variable primary flow arrangements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before water chiller installation, examine roughing-in for concrete equipment bases, or structural supports, anchor-bolt sizes and locations, piping, and electrical to verify actual locations, sizes, and other conditions affecting water performance, maintenance, and operations.

1. Final water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install in accordance with manufacture's instructions.

B. Connect to electrical service. Refer to Division 26.

C. Connect to chilled water piping, refer to Division 23. On inlet, provide well for temperature controller, well for temperature limit controller, well for ATC, thermometer, pressure gauge, flow switch, flexible pipe connector, and shut-off valve. On outlet, provide flexible pipe

connector, thermometer, pressure gauge, well for ATC, shutoff and balancing valves. Comply with manufacturer's instructions.

D. Field install heat tape and insulation for any piping located on roof; extend to 24" below roof also. Refer to div 23 specification sections that apply.

E. Provide all appurtenances required to insure a fully operational and functional chiller(s).

F. Maintain manufacturer's recommended clearances for service and maintenance.

G. Charge water chiller with refrigerant and oil if not factory charged.

H. Install separate devices furnished by manufacturer.

3.3 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties. Comply with manufacturer's instructions.

B. Install piping adjacent to water chillers to allow service and maintenance.

C. Evaporator Connections: Follow detail on the drawings.

D. Ground water chillers according to Division 26 Section "Grounding and Bonding."

E. Connect wiring according to Division 26 Section "Wires and Cables."

F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 MANUFACTURERS' FIELD SERVICES

A. Provide factory trained representative to review and fill out manufacturer's checklists, assist the commissioning agent in commissioning of units, prepare and start systems under provisions of Division 23 – Common Work Results for HVAC.

B. Supply service of factory trained representative for a period of 2 days to supervise testing, dehydration and charging of machine, start-up, and instruction on operation and maintenance to Owner, Refer to Division – Common Work Results for HVAC.

C. Provide initial charge of refrigerant and oil.

D. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

E. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
2. Verify that pumps are installed and functional.
3. Verify that thermometers and gages are installed.
4. Operate water chiller for run-in period according to manufacturer's written instructions.
5. Check oil levels.
6. Verify proper motor rotation.
7. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
8. Verify and record performance of chilled water flow and low-temperature interlocks.
9. Verify and record performance of water chiller protection devices.
10. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

F. Prepare a written startup report that records results of tests and inspections.

G. Occupancy Adjustments: When requested within 12 months of Date of Final Acceptance, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy for this purpose.

END OF SECTION 23 64 43

SECTION 23 74 00 - PACKAGED ROOFTOP AIR CONDITIONING UNITS - 2 TO 25 TONS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Packaged Rooftop Units

B. Unit Accessories

1.2 RELATED WORK

A. Division 23 – Scope of Work

B. Division 23 – Common Work Results for HVAC

C. Division 23 – Common Motor Requirements for HVAC Equipment

D. Division 23 – Vibration Isolation

E. Division 23 – Sequence of Operation

F. Division 23 – Variable Frequency Drives

1.3 QUALITY ASSURANCE

A. Performance Ratings: Conform to AMCA 210

B. Sound Ratings: AMCA 301, Tested to AMCA 300

C. Fabrication: Conform to AMCA 99

1.4 REFERENCES

A. AMCA 99 – Standard Handbook

B. ARI670 – Fans and Blowers

C. Energy Conservation Construction Code of New York State, 2002

D. ASHRAE 90.1-1999

1.5 SUBMITTALS

A. Product Data: Include manufacturer's technical data for each model indicated, including rated capacities of selected model clearly indicated; dimensions; required clearances; location and size of field connections; shipping, installed, and operating weights; electrical nameplate data; control and power wiring diagrams; furnished specialties; accessories; and installation and startup instructions.

B. Shop Drawing: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.

1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

C. Commissioning Reports: Indicate results of startup and testing commissioning requirements. Submit copies of checklists.

D. For substitutions, submit layout and with factory service clearances indicated.

E. Noise Criteria: Submit certified noise criteria and distance measured at.

F. Warranties: Special warranties specified in this Section.

G. Submit manufacturer's installation instructions under provisions of Division 23.

H. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members to which condensing units will be attached.

I. Field quality-control test reports.

J. Structural steel fabrication and installer shall be responsible for the coordination of all framed openings in roof with approved equipment manufacturers. (Openings such as, but not limited to mechanical units, exhaust fans, curb mounted equipment, roof drains, skylights, stair openings, roof hatches, duct through roof penetrations, expansion joints, etc.) Exact sizes and exact locations of openings are to be verified with the approved shop drawings issued for the installation. The exact sizes shall be coordinated prior to any fabrication and installation by any/all trades. Sizes and locations indicated on Contract Drawings are diagrammatic and for information only. Any fabrication and/or installation which has not been properly coordinated with approved equipment manufacturer and must be repaired, relocated, altered, replaced, re-installed or modified in any manner will be done to the satisfaction of the Owner with no additional cost to the Owner or design professional.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Division 23.

B. Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.

1.7 QUALITY ASSURANCE

A. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."

B. Energy Efficiency Ratio: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

C. Listing and Labeling: Provide electrically operated components specified in this Section that are listed and labeled.

1. The rooftop unit(s) shall be certified in accordance with UL Standard 1995 and ANSI Standard Z21.47
2. The rooftop unit(s) shall be safety certified by an accredited testing laboratory and the nameplate shall carry the label of the certification agency.

1.8 DELIVERY, STORAGE, PROTECTION AND HANDLING

A. Deliver, store, protect and protect products under provisions of Division 23.

B. Protect units from physical damage by storing off site until roof mounting frames are in place, ready for immediate installation of units.

C. Deliver rooftop units as factory-assembled units with protective crating and covering as recommended by the manufacturer.

D. Coordinate delivery of units in sufficient time to allow movement into building.

E. Handle rooftop units to comply with manufacturer's written rigging and installation instructions for unloading and moving to final location.

1.9 WARRANTY

A. Provide one year warranty on parts and labor from Date of Final Acceptance.

B. Include 5 year compressor parts and labor warranty from Date of Final Acceptance.

C. Include 10 year parts and labor warranty on the gas fired heat exchanger from Date of Final Acceptance

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. AAON (Basis of Design)

B. Trane

C. Daikin

2.2 ROOFTOP UNITS

A. Manufacturers other than the Basis of Design, must submit a detailed 1/4" per foot scale layout including proposed unit locations with manufacturer's recommended clearances around each unit for accessibility, maintenance requirements, ductwork layouts including interferences with structural members clearly identified and resolved, proposed ductwork fittings and elbows and including static pressure calculations and electrical service change requirements resulting from deviations from the original design, min 10'-0" distances between intake air locations and exhaust fan outlet locations clearly identified, performance data and deviations from design clearly identified, fan curves with the operating point clearly identified and performance criteria. Any work resulting in cost increases due to the proposed substitutions shall be borne by the manufacturer proposing the units. The layouts and information shall be reviewed by the Engineer for conformance to the present intended layout and the design concept which takes into consideration the above mentioned factors.

B. Manufacturers are listed for a quality assurance level only. Although a manufacturer is listed does not constitute compliance with the specification size, weight, functionality, capacity, noise, or performance levels. It is this contractor's responsibility to assure the proposed manufacturer has complete compliance with the Contract Documents, **prior to bidding**.

C. Construction:

1. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.
2. Unit insulation shall have a minimum thermal resistance R-value of 16. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D-1929-11 for a minimum flash ignition temperature of 610°F.
3. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break. Double wall construction with a thermal break prevents moisture accumulation on the insulation, provides a cleanable interior, reduces heat transfer through the panel, and prevents exterior condensation on the panel.
4. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Cabinet leakage shall not exceed 1% of total airflow when tested at 3 times the minimum external static pressure provided in AHRI Standard 340/360. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, at a maximum 8 inches of positive or negative static pressure, to reduce air leakage. Deflection shall be measured at the midpoint of the panel height and width. Continuous sealing shall be included between panels and between access doors and openings to reduce air leakage. Piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.

5. Roof of the air tunnel shall be sloped to provide complete drainage. Cabinet shall have rain break overhangs above access doors.
6. Access to filters, dampers, cooling coils, reheat coil, energy recovery wheels, compressors, and electrical and controls components shall be through hinged access doors with quarter turn, zinc cast, lockable handles. Full length stainless steel piano hinges shall be included on the doors.
7. Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.
8. Units with cooling coils shall include double sloped 304 stainless steel drain pans.
9. Unit shall be provided with bottom discharge and bottom return air openings or end discharge and eight return air openings. Openings shall have upturned flanges of at least 1/2 inch in height around the opening.
10. Unit shall be provided with end discharge and right return air openings. Openings shall have upturned flanges of at least 1/2 inch in height around the opening.
11. Unit shall include lifting lugs on the top of the unit.

D. Electrical

1. Unit shall be provided with standard power block for connecting power to the unit.
2. Unit shall have a 10 kAIC SCCR.

    a. Unit shall be provided with factory installed and factory wired, non-fused disconnect switch.
    b. Unit shall be provided with factory installed and factory wired 115V, 12 amp GFI outlet with outlet disconnect switch in the unit control panel.
    c. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more that 10% out of balance on voltage, the voltage is more that 10% under design voltage, or on phase reversal.
    d. Unit shall be provided with manual reset low temperature limit controls that shut off the unit when the discharge temperature reaches a field adjustable setpoint. Supply air temperature sensor shall be factory provided for field installation in the supply air ductwork.
    e. Control Panel LED Service lights
    f. (3) Interior Marine Service lights

E. Controls

1. Controls by FMCS contractor, refer to Division 23.
2. Unit shall be furnished with terminal strip for interface to BMS.

F. Electrical Power Panel

1. Unit shall be provided with a factory installed and wired internal disconnect and single point power connection.
2. Unit shall be provided with phase and brown-out protection to shut down all motors in the unit if the phases are more than 10% out of balance on voltage, or the voltage is more than 10% under design voltage or on phase reversal. Provide main and coated power fusing.

3. Unit shall be provided with a factory installed and field wired 115 volt, 15 amp ground fault service receptacle.
4. Power factor correction capacitors shall be applied to the compressors only and shall achieve 95% power factor.

G. Accessories

1. Low Limit Controls – shall be factory a mounted temperature limit switch. Mounted in the unit, supply airstream to shut off unit when discharge temperature reaches setpoint. The switch is adjustable from -30ºF to 100ºF, and is manually reset by disconnecting power to the unit.
2. Phase & Brown Out Protection shall include a 3 phase power monitor that shuts down the unit if the supplied power phases are out of balance, or over/under voltage, or in case of a phase loss. It protects motors and compressors from electrical phase loss or low voltage brownout. Reset shall be automatic.
3. Smoke detector(s) shall be furnished under Division 26 and installed in the unit where indicated by the Mechanical Contractor. All wiring shall be provided under Division 26.

2.3 ROOF CURBS

A. Manufacturers

1. BRD Noise and Vibration Control as Basis of Design.
2. Reviewed equivalent

B. Materials Curb System shall consist of a Seismic/Vibration Curb with In Curb Acoustical Treatment System.

1. Base System Seismic/Vibration curbs with RSVC structural steel spring isolation curbs shall bear directly on the roof support structure and be flashed and waterproofed into the roof's membrane waterproofing system.

    a. The curb shall be capable of being re-flashed without lifting the unit.

2. Equipment manufacturers or field fabricated curbs shall not be used.
3. Curb sides and ends shall be manufactured from minimum 14 ga. G90 galvanized sheet metal (expanded metal or painted steel is not acceptable), reinforced and cross braced as required.
4. All springs shall provide a minimum of 85% vibration isolation efficiency

    a. All springs shall be adjustable for leveling.
    b. Spring assemblies shall contain restraints and snubbers to resist wind and seismic forces.

5. Spring static deflection and seismic performance criteria shall be as shown or indicated on the drawings, schedules or in the vibration control specification.
6. The curb shall accept standard 2" roof insulation supplied and installed by the roofing contractor.

7. An airtight neoprene seal shall be incorporated into the curb design to prevent air leakage or infiltration. The seal shall be affixed after spring adjustments and leveling has been completed.
8. Wood nailer and flashing shall be provided and curbs shall be manufactured to NRCA standards.
9. Curb height shall be 24" high minimum or as shown on the drawings.
10. Curbs shall be shipped pre-assembled. Knocked down kits are not acceptable.
11. All non-galvanized materials shall be prime paint finished.
12. All duct supports, bracing, flashing and safing as required.
13. Unless otherwise recommended by the RTU manufacturer, all curbs shall be full perimeter type. Curbs with condenser pedestal rails are unacceptable.

C. In-Curb Multi-Layer Acoustical Treatment

1. Component products shall be as listed:

   a. HUSHCORE™ DS-52 acoustical composite
   b. HUSH BATT™ DS-49 Deck System
   c. HUSH SEALANT™ HSAC-100 acoustical caulk

2. HUSHCORE™ DS-52 acoustical composite

   a. The composite shall meet ASTM E-84 Class "A" for flammability.
   b. The overall installed composite shall have an installed thickness of 8" for the DS-52 composite.
   c. The installation DS-52 shall have a thermal value of R-27.
   d. The composite panels shall get HUSH SEALANT™ model HSAC-100 acoustical grade caulk at seams and all perimeter edges inside the curb.
   e. Seams for each layer shall be staggered.
   f. Acoustical composite shall have 65% post-consumer recycled content.

3. HUSH SEALANT™ HSAC-100 acoustical caulk

   a. Shall be a non-hardening formulation
   b. The acoustical sealant must be applied around the entire perimeter of the curb, around duct drop penetrations of the decking, and at all seams between Hush Core composite panels.

4. Where acoustical treatment is exposed to the air stream, model DS-49 Deck System, rated at STC 49 shall be supplied. The DS-49 in-curb is rated Class A for flammability per ASTM 84.

2.4 DECKING

A. Decking shall be maintained inside the RTU roof curb to a clearance of ¼" maximum around all duct drops but never contact the duct.

1. Pack all air gaps around duct drops for return and supply with HUSH BATT and seal with HUSH SEALANT™ HSAC-100.

2.5 PERFORMANCE

A. To assure optimized aerodynamic and acoustic performance as well as proper integration and coordination of the final installation, the Curb System shall be supplied by the rooftop unit manufacturer as part of a turnkey package.

B. HUSHCORE™ In-Curb Acoustic Treatment Acoustical Performance

1. The combination of all layers shall be tested for Sound Transmission Loss in accordance with procedure ASTM E-90-10. The assembly shall be rated at not less than STC-52 with 1/3 octave performance values as listed below for sound radiation through the deck inside the curb.

Freq. (Hz)	80	100	125	160	200	250	315	400	500	630	800	1K
TL (dB)	26	27	33	32	35	42	45	45	50	56	59	60
Freq. (Hz)	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000	STC	
TL (dB)	62	63	64	65	67	71	74	78	80	80	52	

2.6 ADAPTOR CURB

A. Adapter Curb

1. Provide all labor, materials and equipment in connection with the complete installation of the Adapter Curb. Curb shall be designed to transition seamlessly from your existing roof curb to new equipment without penetrating the roof membrane.
2. All adapters are fully insulated with customized internal dividers that allow for smooth airflow transition for supply and return airstreams.
3. Custom Prefabricated roof curb to be manufactured of prime galvanized steel construction, 14-gauge, meeting ASTM A653/653M, with welded corners and with seams joined by continuous water and airtight welds. Roof curb shall be internally reinforced with angles 48" on center and factory installed wood nailer. Top of all roof curbs shall be level, with pitch built into curb when deck slopes
4. Each curb is specifically engineered for proper load distribution of the unit to be installed. See Specification 23 05 46 for Vibration Isolation requirements.
5. Prefabricated isolation rail to be manufactured of prime galvanized steel, meeting ASTM A653/653M, with welded corners. Isolation rail shall be designed to connect unit openings to existing curb openings via the use of pre-installed duct transitions. Unit shall have adjustable spring isolators with non-conductive material minimizing sound transitions and designed to provide a minimum of 90% isolation efficiency with 2” deflection springs. A removable EPDM weather shield shall allow access to the isolators.

6. Adapter Curbs shall be constructed using minimum 14-gauge galvanized steel with fully welded corners, 2", R-12 curb liner insulation on inside of curb. Provide 18-gauge internal curb liner.
7. Transition Ducts to contain 1" internal duct liner on air impacted surfaces, and 18-gauge galvanized steel turning vanes as per SMACNA requirements.
8. Minimum curb height: 14" above existing roof curb.
9. Curb shall be custom fabricated to transition from new unit supply and return air openings to existing curb openings while accommodating the site-specific conditions. Manufacturer's representative to field verify site conditions.
10. Adapter Curbs shall be installed in strict accordance with manufacturers printed instructions and as detailed on drawings.
11. Size of Curbs and required options shall be coordinated by support manufacturer with general contractor and mechanical contractor prior to fabrication.
12. Adapter Curbs shall be guaranteed against defects in material and/or workmanship for a period of one (1) year.
13. Adaptor Curb shall be by Thy Curb, AES, SMS Specialists or Reviewed Equivalent.

PART 3 - EXECUTION

3.1 GENERAL

A. Installation of rooftop units shall be the responsibility of the Mechanical Contractor. Follow the manufacturer's written installation instructions.

B. Any rigging devices (cranes, scaffolds) required shall be provided by the installing (Mechanical) Contractor.

3.2 EXAMINATION

A. Verify that roof is ready to receive work and opening dimensions are as illustrated by the manufacturer.

B. Verify that proper power supply is available.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Provide sheave and belt change-outs as required for final system balance requirements.

C. Set two alternating layers of 5/8" thick cementious board and 2" thick mineral wool under entire unit. See Division 23 Ductwork Insulation for specification of acoustical insulation within roofcurb. Installation of cementious board/acoustical insulation shall be performed prior to setting of units on curbs and must be witnessed by the Architect/Engineer.

D. Ductwork penetrations through the roof shall be sealed with acoustical fill and acoustical grade caulk in order to eliminate gaps and resulting noise paths.

E. Provide flexible connections on ductwork systems connected to each rooftop unit.

F. Check belt alignment and adjust as required.

G. Check belt tension and adjust as required.

H. Set units on roofcurbs. Turn over roofcurbs to the General Contractor for installation and roofing/flashing.

I. Check unit safeties and interlocks with fire alarm system.

J. Check unit operation for compliance with the sequence of operation.

K. Install clean filters upon Final Acceptance of Project.

3.4 MANUFACTURERS' FIELD SERVICES

A. Provide for initial start-up and shutdown during first year of operation, including routine servicing and check-out.

B. Provide programming of the unit for optimum start/stop, morning cool-down cycle, morning warm-up cycle, timed override, date (daily, weekly, monthly, holiday, etc) occupied and unoccupied periods as well as all programming required for the sequence of operation.

3.5 TESTING

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate and maintain rooftop units.

1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing and maintaining equipment and schedules.

2. Review data in maintenance manuals. Refer to Division 01 and Division 23.

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

END OF SECTION 23 74 00

SECTION 23 82 00 - HYDRONIC TERMINAL HEATING UNITS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Cabinet heaters

B. Finned tube radiation

C. Reheat coils

1.2 RELATED WORK

A. Section 23 05 00 – Common Work Results for HVAC

B. Section 23 05 46 - Vibration Isolation

C. Division 26 – Electrical

1.3 REFERENCES

A. ASTM - American Society for Testing and Materials

B. ANSI - American National Standards Institute

C. ARI - Air Conditioning and Refrigeration Institute

D. IBR – Hydronic Institute of Boiler and Radiator Manufactures

E. NFPA - National fire Protection Association

F. UL - Underwriters Laboratories Inc.

1.4 SUBMITTALS

A. Submit shop drawings, product data, operational and maintenance data under provisions of Section 23 05 00, Common Work Results for HVAC.

B. Include cabinet style, cross section, grilles, bracing and reinforcing, coil connection locations and weights.

C. Include schedules of equipment and enclosures indicating length and number of elements and enclosure pieces, corners, end caps, cap strips, access doors, pilaster covers, gaskets, comparison chart of specified heat output to actual heat output provided and electrical requirements.

D. Submit certification to references listed herein.

E. Submit full range color charts.

F. Submit power, signal and control wiring diagrams.

G. Submit field quality control test reports.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 DELIVERY, STORAGE, PROTECTION AND HANDLING

A. Deliver, store, protect and handle products under provisions of Section 23 05 00, Common Work Results for HVAC and per manufacturer's written instructions.

B. Protect units from damage by storing in protected areas and leaving in shipping boxes until ready for installation.

1.7 SEQUENCING AND SCHEDULING

A. Sequence and schedule work under provisions of Section 23 05 00, Common Work Results for HVAC.

B. Install units (exposed to finished areas) after walls and ceilings are finished and painted. Avoid damage to completed building surfaces.

PART 2 - PRODUCTS

2.1 CABINET HEATERS

A. Enclosure - Horizontal, vertical, recessed or concealed enclosure type as scheduled, min. 18 ga steel, factory cleaned, bonderized, phosphatized and finished in 2 coats baked enamel (custom color selected by Architect/Engineer). Internally insulate front panels and secure panel to cabinet with cam-lock fasteners. Provide front and rear duct flanges for concealed units.

B. Coils - ASTM B88 seamless copper tubing, 5/8" OD, .025" wall thickness, mechanically expanded into aluminum plate fins, silver brazed to steel headers, where applicable, sweat or threaded connections, ARI certified performance, factory leak tested to 250 psig air tube pressure (under water) to no leakage.

C. Fan - Direct driven, DWDI, centrifugal type, statically and dynamically balanced.

D. Fan motor - Shaded pole 3 speed type with thermal overload protection, NEMA frame, provided with permanently lubricated sleeve bearings, resiliently mounted in cabinet and quick-detach locking prong power chord.

E. Filter - 1" thick woven glass, throwaway. Provide spare filter for each unit.

F. Fan cycling control - Factory wired, mounted and tested assembly consisting of DPDT thermostat, solenoid valve, manual motor starter and Off/Auto/High/Med/Low speed selector switch. Locate components inside cabinet casing. Unit fan shall operate when hot water flows thru the coil and when thermostat is calling for heat.

G. Piping package - Factory furnished and field piped assembly consisting of one 2-port electric solenoid control valve, ball valve on supply line, manual circuit balance valve (y-pattern globe type) on return line and unions on coil connections. Use piping hookup packages.

H. Nameplate - Factory provided for each unit and shall include model number, serial number, performance data, electrical data and unit tag number.

Manufacturer
Rittling
Sterling
Trane

2.2 HYDRONIC FINNED TUBE RADIATION

A. Enclosure - Min. 18 ga steel, factory cleaned, bonderized, phosphatized and finished in baked enamel (custom color selected by Architect/Engineer). All enclosures shall be hinged mounted which permit removal and fastened to min. 14 ga enclosure brackets on maximum 4'-0" centers. Provide enclosures as indicated on the drawing. Provide end caps, corner pieces, enclosure extensions, back panels, gaskets, pedestals and other accessories required for a complete installation.

B. Element - ASTM B88 seamless copper tubing, mechanically expanded into aluminum plate fins, sweat or threaded connections, IBR certified performance. For differences in heat output between manufacturers, provide the same length element as Basis of Design scheduled.

Manufacturer
Rittling
Sterling
Trane

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, plenums, casings and walls to receive units for compliance with requirements for installation tolerances and other conditions affecting coil performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.

C. Examine roughing-in for piping and electrical connections to verify actual locations before unit installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install per the manufacturer's instructions. Install plumb and level.

B. Suspend units (with fans) from structure and on vibration isolators per Section 23 05 46. Maintain headroom clearances.

C. Pipe coils per details on the drawings.

D. Locate wall mounted radiation as indicated on the plans and run with continuous enclosure unless otherwise indicated. Center elements under windows. Provide back plate gaskets and install to insure dirt-streak free operation.

E. Field coordinate wall and ceiling opening requirements for recessed mountings with General Contractor.

F. Protect units from construction dusts and damage with covers and/or plastic sheeting.

G. Comb coils.

H. Install gasket behind fan tube radiation.

3.3 CLEANING

A. Clean exposed surfaces of all units. Vacuum coils and inside of cabinets. Touch-up enclosures scratched or marred with manufacturer's paint. Replace enclosures damaged during construction.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings and specialties.

B. Install piping adjacent to coils to allow service and maintenance.

C. Ground equipment according to Division 26 Section "Grounding and Bonding".

D. Connect wiring according to Division 26 Section "Conductors and Cables."

E. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, operate units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 23 82 00

SECTION 23 82 19 - FAN COIL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes fan-coil units and accessories.

1.3 DEFINITIONS

A. BAS: Building Automation System.

1.4 SUBMITTALS

A. Product Data: Include manufacturer's technical data for each model indicated, including rated capacities of selected model clearly indicated; dimensions; required clearances; location and size of field connections; shipping, installed, and operating weights; electrical nameplate data; control and power wiring diagrams; furnished specialties; accessories; and installation and startup instructions.

B. Shop Drawing: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.

1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

C. Commissioning Reports: Indicate results of startup and testing commissioning requirements. Submit copies of checklists.

D. For substitutions, submit layout and with factory service clearances indicated.

E. Noise Criteria: Submit certified noise criteria and distance measured at. Include sound attenuators with submittal and calculation to ensure design intent of room sound levels are met satisfactorily.

F. Submit full range color charts. Architect to select custom color as required.

G. Warranties: Special warranties specified in this Section.

H. Submit manufacturer's installation instructions under provisions of Division 23.

I. Field quality-control test reports.

J. Operation and Maintenance Data: For fan-coil units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

K. Warranty: Special warranty specified in this Section.

L. Local/Regional Materials:

1. Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
2. Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 DELIVERY, STORAGE, PROTECTION AND HANDLING

A. Deliver, store, protect and handle products under provisions of Division 23.

B. Protect units from physical damage by storing off site until roof mounting frames are in place, ready for immediate installation of units.

C. Deliver rooftop units as factory-assembled units with protective crating and covering as recommended by the manufacturer.

D. Coordinate delivery of units in sufficient time to allow movement into building.

E. Handle rooftop units to comply with manufacturer's written rigging and installation instructions for unloading and moving to final location.

1.7 COORDINATION

A. Coordinate layout and installation of fan-coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

1.8 WARRANTY

A. Provide one (1) year parts and labor from Date of Final Acceptance.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Furnish one (1) spare filters for each filter installed to be installed upon Final Acceptance of project.
2. Furnish one (1) spare fan belt for each unit installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers – Fan Coil Units

1. International Environmental Corporation (Basis of Design)
2. Trane
3. Daikin

2.2 CONFIGURATION

A. General:

1. Factory assembled Horizontal fan coil units complete with coil, fan, motor, drain pan, and all required wiring, piping and controls.
2. Cabinet shall be made of 18 heavy gauge galvanized steel.
3. The interior surfaces shall be lined with 1/2 standard fiberglass insulation. Insulation and adhesive shall meet NFPA-90A requirements for flame spread and smoke generation.
4. Adhesive shall be certified according to the GREENGUARD Indoor Air Quality (IAQ) Certification for Low Emitting Products. Reference Standard: GGPS.001 GREENGUARD IAQ Standard for Building Materials, Finishes, and Furnishings. Reference Standard: GGPS.002 GREENGUARD Children & Schools Standard.
5. Units shall have a stainless-steel drain pan extending the entire width of the coil. Drain pan shall comply with ASHRAE 62.1.
6. Stainless steel pans shall be externally coated with 2-part closed cell foam insulation

B. CXB Horizontal Cabinet Units:

1. The unit shall have a stamped discharge grille.
2. Units shall have removable bottom access panel with stamped return air grille and filter rack.

3. Units shall be equipped with a non-woven synthetic throwaway filter.
4. Cabinet shall be painted with a Bright White powder-coat finish.
5. Bottom panel shall be interlocking with cabinet and fastened with tamper proof quarter-turn fasteners.

2.3 CERTIFICATION

A. Safety Agency:

1. Units shall be listed by ETL indicating the units comply with the minimum requirements of the U.S. and Canadian national product safety standard, ANSI/UL Standard 60335-2-40, and with CSA C22.2 No. 236.

B. Capacities:

1. Fan coils shall be certified and listed in accordance with AHRI Standard 440.

2.4 MATERIALS

A. Coils:

1. All coils shall have 1/2" copper tubes, manual air vent(s), and aluminum fins, galvanized end sheets, 10 fins per inch spacing. Coil fins shall be mechanically bonded to copper tubes. SureFlow coils shall be designed for use with a circulator matched for SureFlow applications.
2. Copper tubes must comply with ASTM B-75
3. Fin thickness shall be 0.0045.
4. Tube thickness shall be 0.016.
5. Coil rows shall be as indicated on the drawings.

B. Valves:

1. No valve package furnished.
2. Valve package shall be equipped with specialty devices as indicated on the drawings.

    a. Coil Connections - standard factory arrangement
    b. Flow Controls

        1) Primary - Not supplied
        2) Secondary - Not supplied

    c. Hoses - Not supplied
    d. Service Fittings

        1) Primary - Not supplied
        2) Secondary - Not supplied

e. Strainer

1) Primary - Not supplied
2) Secondary - Not supplied

f. Balance Valve

1) Primary - Not supplied
2) Secondary - Not supplied

g. Combination Valves

1) Primary - not supplied
2) Secondary - not supplied

C. Fans:

1. Fans shall be direct-drive, double-width fan wheels with forward-curved blades.
2. Blower wheels shall be statically and dynamically balanced.
3. Scrolls and fan wheels shall be constructed of galvanized steel.
4. Shall be easily removable.

D. Motors:

1. Motors shall be 3-speed, single phase, 60 Hz constant-torque ECM motors with means for potentiometer field adjustment of each speed, for 115 volts, permanently lubricated ball bearings.
2. Motors shall be connected with quick connect electrical plugs.
3. Motors shall have internal thermal overload protection with automatic reset.

E. Controls:

1. Controls Voltage:

a. Units shall be equipped with 24V controls.

2. Control Package shall be equipped with specialty devices listed below:

a. No Condensate overflow switch supplied.
b. Thermostat control by others

F. Operating Characteristics:

1. A 4-pipe system shall be capable of providing heating and cooling on demand.

G. Electrical Requirements:

1. Standard unit shall operate on 115 volts, single phase, 60 Hz electrical power, and all exposed wiring shall be in flexible conduit.

H. Options and Accessories:

1. Units not equipped with electric heat
2. No Service Switch supplied.
3. No bipolar ionizer supplied.
4. Risers

a. Riser diameter shall be specified on equipment drawings.
b. Riser insulation thickness shall be specified on equipment drawings
c. Drain riser shall be minimum 1in. diameter Type M copper.
d. f. Riser extensions shall be specified on equipment drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive fan-coil and blower coil units for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan-coil-unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, OPERATION, AND MAINTENANCE

A. Installation, Operation and Maintenance manual shall be supplied with the unit.

B. Installing contractor shall install unit, including field installed components, in accordance with Installation, Operation, and Maintenance manual instructions.

C. Start up and Maintenance requirements shall be complied with to ensure safe and correct operation of the unit.

D. Install fan-coil units level and plumb.

E. Install fan-coil units to comply with NFPA 90A.

F. Suspend fan-coil units from structure with elastomeric hangers. Vibration isolators are specified in Division 23.

G. Verify mounting height in first paragraph below with authorities having jurisdiction to comply with requirements of the Americans with Disabilities Act.

H. Verify locations of thermostats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above finished floor, level with light switches.

I. Install new filters in each fan-coil unit within two weeks after Final Acceptance of project.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.
2. Connect piping to fan-coil-unit and blower coil unit with hydronic piping package. Refer to Div. 23 Hydronic Accessories and follow details on drawings.
3. Connect condensate drain to insulated indirect waste.

    a. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.
    b. Connect to condensate pump where indicated.

B. Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Division 23 Section "Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

C. Install secondary pan below entire unit and with moisture sensor within pan tied into unit controller to shut down unit and alarm DDC upon sensing of moisture.

D. Ground equipment according to Division 26 Section "Grounding and Bonding."

E. Connect wiring according to Division 26 Section "Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Occupancy Adjustments: When requested within 12 months of date of Final Acceptance, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to one (1) visit to Project during other than normal occupancy hours for this purpose.

END OF SECTION 23 82 19

SECTION 23 82 23 - UNIT VENTILATORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Unit ventilators and appurtenances.

1.2 RELATED SECTIONS

A. Division 23 - Scope of Work

B. Division 23 - Hydronic Piping

C. Division 23 - Hydronic Specialties

D. Division 23 – Direct Digital Control

E. Division 26 - Equipment Wiring Systems: Electrical supply to units.

1.3 REFERENCES

A. ANSI/NFPA 70 - National Electrical Code.

B. NFPA 90 A & B - Installation of Air Conditioning and Ventilation Systems and Installation of Warm Air Heating and Air Conditioning Systems.

C. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

D. ARI 350 - Standard for Sound Rating of Non-Ducted Indoor Air-Conditioning Equipment.

E. ANSI S1.32 - Precision methods for the determination of sound power levels of discrete-frequency and narrow-band noise sources in reverberation rooms.

F. ARI 840 – Unit ventilators.

G. ASHRAE 79 - Methods of testing for Room Fan-Coil Air-Conditioners.

H. UL 181 - Factory-Made Air Ducts and Connectors

1.4 SUBMITTALS

A. Submit shop drawings and product data sheets indicating cross section of cabinets, general assembly, and materials used in fabrication.

B. Submit product data indicating typical catalog of information including arrangements.

C. Indicate mechanical and electrical service locations and requirements, specifically indicating deviations from indicated products.

D. Submit manufacturer's installation instructions.

E. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components and location and size of each field connection.

1. Plans, elevations, sections, and details.
2. Details of anchorages and attachments to structure and to supported equipment.
3. Wiring Diagrams: Power, signal, and control wiring and power requirements.
4. Capacities and performance data.
5. Sound power data.

F. Samples for Initial Selection: Submit metal sample consistent with the gauge for the unit ventilator cabinet with the factory-applied color for approval.

1.5 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include manufacturer's descriptive literature, operating instructions, installation instructions, and maintenance and repair data.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum five (5) years documented experience.

1.7 REGULATORY REQUIREMENTS

A. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

1.8 SEQUENCING AND SCHEDULING

A. Sequence work

B. Schedule work under the provisions of Division 01.

C. Install vertical console type unit ventilators after walls and ceiling are finished and painted. Avoid damage.

1.9 HANDLING

A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

B. Protect units on site from damage. Leave factory shipping covers in place until installation.

1.10 WARRANTY

A. One-year Parts and Labor warranty from date of final acceptance.

1.11 COORDINATION

A. Coordinate layout and installation of unit ventilators and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate size and location of wall sleeves for outdoor-air intake and relief dampers and condenser sections.

1.12 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Unit Ventilator Filters: Furnish one spare filter for each filter installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS - UNIT VENTILATORS

A. General

1. Units shall be ARI certified or tested by an independent testing and balancing lab witnessed by owner's representative. Non-ARI manufacturers must be within 10 percent

of catalog airflow and capacities, or removal of these units from the jobsite will result at the expense of the manufacturer or contractor.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

Manufacturers are listed for a quality assurance level only. Although a manufacturer is listed does not constitute compliance with the specification size, weight, functionality, capacity, noise, or performance levels. It is this contractor's responsibility to assure the proposed manufacturer has complete compliance with the Contract Documents, **prior to bidding.**

1. Magicair (Basis of Design)
2. Daikin

2.2 UNIT VENTILATORS

A. The unit shall be a factory-assembled bolt-together unit ventilator. Contained within the unit enclosure shall be factory-installed motor, wiring, blowers, coil(s), bearing, outdoor/return air damper, optional face/bypass damper and optional controls. Unit shall have a draw-thru design for uniform air distribution across the coil and even discharge temperatures.

2.3 CONSTRUCTION AND COMPONENTS

A. Construction:

1. Unit frame shall be constructed of 14-gauge galvanized steel components that form a rigid foundation and resist corrosion.
2. Unit composed of three main sub-assembled modules: Blower Module, Coil Module and Damper Module. Modules shall be removable without disassembling the unit.
3. Modules shall be externally insulated using at least 3/8” closed cell insulation.
4. Unit back shall be insulated using at least 3/8” closed cell insulation.
5. Exterior access panels shall be constructed of heavy gauge galvanized steel of at least 16 gauge material that have been cleaned and pretreated before painting to maximize corrosion resistance. Exterior service access panels shall be retained by tamper-resistant fasteners. Panels are electrostatically coated with polyester powder baked on textured paint.

B. MAUV (Vertical unit):

1. Unit standard depth of 16 5/8 in. (21 7/8 in. depth optional), 30-in. tall cabinet with three standard 16-gauge exposed front panels, and service access panels with tamper-resistant hex socket head threaded fasteners and retainer chains for safety and ease of service. 14-gauge panels are optional.
2. Cabinet models shall have standard textured baked powder finished panels. Cabinet tops shall be at least 16-gauge and charcoal bronze as standard with a steel bar-stock discharge grille. Optional Mesh Screen shall be available with spacing no more than .25” in order to prevent objects from entering unit (pencil proof). Optional textured baked power paint

colors to match panels will be available for cabinet top. Unit top shall be easily removed for routine maintenance.

3. External access panels shall be easily removed from outside of the unit for easy access to filters and routine maintenance. End panel corners shall be welded and ground smooth for appearance and durability.
4. Unit shall include a leveling leg on each side of the bottom kick plate to compensate for floor irregularities.

C. Components:

1. Coils:

   a. Chilled water and combination chilled/hot water coils shall be constructed of mechanically expanded copper tubing, minimum wall 0.0 16 in. inside, aluminum fins, with a minimum thickness of 0.025 in. The fin surface shall be enhanced to the maximum degree by incorporated a raised lance design.
   b. Hot water coils shall be constructed of mechanically expanded copper tubing with a minimum wall of 0.016 in., inside aluminum fins shall have a minimum thickness of 0.045 in. Coils shall have a factory-mounted low limit (freezestat) device mounted on the leaving side of the heating coil. The device shall be single-pole, double-throw and shall activate at 38 F if the capillary device senses a temperature change along any 6 in. of the device.
   c. Direct expansion (DX) coils shall be furnished with a thermal expansion valve (TXV) sized to accommodate the condensing unit selected to meet the load.
   d. Steam coils shall be the freeze resistant double tube, distribution type utilizing a tube-in-tube design with a long-life copper header. Non-distributing type coils are not acceptable. Ferrous materials in the header are also not acceptable.
   e. All coils shall be pressure tested at no less than 350 psig at the factory to ensure that they are leak tight.
   f. Electric heat elements shall be the open wire type. They shall be mounted in individual heavy gauge galvanized steel frames and suspended in ceramic insulators.
   g. Dual capillary type thermal sensing elements, one automatic reset and one manual reset, shall be employed to protect the unit from overheating in the event of abnormal operation.
   h. Each circuit above 48 amps shall be protected by its own fuses rated for the duty and voltage to which they are applied
   i. The unit must be constructed such that troubleshooting or adjustment of the controls can be done while the unit is operating normally.

2. Pipe Tunnel: Rated 500 to 1500 CFM vertical units and rated 750 to 1500 CFM horizontal units shall have an integral pipe tunnel that can be used for piping across the unit. This tunnel shall be insulated, with 3/8” closed cell insulation, from the unit and accessible from each end compartments to allow maximum flexibility of crossover piping installation.

3. Drain Pans:

   a. Unit drain pan shall be double sloped welded galvanized steel or stainless steel to prevent standing water.
   b. Drain pan will be coated to prevent external condensation during cooling.
   c. Drain connections shall be supplied on both ends of pan for field conversion of slope and drain hand connection if required.
   d. Drain pan slope shall be field convertible without removing the coil module.
   e. Heating only units shall come equipped with a double sloped drain pan for future cooling needs.
   f. Horizontal units shall have drain pan connection centerline located 4.5 in. above the bottom to provide easy piping to condensate disposal system.

4. Fans and Motor:

   a. Fan and motor assembly shall be direct driven. One end of drive shaft shall be mounted in a sleeve-type or ball bearing, with other end of shaft supported by motor bearings.
   b. Fan wheels shall be double-width, double-inlet with forward-curved blades, and shall operate at low speed. Fan wheels shall be large diameter (at least 8") for low speed, quiet operation and shall be constructed of high impact mineral filled polymer material (500-1500 CFM) Fan wheels shall be mounted on a hollow one-piece steel shaft.
   c. Fan wheels shall be statically and dynamically balanced.
   d. Fan (blower) housings shall be constructed from heavy-gauge steel and mounted to a heavy-gauge galvanized steel fan deck.
   e. To prevent vibration transmission to the unit frame, motor and shaft bearing shall be resiliently mounted. The drive shaft shall be connected to motor with a flexible coupling.
   f. Fan motors shall be mounted outside of the airstream on a heavy-gauge steel partition and removable without removing the blower module.
   g. Standard shall be supplied with permanently split capacitor (PSC) multi-tap
   h. transformer motors. Units that are used in high-static applications or that require higher efficiency shall be supplied with 3-speed, 120, 240 or 277 volt, single-phase, 60 Hz, electronically commutated motors (ECM). Units without controls shall be supplied with permanently split capacitor (PSC) multi-tap transformer motors. All motors shall have integral high temperature reset and shall be protected with cartridge-type fuse(s).

5. Filters:

   a. Unit shall be supplied with a one piece 1-in. throwaway filter. The unit shall be capable of incorporating a 2 in. filter. For even loading, filter shall be positioned to filter mixed outdoor and return air.
   b. Filter track shall be field adjustable to accept 1-in. or 2-in. permanent or renewable media replacement filters.
   c. (UPDATE WITH PERM / REN. INFO AS OPTIONAL.)

6. Dampers:

   a. Unit shall contain a single outdoor-air/return-air damper with a continuous seal the length of the damper. The Damper shall be constructed of extruded alumi- num that has an integral curved web to afford maximum rigidity. External closed cell insulation shall be applied. The damper assembly shall include an anti- draft plate to prohibit outdoor air from penetrating the classrooms through the damper assembly.
   b. A single face and bypass damper with a continuous seal the length of the damper constructed of extruded aluminum shall be available.

7. Controls and Safeties:

   a. The manufacturer shall furnish, install, wire and factory test a complete DDC ready control package suitable for the unit type(s) selected. The DDC ready control package shall be capable of receiving a customer supplied controller for field installation. The DDC ready package shall have the transformer, terminal strip, low limit thermostat, fan start/stop relay and appropriate outside air and/or face and bypass actuator to assist in unit control and ensure complete and safe operation of the unit.
   b. The minimum position of the outdoor-air/ return-air actuator shall be adjustable by the installing contractor and/or the owner/ operator.
   c. The unit shall be shipped from the factory with an ETL listing.

8. Special Features:

   a. Cabinet full adapter back shall be available with an open space behind the back of cabinet for piping and electrical conduits. Cabinet will be properly gusseted to support the top of unit over the false back area.
   b. Valve package options shall include all valves required for both 2-way and 3- way cooling and heating applications. Valve package options shall include wye strainers, flow setters, P/T (pressure/temperature) ports, ball valve and unions. The valve package shall include all valves required to match to the ASHRAE II control cycle.
   c. Optional End panels with cutouts to match adapter backs or custom needs. End panels shall be available in 1 in. standard sizes with 2”-4” sizes available.
   d. Sub bases shall be available as an option for vertical units in sizes 2” to 12”.
   e. Utility Cabinets shall be available to install alongside of the vertical units. The cabinets will be available for in 16 5/8” and 21 7/8” depths and 12”, 18”, and 24” widths. The cabinets shall be available with colors to match unit cabinet and top.
   f. A dual mount Wall Stat shall be provided with units containing factory supplied DDC Controls and be capable of wall mounting.
   g. Units shall be capable of accepting a field installed CO2 sensor with the factory installed IAQ DDC Control packages.
   h. Outdoor Air Louvers shall be available in vertical and horizontal blade styles. Options shall include with and without decorative lattice.
   i. Trim flanges shall be available for horizontal units.
   j. Touch-up paint shall be available to match cabinet color.

k. Architectural accessories shall be available to install together with vertical units. Cabinets in standard sizes 2’ to 5’ available with custom options.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are ready to receive work and opening dimensions are as indicated on shop drawings.

B. Verify that required utilities are available, in proper location, and ready for use.

C. Beginning of installation means installer accepts existing surfaces. Proceed with installation only after unsatisfactory conditions have been corrected.

D. Examine roughing-in for piping and electrical connections to verify actual locations before unit ventilator installation.

E. Coordinate wall opening sizes with applicable trades. Provide lintels.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install as indicated. Coordinate to assure correct recess size for recessed units. Install unit ventilators to comply with NFPA 90A.

C. Locate unit ventilators as indicated, level and shim units, and anchor to structure. Coordinate exact location of wall louvers. Install shelving and auxiliary cabinetry. Provide wall trim pieces for continuous wall-to-wall installation.

D. Protect units with protective covers during balance of construction.

E. Provide hydronic units to include shut-off valve on supply and lockshield balancing valve on return piping. If not easily accessible, extend vent to exterior surface of cabinet for easy servicing. Follow details as indicated on the drawings for all valves and specialties.

F. Furnish copy of manufacturer's wiring diagram submittal. Verify that electrical wiring installation is in accordance with manufacturer's submittals and installation requirements of Division 26 sections.

3.3 CLEANING

A. Clean work.

B. After construction is completed, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.

C. Touch-up marred or scratched surfaces of factory-finished cabinets, using finish materials available from manufacturer.

D. Install new filters upon project final acceptance.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to units to allow service and maintenance.
2. Provide piping unions at all supply and return connections at the unit ventilator installation.
3. Connect condensate drain as indirect waste.

B. Ground equipment according to Division 26 – "Grounding and Bonding."

C. Connect wiring according to Division 26 – "Conductors and Cables."

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect and adjust field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices replace damaged and malfunctioning controls and equipment.
4. Record temperatures entering and leaving energy recovery wheel when outdoor-air temperature is a minimum of 15 deg F higher, or 20 deg F lower, than room temperature.

C. Remove and replace malfunctioning units and retest as specified above until acceptance is granted.

3.6 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Occupancy Adjustment: When requested within 12 months of date of Final Acceptance, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

3.7 DEMONSTRATION

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

END OF SECTION 23 82 23

SECTION 23 84 19 - INDOOR POOL DEHUMIDIFIER AND CONDENSER

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Mechanical dehumidification units and supporting equipment such as remote air-cooled condensers.

1.2 RELATED SECTIONS

A. Section 23 05 00 – Common Work Results for HVAC

B. Section 23 08 00 – Commissioning of HVAC

C. Section 23 23 00 – Refrigerant Piping

D. Section 26 05 00 - Common Work Results for Electrical

1.3 ALTERNATIVES

A. If an alternate piece of equipment is being submitted it must be verified to meet the criteria as indicated on the equipment schedule and include the Moisture Removal Capacity at the occupied and unoccupied design conditions, as well as the exhaust air energy recovery capacity and performance.

B. Any alternatives must be approved by the engineer of record at least two weeks prior to the bid date for the equipment.

C. The substituted equipment must require the same electrical service as specified. If greater, the mechanical contractor must pay all additional costs for the engineer of record to verify and approve of any increased service to the building and substituted equipment service.

D. All additional associated costs to other contractors must be part of the alternate proposal.

1.4 REFERENCES

A. Abbreviations and Acronyms

1. Moisture Removal Capacity (MRC). The amount of condensate produced by the unit which includes the effects of evaporator coil, wrap-around coils, reheat coils, circulating fans and other components in the air stream; excluding supplementary heating, cooling or outdoor air. Expressed in pounds of moisture removed per hour as defined in AHRI Standard 910 and applied to units larger than indicated in the standard.

2. Moisture Removal Efficiency (MRE). A ratio of the MRC in pounds of moisture per hour to the power input values in kW at any given set of Rating Conditions expressed pounds of moisture/kWh as defined in AHRI Standard 910 and applied to units larger than indicated in the standard.

B. Definitions

1. Heat Pipe: A heat pipe is a heat-transfer device that employs phase transition to transfer heat between two solid interfaces in order to enhance moisture removal efficiency. At the hot interface of a heat pipe, a volatile liquid in contact with a thermally conductive solid surface turns into a vapor by absorbing heat from that surface. The vapor then travels along the heat pipe to the cold interface and condenses back into a liquid, releasing the latent heat. The liquid then returns to the hot interface through either capillary action, centrifugal force, or gravity and the cycle repeats.
2. Hot Gas Reheat: The high temperature refrigerant gas from the compressor discharge is used to heat the dehumidified supply air coming from the evaporator coil. It raises the temperature of the dehumidified supply air to a temperature that is appropriate for the conditioned zone.
3. Exhaust Air Energy Recovery: is an energy recovery ventilation system which works between the exhaust air and another medium like refrigerant or water. Heat recovery is a method which is used to reduce the heating requirements ventilation air or the heating of water for a pool.
4. Source Capture or Low Source Capture: A methodology to remove the byproducts of the disinfection process that results from chlorination of a pool. It is important to remove these byproducts from the building as they are hazardous to human health.
5. EC: Electronically commutated fans or motors are brushless, permanent-magnet motors that incorporate a built-in power inverter to convert AC to DC voltage.
6. AC: An alternating current fan or motor that uses electromagnetic induction.

C. Reference Standards

1. ASHRAE 90.1 – 2019
2. AHRI 910: Performance Rating Indoor Pool Dehumidifiers (As a method of calculating MRC and MRE)
3. ANSI/UL 1995, Standard for Heating and Cooling Equipment
4. CSA B52, Mechanical Refrigeration Code
5. CSA C22.1, Canadian Electrical Code
6. NFPA 90A, Installation of Air Conditioning and Ventilating Systems
7. Air Movement and Control Association (AMCA) Publication 511-13
8. NEMA MG1 Motors and Generators
9. ASTM B117 / DIN 53167 Salt Spray
10. ASTM A653/A653M (2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
11. ANSI Z83.8-2006, CSA 2.6-2006 Gas Unit Heaters and Gas-Fired Duct Furnaces.
12. ASTM A268, Standard Specification for Seamless and Welded Ferritic and Martensitic Stainless-Steel Tubing for General Service
13. International Conservation Construction Code of New York State 2022

1.5 ADMINISTATIVE REQUIREMENTS

A. Pre-installation meeting: Convene a minimum of two weeks prior to the commencement of work. The meeting to include contractors, engineers, and manufacturer.

B. Sequencing of construction: Ensure that products of this section are supplied to affected trades in time to prevent interruption of construction progress.

1.6 SUBMITTALS

A. Submit under provisions of Division 01 and 23.

B. Product Data

1. Dehumidifier performance shall include the following capacities and provided for the design conditions specified on the equipment schedule.

    a. Supply Air volume in cubic feet per minute (CFM).
    b. Outdoor air volume in cubic feet per minute (CFM).

        1) Occupied hours outdoor air volume.
        2) Maximum outdoor air volume.

    c. Exhaust Air volume in cubic feet per minute (CFM).

        1) Occupied hours exhaust volume.
        2) Maximum exhaust air volume.

    d. Total capacity in MBH
    e. Sensible capacity in MBH
    f. Latent capacity in MBH
    g. Moisture removal capacity at design conditions in pounds of moisture removed per hour.
    h. Moisture Removal Efficiency (MRE) as defined by ANSI/AHRI 910 (I-P/2014): Performance Rating of Indoor Pool Dehumidifiers as the method of calculating MRE.

2. Air-Cooled Condenser performance (if provided) shall include the following capacities provided for the design conditions specified on the equipment schedule.

    a. Available heat of rejection (THR) in MBH at the ambient condition shown in the schedule.

C. Shop Drawings

1. Shop drawings shall include certified dimensions including size and locations of roof openings, performance data, weights by sections, fan curves, water heating capacity, moisture removal capacity, power wiring diagrams, control wiring diagrams and sequence of control.

2. Submit manufacturer's installation instructions under provisions of Division 23.

D. Manufacturer’s Instructions

1. Preparation instructions and recommendations.
2. Storage and handling requirements and recommendations.
3. Guidance on equipment rigging.
4. Installation methods.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Division 23.

B. Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing

1.8 DELIVERY, STORAGE AND HANDLING

A. Deliver, store and protect products under provisions of Division 01 and 23.

B. Protect units from physical damage by storing off site until roof mounting frames are in place, ready for immediate installation of units.

C. All warranties shall start from the Date of Final Acceptance.

1.9 QUALITY ASSURANCE

A. Manufacturer Qualifications

1. Minimum 5 years experience manufacturing similar products.
2. Member in good standing in the Air Conditioning, Heating, and Refrigeration Institute (AHRI)

B. Installer Qualifications

1. Minimum 2-year experience installing similar products
2. North American Technician Excellence (NATE) Certification, HVAC Excellence Certification or equivalent certification.
3. Cost for startup assistance by manufacturer’s personal or manufacturer’s designated and trained third party must be included with each product specified.

C. Delivery, Storage and Handling

1. Handle materials as recommended by manufacturer to avoid damage.

1.10 FIELD CONDITIONS

A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's recommended limits.

B. Do not operate dehumidifier for temporary cooling, heating, or dehumidification during construction.

1.11 WARRANTY

A. The manufacturer shall warrant all components (except as noted) for a period of two (2) years from the date of shipment. This warranty shall be limited to the supply of new or rebuilt parts, at the discretion of the manufacturer, for the part which has failed because of defects in workmanship or material, and does not include the cost for labor, transportation or other costs not herein provided for. Replaced parts are warranted only for the remaining portion of the original warranty period.

B. Compressor Three (3) -Year Extended Warranty (if included): This extended warranty begins after the system's standard two (2)-year compressor part warranty ends. This warranty shall be limited to the supply of new or rebuilt parts for the part which has failed because of defects in workmanship or material, and does not include the cost of labor, transportation or other costs not herein provided for. Replaced parts are warranted only for the remaining portion of the original warranty period.

C. Airside Coils with Corrosion Resistive Coil Coating Eight (8)–Year Extended Warranty (if included): This Eight (8) year extended coil warranty begins after the system's standard two (2)-year warranty ends. This warranty shall be limited to the supply of new or cost of repair which has failed because of defects in workmanship or material, and does not include the cost of labor, transportation or other costs not herein stated. The determination to replace or repair is up to the discretion of the manufacturer. Replaced parts are warranted only for the remaining portion of the original warranty period.

D. Gas Heater Exchanger Eight (8) – Year Extended Warranty (if included): This Eight (8) year extended heat exchanger warranty begins after the system's standard two (2)-year warranty ends. This is a pro-rated heat exchanger warranty over a total of ten (10) years. This warranty shall be limited to the supply of a new heat exchanger which has failed because of defects in workmanship or material, and does not include the cost of labor, transportation or other costs not herein stated. The determination to replace is up to the discretion of the manufacturer. Replaced parts are warranted only for the remaining portion of the original warranty period.

PART 2 - PRODUCTS

2.1 DEHUMIDIFIER

A. Manufacturer

1. Basis of Design: Desert Aire SelectAire Plus Dehumidifier
2. Dectron
3. Pool Pak
4. Substitution Limitations:

    a. Requests for substitution must be submitted to the Engineer of Record for preliminary equipment review a minimum of 14 days prior to the bid date.
    b. All relevant information of the alternate must be provided.
    c. The mechanical contractor shall be responsible for all construction cost differences if alternate is accepted.

B. The size and capacity shall be in accordance with the dehumidifier schedule and include the Performance Criteria identified in Section 1.6.

C. Dehumidifier Description

1. Cabinet

    a. Exterior doors and exterior panels shall be 2 inches thick with inner and outer metal skins.
    b. The exterior cabinet walls shall have an average insulation R value of 13.5.
    c. The dehumidifier shall include a section that shall keep the compressors, accumulators, receivers and water condensers (if included) out of the pool room air stream in a walk-in vestibule or packaged unit's condenser section.
    d. Outdoor units shall be supplied with outdoor air and exhaust air rain hoods with bird screens.
    e. The unit should be designed for roof curb mounting, mounting on slab or mounting on equipment rails.
    f. In order to securely close all doors, the unit shall have cam type handles.
    g. Doors that are frequently accessed for service or maintenance work shall have linkage between handles that are at a height greater than 80" from the top of the curb interface to facilitate opening of these doors without use of ladders or scaffolding. The cabinet shall have double-bypass seals on all doors for superior weather resistance and tight sealing against high static pressures.

2. Electrical

    a. The isolated electrical compartment shall include a hinged access door.
    b. The electrical compartment shall be rated NEMA 4 weatherproof.
    c. The electrical compartment shall be equipped with door disconnect switch.
    d. The dehumidification unit shall be provided with a power connection lug set for single point power connection to serve controls, fans, electric heater (if provided), and compressors.
    e. The high and low voltage electrical components shall be located in separate sections with individual access doors.
    f. The electrical controls shall include low-voltage transformers to supply 24 VAC control power for the unit.
    g. The electrical cabinet shall include terminal strips for both high voltage and low voltage connections.

h. Safeties must include high pressure cutouts per circuit with manual reset.
i. Safeties must include low pressure cutouts per circuit with automatic reset.
j. Safeties must include an anti-short cycling timer to protect against compressor cycling.
k. The electrical nameplate on the unit shall include, but not limited to the MCA (Minimum Circuit Ampacity), the MOPD (Maximum Over-Current Protection Device) and the SCCR (Short Circuit Current Rating).
l. The unit shall be compatible with the electrical voltage, phase and hertz requirements as indicated on the dehumidifier schedule.
m. The unit shall be equipped from the factory with a non-fused disconnect switch.
n. Ground Fault Interrupter (GFI) outlet and unit LED lighting
    1) 120 VAC power for GFI/LED field provided by customer

3. Refrigeration System

a. The system's operating refrigerant shall be R-454B.
b. Compressors

    1) Units shall have two independent refrigerant circuits, an "A" and a "B" circuit.
    2) The compressors shall be heavy-duty scroll-type.
    3) The circuits shall be staged.
    4) Each circuit (of each compressor) shall have a refrigerant sight glass.
    5) The compressor shall be externally vibration isolated using rubber-in-shear isolation.
    6) Each circuit shall have a replaceable core filter dryer.
    7) For outdoor units, each compressor shall be equipped with an electric crankcase heater.

4. Refrigerant Coils

a. Evaporators

    1) The coil shall be a maximum of 45 inches (1143 mm) in height as recommended in Chapter 23.2 of the 2020 ASHRAE Handbook - HVAC Systems and Equipment. This will ensure that the condensate formed on the fins flows into the condensate drain pan to prevent re-evaporation into the air stream.
    2) The evaporator coils shall be designed to maximize moisture removal.
    3) Coils shall be leak tested at the factory.
    4) All evaporators shall be protected by a corrosion resistive coil coating for enhanced corrosion resistance on the complete coil assembly including casing, distributor tubes and header. Phenolic coatings or fin surface only coatings are not acceptable. Manual dip processes or spray application processes will not meet specification.
    5) Each evaporator coil shall have a separate condensate drain pan.
    6) Evaporative Coil "A"

a) Independent refrigeration circuit “A” shall be designed and controlled to increase the air flow over the evaporator coil to increase the sensible performance of this circuit when needed.
b) Circuit “A” shall also include a set of outside air and exhaust dampers to recover heat energy from the exhaust air stream when heating is required.
c) During heating operation, circuit “A” shall operate as an exhaust air energy recovery heat pump system with a minimum COP of 4.0.

7) Evaporative Coil “B”

a) Independent refrigeration circuit “B” shall be designed to be the primary evaporator coil to address the latent performance of the unit when needed.
b) The refrigeration circuit “B” shall include a separate wrap-around heat pipe on the entering and leaving side of the evaporator coil. The wrap-around heat pipe shall enhance the moisture removal capacity by approximately 25%.

b. Refrigerant Reheat Coil

1) Each of the two circuits shall include a refrigerant reheat coil.
2) The reheat coils shall be positioned with a minimum of 8 inches (203.2 mm) clearance from the evaporator coil to prevent re-evaporation of condensate.
3) The reheat coils shall be sized for the full heat of rejection in each circuit.
4) Reheat coils shall be leak tested at the factory
5) The reheat coil shall be protected by a corrosion resistive coil coating for enhanced corrosion resistance on the complete coil assembly including casing, distributor tubes and header. Phenolic coatings or fin surface only coatings are not acceptable. Manual dip processes or spray application processes will not meet specification.

c. Wrap-around Heat Pipe

1) A wrap-around heat pipe shall be installed to enhance the moisture removal efficiency of the evaporator “B” coil by approximately 25%.
2) The tubes shall be ½” OD copper permanently expanded onto the fin collar to form a firm, rigid, and complete pressure contact at all operating conditions. Aluminum tubes will not be allowed.
3) The fin surface shall be continuous plate type aluminum
4) The heat pipe shall have a minimum of two rows on each section
5) The wrap-around heat pipe coils shall be protected by a corrosion resistive coil coating for enhanced corrosion resistance. Phenolic coatings or fin surface only coatings are not acceptable. Manual dip processes or spray application processes will not meet specification.

5. Condensate Drain Pans

a. Drain pans will be sloped and positioned under each evaporator coil.

b. The drain pan will be fitted with a 1.5 inch MPT non-corrosive plastic drainpipe extending from the dehumidifier to be connected to by the contractor.

6. Receivers

a. The unit shall include a refrigerant receiver on each circuit. Receivers shall be sized for year-round operation no matter what method of heat sink is used for the compressor heat of rejection.
b. Each refrigerant receiver will be equipped with ball valves.
c. The receivers shall be sufficiently sized to accommodate the differences between winter design conditions and summer design condition and for operating at the highest efficiency over a wide range of load conditions.
d. The receivers shall be sized for full refrigerant circuit capacity to allow a manual system pump down when servicing.
e. The receiver shall be manufactured in accordance with ASME Sec. VIII, Div. 1 and comply with CSA B51
f. The receiver shall have a Canadian Registration Number (CRN).

7. Fans

a. EC Supply Fans

1) The dehumidifier shall have four plenum fans arranged in a fan array.
2) Each fan in the fan array shall be driven by a direct-drive electronically commutated (EC) motor.
3) To ensure that correct flow rates are maintained, all supply fans automatically modulate to maintain supply air volume.
4) Supply Fan Assembly

a) Fans are single-sided intake, rear-curved motor impeller, energy-optimized for operation without spiral housing through special blade design with rotating, vaneless diffuser for high efficiency.
b) Assembly includes an inlet nozzle with volume flow rate measuring equipment.
c) Fan shafts are designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.
d) Fans are designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
e) The blower assembly shall be statically and dynamically.

b. EC Exhaust Fan Assembly

1) The dehumidifier shall have two plenum exhaust fans arranged in a fan array.
2) Each fan in the fan array shall be driven by a direct-drive electronically commutated (EC) motor.
3) To ensure that correct flow rates are maintained, all exhaust fans automatically modulate.
4) Exhaust Fan Assembly

a) Fans are single-sided intake, rear-curved motor impeller, energy-optimized for operation without spiral housing through special blade design with rotating, vaneless diffuser for high efficiency.
b) Assembly includes an inlet nozzle with volume flow rate measuring equipment.
c) Fan shafts are designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.
d) Fans are designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
e) The complete blower assembly shall be statically and dynamically balanced.

8. Filters (Return and Outdoor Air)

a. Air Filters shall be two-inch pleated MERV 10 disposable filters

9. Dampers

a. Internal Dampers

1) Low leakage control damper with fabricated, insulated airfoil blades
2) Dampers shall be a parallel blade dampers with blade and jamb seals.
3) Dampers shall have a AMCA leakage classification of 1A.
4) Dampers shall be motorized and proportional modulating.
5) The controller shall automatically adjust the dampers to maintain the specified flow rates through the use of integral air flow measurement devices.

b. Backdraft Dampers

1) Should a fan in the array of supply fans fail, backdraft dampers shall prevent the recycling of air within the unit.
2) Backdraft dampers shall be gravity operated.

10. Roof Curb

a. The roof curb shall be of box section design with integral base plate, and shall have continuously welded corner seams.
b. The curb will be internally insulated with three-pound density rigid fiberglass board insulation not less than 1-1/2" thick.
c. The curb will be of a design with integral cants and will be designed to be roofed over.
d. The curb will include a factory-installed wood nailer strip around the top perimeter.
e. The roof curb will be sized to fit the equipment to be supported.
f. Curb height shall be:

1) 18 inches

11. Refrigerant Heat Sinks

    a. Remote Air-Cooled Condenser

        1) The remote air-cooled condenser is described in detail in Section 2.2.
        2) The size and capacity shall be in accordance with and rated at the ambient condition as listed in the remote air-cooled condenser schedule.
        3) The condenser shall have dual refrigerant headers.
        4) The system shall be able to reject all the full total heat of rejection to the outdoors.

    b. Pool or Spa Water Heating

        1) In addition to a remote air-cooled condenser or a water-cooled condenser, each refrigerant circuit in the unit may also have a pool water heat exchanger.
        2) The dehumidifier's circuit "A" shall be equipped with a water condenser that rejects heat to the pool water loop or spa water loop.
        3) The dehumidifier's circuit "B" shall be equipped with a water condenser that rejects heat to the pool or spa water loop.
        4) The condenser shall be rated for 150 PSI (1034.2 kPA) operating fluid pressure.
        5) The condenser(s) shall be sized for the total heat of rejection (THR) of the circuit to which it is connected.
        6) The acceptable entering water temperature range shall be between 36°F (2.2°C) and 104°F (40.0°C).
        7) The dehumidifier shall be equipped with one water flow switch per pool or spa water condenser. A water flow switch shall prevent compressor operation in the event of a loss of water flow and a call for sensible cooling.
        8) A water temperature sensor and well shall be provided for each pool or spa water loop. The sensor(s) shall be installed by the mechanical contractor in the main water loop upstream of the pool heater and dehumidifier.
        9) Constant water flow is required across the temperature sensor in the main water loop.
        10) Control valves and/or pumps for the pool or spa water condenser(s) are contractor provided and field installed.
        11) Water flow in the pool or spa condenser can be turned off and on depending on the need for water heating.
        12) Outdoor units with a pool or spa water condenser shall be wrapped in insulation and heat traced. The heat tracing shall be wired back to the control panel for an independent 120V power connection field supplied and installed by the contractor.

12. Heating

    a. Exhaust Air Energy Recovery

        1) The first stage of heating shall be the energy recovery heat pump operation.

2) The unit shall include a heat pump heating sequence to heat the ventilation air entering the dehumidifier.
3) The "A" circuit of the unit shall be energized to operate during the programmed hours.
4) The system shall provide a minimum COP of 4.0 which will provide the most efficient method of maintaining the supply air above the space dew point during heating operation.

b. Gas Heat:

1) The integral gas heater shall be the second and subsequent stages of heating.
2) The gas heater capacity shall be in accordance with the dehumidifier schedule.
3) The gas heater shall be internal and an integral to the unit.
4) The gas heater shall be an in shot gas burner type with integral carryovers.

a) A turndown ratio of 10 to 1 shall be provided on gas heaters with input capacities from 600 to 1,200 MBH (234.3 to 351.4 kW).
b) A turndown ratio of 20 to 1 shall be provided on gas heaters with input capacities from 1,600 to 2,400 MBH (468.6 to 702.9 kW).

5) The minimum combustion efficiency shall be 81%.
6) The unit shall contain a combustion blower to provide a positive venting.
7) The gas heater shall be equipped with an air proving switch to prove combustion air flow.
8) The gas heater control sequence to include a pre-purge period sufficient to complete a minimum of four (4) air changes prior to burner start.
9) The gas duct furnace shall include an intermittent 100% shut off hot surface ignition.
10) The system shall include a Maxitrol solid state modulating gas control valve with CSA certification.
11) The modulating gas control shall maintain a supply air temperature (SAT) set point (adjustable) to help prevent short cycling of the burners.
12) The gas heater shall be locked out during compressor operation by the unit controller.

13. Control System

a. A digital control system using a microprocessor shall be used to accurately and precisely control the dehumidification system and the space environment.
b. The controller shall include two (2) levels of password protection. An open user level, a password protected service level and a password protected factory level of access in the controller.
c. The controller shall provide precise system control and feature an easy-to-read display which indicates actual operating conditions and set points.
d. The controller shall have a built-in occupancy timer.
e. The integral control system shall maintain the correct proportions of return air, supply, exhaust and ventilation air.

f. Up to five modes of outdoor air flow rates can be programmed. Negative pressure in the space to be maintained via modulating exhaust blowers in each mode.
g. The static pressure, outdoor air flow and exhaust flow can be directly read at the unit's controller.
h. Building Management System (BMS) Compatibility shall be provided through one of these communication protocols.

1) BACnet MS/TP compatible

i. The contractor responsible for the BMS integration shall be responsible for programming the building management system to the points list provided by the dehumidifier manufacturer.
j. Compressor safety trips shall be recorded by the controller and include pressures, date, time of day and the ambient condition if available.
k. Emergency System Shutdown

1) Terminal points are available for a binary contact closure by others to control unit shutdown by smoke detector or another similar device.
2) An open contact in the 24 VAC circuit shall deactivate motors, fans and compressors.

l. Remote Display

1) The system may include an optional remote display terminal (RDT) to allow remote operation and modification of set points of any dehumidifier on the network.
2) The display shall be remote mountable up to 1,640 feet (500 m) from the unit.

14. Remote Monitoring (AireGuard)

a. The unit or units shall include cloud-based monitoring functionality.
b. This feature requires others to field provide an Ethernet connection to the internet for the dehumidification unit.
c. The building’s existing LAN Firewall shall be maintained with no further action from the buildings IT department as long as the facility has internet service.
d. All AireGuard logins are via the cloud-based service. No further local network access is required.
e. The dehumidifier shall include a two-year subscription to the cloud-based AireGuard Service. Subscription can be renewed as the end of the initial subscription.
f. AireGuard shall allow remote operation and modification of set points of any dehumidifier on the network. This includes access to set points, performance information and alarm alerts.
g. AireGuard shall allow remote monitoring and alarming using any internet connected computer or portable device.
h. Alarm notification shall be by e-mail or SMS.
i. Remote system access by staff and external parties are controlled by the owner.
j. Each dehumidifier shall require an Ethernet connection with access to the internet.

15. Sensors

    a. Temperature and humidity sensor.

        1) Factory installed in the return of the unit

    b. Unit shall be equipped with an airflow switch to prevent the compressors from starting or operating on a loss of airflow.
    c. A pressure switch to prove air supply for combustion shall be provided with gas heaters.
    d. A barometric pressure transducer shall be provided for room pressure control to maintain the zones pressure with varying amounts of outdoor air.

        1) A pressure transducer is factory installed inside dehumidifier.
        2) The contractor must install a sensor tube to the natatorium and a sensor tube to the outdoors.
        3) Outdoor pressure transducer supplied by factory and field installed by contractor along with the tubing.

    e. The dehumidifier shall have internal transducers for monitoring refrigerant pressures.
    f. A water temperature sensor and well shall be provided for each pool or spa water loop. The sensor(s) shall be installed by the mechanical contractor in the main water loop upstream of the pool heater and dehumidifier, constant water flow required across the main water loop sensor.
    g. Condensate Overflow Switch shall be included in the unit and cause the unit to alarm upon an overflow of the condensate drain pan. The compressors will shut down but leave the supply fan to continue operating.
    h. Dirty Filter Pressure Transducer shall be included in the unit and cause the unit to alarm if the static pressure limit is exceeded. The alarm point can be set by the owner from the unit controller.
    i. A voltage/phase monitor shall be included in the dehumidifier to protect against phase loss, phase reversal, under voltage conditions and unbalanced voltage conditions. The entire unit will shut down in the event of an alarm.

16. Sequence of Operation

    a. Supply fan blower runs continuously.
    b. Air Balancing

        1) The integral control system shall automatically maintain the correct proportions of return, supply, exhaust and ventilation air to maintain a negative pressure in the room.
        2) The static pressure, outdoor air flow. and exhaust air flow can be directly read at the unit's controller.
        3) Up to 50% of the supply air volume can be made up of ventilation air.
        4) Up to 50% of the supply air volume can be exhausted.
        5) The maximum amount of ventilation and exhaust air is listed on the dehumidifier schedule.

6) The system will monitor the differential static pressure at the following locations.

a) The ventilation air damper will modulate based on the pressure differential across a ventilation air orifice plate to ensure the correct amount of ventilation air during occupied times.
b) Across the evaporator coil in order to modulate the evaporator by-pass damper and ensure the proper amount of evaporator cfm for optimal moisture removal at all conditions.
c) The pressure difference between the pressure in the zone and ambient in order to vary the exhaust fan volume to help guarantee a negative pressure within the space.

7) Up to five modes of outdoor air flow rates can be programmed.

a) Negative pressure in the space to be maintained via modulating exhaust blowers in each mode. These include one or more of the following air flow modes of operation.

1. Occupied mode (ventilation for occupants).
2. Unoccupied mode.
3. Event mode (additional ventilation for events that result in additional people in the space).
4. Maximum ventilation mode to bring in the programmed amount of outdoor air volume to air borne contaminates.
5. Purge mode (Up to 50% of the supply air volume as ventilation air to eliminate potential contaminates from occasional human activity that might require super chlorination of the pool water.)

8) Unoccupied Ventilation for Source Capture Exhaust Air

a) This is only required if there is a low level, pool adjacent, source capture system operating during the unoccupied hours.
b) The source capture equipment is separate and independent of the dehumidifier.

c. Control of Volatile Organic Compounds (VOC)

1) With ordinated control of any modulating source capture devices (an exhaust fan with a VFD provided by others or a RecoverAire unit).

a) During occupied hours, the dehumidifier shall have the ability to exhaust additional air from the zone and introduce the maximum amount of outdoor air when VOC levels are higher than set point.
b) The controller will air balance the exhaust fan operation in the dehumidifier and any modulating source capture devices to maintain negative pressure in the room.
c) During unoccupied hours, the outdoor air flow and the exhaust air flow shall be reduced to a minimum amount as specified. The

dehumidifier's dampers, exhaust fan and any modulating source capture devices will automatically be adjusted to provide the specified negative pressure in the space.

2) No coordinated control of any field provided exhaust fan,

a) During occupied hours, the dehumidifier shall have the ability to exhaust additional air from the zone and introduce the maximum amount of outdoor air when VOC levels are higher than set point.
b) The controller will air balance the exhaust fan operation in the dehumidifier to maintain negative pressure in the room.
c) During unoccupied hours, the outdoor air flow and the exhaust air flow shall be reduced to a minimum amount as specified. The dehumidifier's dampers, exhaust fan will automatically be adjusted to provide the specified negative pressure in the space.

d. Cooling Mode

1) First Stage

a) The exhaust damper located before the evaporator coils opens and exhausts room air before the evaporator coils.
b) Internal balancing dampers will open to direct air through the circuit "A" evaporator.
c) Circuit "A" compressor(s) will start and operate.
d) The reheat coil will be inactive during cooling operation.
e) The heat of rejection shall be directed to the heat sink or sinks in the priority they are assigned as defined in the controller by the building operator. (Note: The order is typically pool heating and then either an air-cooled condenser or a water-cooled condenser).

2) Second Stage:

a) Circuit "B" compressor(s) will start and operate.
b) Internal balancing dampers will balance airflow through both circuit "A" evaporator and the circuit "B" evaporator.
c) The reheat coil will be inactive during cooling operation.

d) The heat of rejection shall be directed to the heat sink or sinks in the priority they are assigned as defined in the controller by the building operator. (Note: The order is typically pool heating and then either an air-cooled condenser or a water-cooled condenser).

e. Dehumidification

1) First Stage

a) The exhaust damper located before the evaporator coils opens and exhausts room air before the evaporator coils.

b) Internal balancing dampers close in order to direct air into the wrap-around heat pipe coil and the circuit "B" evaporator.
c) The reheat coil will be active.
d) Any remaining heat of rejection not used by the reheat coil shall be directed to the heat sink or sinks in the priority they are assigned as defined in the controller by the building operator. (Note: The order is typically pool heating and then either an air-cooled condenser or a water-cooled condenser).

2) Second Stage:

a) Circuit "A" compressor(s) will start and operate.
b) Internal balancing dampers will balance airflow through both circuit "A" evaporator and the circuit "B" evaporator.
c) The reheat coil will be active.
d) Any remaining heat of rejection not used by the reheat coil shall be directed to the heat sink or sinks in the priority they are assigned as defined in the controller by the building operator. (Note: The order is typically pool heating and then either an air-cooled condenser or a water-cooled condenser).

f. Air Side Economizer Operation

1) Cooling mode

a) The air side economizer function will bring in the maximum outdoor air amount programmed in the unit in order to reduce the energy needed for cooling the room when the outside air wet bulb temperature is below room set point and above room dew point set point.

2) Dehumidification mode

a) The air side economizer function will bring in the maximum outdoor air amount programmed in the unit in order to reduce the energy needed for dehumidifying the room when the outside air wet bulb temperature is below room set point and above room dry bulb set point.

3) Cooling or dehumidification mode

a) The air side economizer function will bring in the maximum outdoor air amount programmed in the unit in order to reduce the energy needed for either cooling or dehumidifying the room when the outside air dry bulb temperature is above a programmed set point but below the room dry bulb temperature set point.

g. Heating

1) First Stage – Exhaust Air Energy Recovery Heat Pump Operation

a) On a call for heating, energy is recovered from the exhaust air by passing it through the circuit "A" evaporator.
b) The cooled exhaust air is then expelled from the unit.
c) The recovered energy from the exhaust air stream and the refrigerant heat of rejection are sent to the circuit "A" reheat coil where outside air is heated.
d) This heat pump operation shall provide a COP of 4.0 to maintain the supply air above the space dew point.
e) Any heat not required by the reheat coil shall be directed to the heat sink or sinks in the priority they are assigned as defined by the operator in the controller.

2) Second Stage

a) If additional heat is required to maintain the space set point, the heating system shall be energized.
b) If a gas heater is included, heating capacity shall be staged.

17. Materials

a. Cabinet

1) Cabinet panels shall have 20 gauge (1.006 mm) Galvanneal steel inner and other skins.
2) The interior and exterior panels shall have a powder coat paint. Prior to painting, all metal parts shall be pretreated to remove oils and dirt and rinsed with an ionized solution. Painting shall be by a powder coat technique to assure positive adherence with a high impact finish. All sides of panels shall be painted after manufacturing. The paint shall be High Yield Polyester. The paint shall be rated to meet a minimum of 1,000-hour salt spray test (ASTM B117), have a minimum Direct Impact Resistance of 160 in-lbs (ASTM D2794), have a minimum flexibility of ¼" Mandrel (ASTM D522, Method B) and a minimum 1000-hour Humidity Resistance (ASTM D2247). The unit color shall be light gray.

b. Roof Curb shall be of heavy-gauge galvanized steel construction.
c. Refrigerant Coils (Evaporator, Reheat and Integral Air-Cooled Condenser Coil)

1) Coils shall be fabricated from seamless drawn copper. The tubes shall be hydraulically expanded into the aluminum fins to form a permanent metal-to-metal bond for maximum heat transfer and stability.
2) The fin surface on the refrigerant coils shall be continuous plate type aluminum
3) All air-side refrigeration coils shall be protected by a corrosion resistive coil coating for enhanced corrosion resistance on the complete coil assembly including casing, distributor tubes and header. Heat transfer coefficient loss shall be less than 1% after coating. Minimum salt spray resistance per ASTM B117-97 / DIN 53167 after coating shall be 15,000 hours. Phenolic

coatings or fin surface only coatings are not acceptable. Manual dip processes or spray application processes will not meet specification.

d. Packaged Refrigerant Condensing Section

1) Additionally, fan guards shall be heavy-gauge, closed-mesh steel wire with vinyl coating. Guards shall be contoured for maximum rigidity.
2) If required for seacoast or corrosive environments, the integral air-cooled condenser coil shall be coated with corrosion resistive coil coating.

e. Wrap Around Heat Pipe

1) The wrap around heat pipe shall be fabricated from seamless drawn copper. Aluminum tubes will not be allowed on the wrap around heat pipe.

2) The fin surface of the wrap around heat pipe shall be continuous plate type aluminum.

f. Supply Fans

1) EC Fan Arrays

a) Centrifugal impeller made of high-strength composite material, coated steel, or aluminum.
b) Air inlet nozzle shall be made of galvanized steel.
c) Plenum Fan Housing: Steel frame and panel; fabricated without fan scroll and volute housing.

g. Exhaust Fans

1) EC Fan Arrays

a) Centrifugal impeller made of high-strength composite material, coated steel, or aluminum.
b) Inlet nozzle shall be made of galvanized steel.
c) Plenum Fan Housing: Steel frame and panel; fabricated without fan scroll and volute housing.

h. Dampers

1) Damper shall be constructed out of single thickness aluminum and are insulated.

i. Condensate Drain Pan

a) The condenser drain pan shall be made of 304 stainless-steel.

j. Water-Cooled Condensing (if provided)

1) The condenser shall be tube-in-tube coaxial heat exchanger with cupronickel construction with CPVC schedule 40 stub-outs.

k. Pool Water Heating (if provided)

1) The condenser shall be tube-in-tube coaxial heat exchanger with cupronickel construction with CPVC schedule 40 stub-outs.

2.2 REMOTE AIR-COOLED CONDENSER

A. Manufacturer

1. Basis of Design: Desert Aire Air-Cooled RCE Series and RCF Series Remote Condensers.
2. Substitution Limitations: No Substitutions

B. Remote Air-Cooled Condenser Description

1. The size and capacity shall be in accordance with the unit schedule. The system shall be able to reject all the recovered heat (T.H.R.) from both circuit A and circuit B to the outdoor condenser. The outdoor condenser shall have dual headers.
2. The system shall be able to reject all the recovered heat (T.H.R.) from circuit A to the outdoor condenser. The size and capacity shall be in accordance with the unit schedule.
3. The system shall be able to reject all the recovered heat (T.H.R.) from circuit B to the outdoor condenser. The size and capacity shall be in accordance with the unit schedule.
4. The fan motors are direct drive external rotor type. Swept fan blades are designed as part of the motor.
5. The fans shall be cycled based on internal head pressure.
6. Electrical

a. The remote air-cooled condenser shall be provided with a weatherproof electrical panel with factory mounted door interrupt disconnect switch.
b. Motor lead raceways shall be fully enclosed to protect wiring.
c. Electrical nameplate on the unit shall include, but not limited to the MCA (Minimum Circuit Ampacity), the MOPD (Maximum Over-Current Protection Device) and the SCCR

d. The units shall be compatible with the electrical voltage, phase and hertz requirements as indicated on the dehumidifier schedule.

7. Refrigeration system

a. The system's operating refrigerant shall match the refrigerant used by the dehumidifier in Section 2.1.

8. Coil

    a. Round Tube Coils-Enhanced tubing with advanced sinusoidal fin design
    b. Coils shall be factory leak-tested and sealed with caps.

9. Fans

    a. Swept fan blades are designed as part of the motor assemblies, not an addition to them.
    b. RC5 Series Condenser

        1) The condenser will be provided with a 1100 RPM motor designed fan blade to produce 69dbA or less noise @ 3 meters in accordance with AHRI standard 370-2001.

    c. RC8 Series Condenser

        1) The condenser will be provided with a 540 RPM motor combined with a specially designed fan blade to produce 52 dbA or less noise @ 3 meters in accordance with AHRI standard 370-2001.

10. Controls

    a. Fan(s) shall be controlled based on the refrigerant head pressure.
    b. Condenser shall continue to operate and automatically maintain condensing temperature at ambient conditions as low as -20°F (-17°C) Control
    c. No control wire shall be required between the remote air-cooled condenser and the dehumidifier.
    d. The condenser fans shall operate based on the refrigerant pressure measured at the condenser.
    e. The maximum ambient temperature is per the schedule

11. Sensors

    a. Each circuit in the air-cooled remote condenser shall be equipped with a refrigerant pressure transducer.

12. Sequence of Operation

    a. For energy savings, fans should be sequenced in response to increasing or decreasing refrigerant pressure and not all run at the same time.

13. Material

    a. Cabinet

        1) The remote air-cooled condenser cabinet shall be constructed of G90 galvanized steel.
        2) Fan guards shall be heavy-gauge, closed-mesh steel wire with vinyl coating. Guards shall be contoured for maximum rigidity.

b. Coil

1) The condenser coil shall be fabricated from seamless drawn copper. Aluminum tubes will not be allowed.
2) The fin surface on the refrigerant coils shall be continuous plate type aluminum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Do not begin installation until wall openings and rough-in have been properly prepared.

B. If preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

3.2 PREPARATION

A. Prepare conditions using the methods recommended by the manufacturer for achieving the best result for the operation under the project conditions.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions. Test for proper operation and adjust as required until satisfactory results are obtained.

3.4 If specifically requested by the engineer or owner, a factory tour and equipment inspection at the factory shall be made available at an additional cost.

3.5 FACTORY ASSISTED STARTUP

A. Manufacturer is required to provide a technician on site to assist the installing contractor with the startup of the equipment. The cost of the factory assisted startup must be included in the price of the equipment.

3.6 TRAINING

A. Owner/operator training shall be provided by factory technicians or factory authorized personnel to provide this training during the factory assisted startup.

B. Service technician training shall be periodically available to service contractors at the manufacturer’s factory.

3.7 PROTECTION

A. Protect installed products until completion of project.

B. Touch-up, repair or replace damaged products before substantial completion.

END OF SECTION 23 84 19

SECTION 26 05 00 - COMMON WORK RESULTS - ELECTRICAL

PART 1 - GENERAL

1.1 EXECUTION OF THE WORK

A. These specifications call out certain duties of the Electrical Contractor and his Subcontractors. They are not intended as a material list of items required by the Contract. Any reference in these specifications and on the accompanying drawings to the Contractor, Electrical Contractor, Electrical Subcontractor or abbreviation "E.C.", shall be construed to mean the Contractor responsible for all electrical construction (Division 26) work for this project.

B. This division of the specifications covers the electrical systems of the project. It includes work performed by the electrical trades as well as trades not normally considered as electrical trades.

C. Provide all items and work indicated on the Drawings and all items and work called for in this division of the specifications in accordance with the conditions of Contract (Division 01 General Requirements Documents). This includes all incidentals, equipment, appliances services, hoisting, scaffolding, supports, tools supervision, labor consumable items, fees licenses, etc., necessary to provide complete systems. Perform start-up and checkout on each item and system to provide fully operable systems.

D. Comply with all provisions of the Contract Documents including the General Conditions, and Division 01 General Requirements of the specifications.

E. Certain terms such as "shall, provide, install, complete, start-up" are not used in some parts of these specifications. This does not indicate that the items shall be less than completely installed or that systems shall be less than complete.

F. Examine and compare the Electrical Drawings with these specifications and report any discrepancies between them to the Architect/Engineer and obtain from him written instructions for changes necessary in the work. At time of bid the most stringent requirements must be included in said bid.

G. Examine and compare the Electrical Drawings and Specifications with the Drawings and Specifications of other trades and report any discrepancies between them to the Architect/Engineer and obtain from him written instructions for changes necessary in the work. At time of bid, the most stringent requirements must be included in said bid.

H. Install and coordinate the electrical work in cooperation with other trades installing interrelated work. Before installation, make proper provisions to avoid interferences in a manner approved by the Architect/Engineer. All changes required in the work of the Contractor, caused by his neglect to do so, shall be made by him at his own expense.

I. It is the intent of the Drawings and Specifications to provide a complete workable system ready for the Owner’s operation. Any item not specifically shown on the Drawings or called for in the

Specifications, but normally required to conform to the intent, are to be considered a part of the Contract.

J. These specifications are basically equipment, installation, and performance Specifications. Some installation details are indicated on the Drawings. Where these differ from the Specifications, apply the more stringent at time of bid. Upon award of bid, contact Architect/Engineer for definite instructions.

K. All materials furnished by the Contractor shall be new and unused (temporary lighting and power products are excluded) and free from defects. All materials used shall bear the Underwriter's Laboratory, Inc. label provided a standard has been established for the material in question.

L. All products and materials shall be new, clean, free of defects and free of damage and corrosion.

M. The exclusion from, or limitation in, the symbolism used on the Drawings or the language used in the Specifications for electrical work shall not be interpreted as a reason for omitting the accessories necessary to complete any required system or item of equipment.

N. The use of words in the singular shall not be considered as limiting where other indications denote that more than one item is referred to.

O. Except for conduit, conduit fittings, outlet boxes, wire and cable, all items of equipment or material shall be the product of one manufacturer throughout. Multiple manufacturers will not be permitted.

P. Receive, inspect, store, install and wire Owner-furnished equipment where Owner furnished equipment is supplied.

Q. Painting

1. All manufactured electrical equipment such as panelboards, control equipment, lighting fixtures, etc., shall have factory-applied finish as specified in the appropriate article in the Electrical Parts of the Specification.
2. All other uncoated steel items such as boxes supports, hanger, rods, etc., shall be galvanized or have a shop coat of paint applied under this Part of the Specification. Normally shop coats shall be an approved primer containing at least 50 percent rust inhibitive pigment, applied before assembling the different parts.
3. Including painting and retouching of:

    a. Pre-finished enclosures of switchboards, panelboards, switches, wireways, etc., where the finish has been slightly damaged in transit before assembling the different parts.
    b. Any woodwork furnished in the electrical work.
    c. Fixture hangers, except those received from manufacturers that are prefinished.
    d. Miscellaneous iron brackets and supports.
    e. Steel conduits buried in earth (asphaltum).

4. Woodwork installed under this part of the specification shall be finished with filler sealer plus two (2) coats of PPG "Water Spar" gloss varnish.

1.2 COORDINATION OF THE WORK

A. Certain materials will be provided by other trades. Examine the Contract Documents to ascertain these requirements.

B. Carefully check space requirements with other trades and the physical confines of the area to ensure that all material can be installed in the spaces allotted thereto including finished suspended ceilings and the spaces within the existing building. Make modifications thereto as required and approved.

C. No items foreign to the electrical system shall be run in the dedicated space of the electrical equipment. Dedicated space shall be defined as the width and depth of the equipment from the floor to the bottom of the structural ceiling. Foreign systems include but are not limited to ductwork, piping, sprinklers, drip trays, etc. Contractor shall be responsible to coordinate the locations of the dedicated spaces with all trades as required.

D. Transmit to other trades all information required for work to be provided under their respective Sections in ample time for installation.

E. Wherever work interconnects with work of other trades, coordinate with other trades to ensure that all trades have the information necessary so that they may properly install all the necessary connections and equipment. Identify all items of work that require access so that the ceiling trade will know where to install access doors and panels.

F. Due to the type of installation, a fixed sequence of operation is required to properly install the complete systems. Coordinate, project and schedule work with other trades in accordance with the construction sequence.

G. The locations of lighting fixtures, outlets, panels and other equipment indicated on the Drawings are approximately correct, but they are understood to be subject to such revision as may be found necessary or desirable at the time the work is installed in consequence of increase or reduction of the number of outlets, or in order to meet field conditions or to coordinate with modular requirements of ceilings, or to simplify the work, or for other legitimate causes.

H. Exercise particular caution with reference to the location of panels, outlets, switches, etc., and have precise and definite locations approved by the Architect/Engineer before proceeding with the installation.

I. The Drawings show only the general run of raceways and approximate location of outlets. Any significant changes in location of outlets, cabinets, etc., necessary in order to meet field conditions shall be brought to the immediate attention of the Architect/Engineer and receive his approval before such alterations are made. All such modifications shall be made without additional cost to the Owner.

J. Obtain from the Architect/Engineer in the field, the location of such outlets or equipment not definitively located on the Drawings.

K. Circuit "tags" in the form of arrows are used where shown to indicate the home runs of raceways to electrical distribution points. These tags show the circuits in each home run and the panel designation. Show the actual circuits numbers on the finished record tracing and on panel directory card. Where circuiting is not indicated, Electrical Contractor must provide required circuiting in accordance with the loading indicated on the drawings and/or as directed.

L. The Drawings generally do not indicate the exact number wires in each conduit for the branch circuit wiring of fixtures, and outlets, or the actual circuiting. Provide the correct wire size and quantity as required by the indicated circuiting and/or circuit numbers indicated and control, wiring diagrams, if any, specified voltage drop or maximum distance limitations, and the applicable requirements of the NEC.

M. Adjust location of conduits, panels, equipment, pull boxes, fixtures, etc. to accommodate the work to prevent interferences, both anticipated and encountered. Determine the exact route and location of each raceway (and bus duct) prior to fabrication.

1. Right-of-Way:

a. Lines which pitch have the right-of-way over those which do not pitch. For example: condensate and plumbing drains normally have right-of-way. Lines whose elevations cannot be changed to have right-of-way over lines whose elevations can be changed.
b. Make offsets, transitions and changes in direction in raceways as required to maintain proper headroom in pitch of sloping lines whether or not indicated on the Drawings.

N. Wherever the work is of sufficient complexity, prepare additional Detail Drawings to scale similar to that of the bidding Drawings, prepared on tracing medium of the same size as Contract Drawings. With these layouts, coordinate the work with the work of other trades. Such detailed work shall be clearly identified on the Drawings as to the area to which it applies. Submit for review Drawings clearly showing the work and its relation to the work of other trades before commencing shop fabrication or erection in the field.

O. Contractor shall furnish services of an experienced Superintendent, who shall be in constant charge of all work, and who shall coordinate his work with the work of other trades. No work shall be installed before coordinating with other trades.

P. Coordinate with contractors for work under other Divisions of this specification for all work necessary to accomplish this contractor’s work.

Q. Where electrical connections are required, to equipment provided by the Owner or by other trades, this Contractor shall verify the exact requirements for these connections prior to ordering any materials or laying out any work. Where there is a discrepancy between the equipment being furnished and that shown on the Contract Drawings, the Contractor shall notify the Architect/Engineer for direction. Failure to comply with this coordination shall not constitute a

reason for extra monies for equipment ordered or installed. Restocking charges will not be paid.

1.3 EXAMINATION OF SITE

A. Prior to the submitting of bids, the Contractor shall visit the site of the job and shall familiarize himself with all conditions affecting the proposed installation and shall make provisions as to the cost thereof. Failure to comply with the intent of this paragraph will in no way relieve the contractor of performing all necessary work shown on the Drawings.

1.4 PROGRESS OF WORK

A. The Contractor shall order the progress of his work so as to conform to the progress of the work of other trades and shall complete the entire installation as soon as the conditions of the building will permit. Any cost resulting from the defective or ill-timed work performed under this section shall be borne by the Contractor.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Ship and store all products and materials in a manner which will protect them from damage, weather and entry of debris. If items are damaged, do not install, but take immediate steps to obtain replacement or repair. Any such repairs shall be subject to review and acceptance of the Architect/Engineer.

B. Delivery of Materials: Deliver materials in manufacturer's unopened container fully identified with manufacturer’s name, trade name, type, class, grade, size and color.

C. Storage of Materials, Equipment and Fixtures: Store materials suitably sheltered from the elements, but readily accessibly for inspection by the Architect/Engineer until installed. Store all items, susceptible to moisture damage, in dry, heated spaces.

1.6 EQUIPMENT ACCESSORIES

A. Provide supports, hangers and auxiliary structural members required for support of the work according to Section 26 05 29 "Hangers and Supports for Electrical Systems" and Section 26 05 48 "Vibration and Seismic Control for Electrical Components."

B. Furnish and set all sleeves for passage of raceways through structural, masonry and concrete walls or floors and elsewhere as will be required for the proper protection of each raceway passing through building surfaces.

C. Wall mounted equipment may be directly secured to wall by means of steel bolts. Maintain at least 1" air space between equipment and supporting wall. Groups or arrays of equipment may be mounted on adequately sized steel angles, channels, or bars. Prefabricated steel channels providing a high degree of mounting flexibility, such as those manufactured by Kindorf, Glob-Strutt and Unistrut, may be used for mounting arrays of equipment.

1.7 CUTTING, PATCHING

A. The work shall be carefully laid out in advance. Where cutting, channeling, chasing or drilling of floors, walls, partitions, ceilings or other surfaces is necessary for the proper installation, support or anchorage of raceway, outlets or other equipment, the work shall be carefully done. Any damage to the building, piping, equipment or defaced finish plaster, woodwork, metalwork, etc. shall be repaired by skilled mechanics or the trades involved at no additional cost to the Owner.

B. The Contractor shall do no cutting, channeling, chasing or drilling of unfinished masonry, tile, etc., unless he first obtains permission from the Architect/Engineer. If permission is granted, the Contractor shall perform this work in a manner approved by the Architect/Engineer

C. Where conduits, mounting channels, outlet, junction, or pull boxes are mounted on a painted surface, or a surface to be painted, they shall be painted to match the surface. Whenever support channels are cut, the bare metal shall be cold galvanized.

D. Slots, chases, openings and recesses through floors, walls, ceilings, and roofs will be provided by the various trades in their respective materials. The trade requiring them to properly locate such openings and be responsible for any cutting and patching caused by the neglect to do so.

E. Structural steel fabricator and installer shall be responsible for the coordination of all framed openings in roof with approved equipment manufacturers. (Openings such as, but not limited to mechanical units, exhaust fans, curb mounted equipment, roof drains, skylights, stair openings, roof hatches, smoke hatches, duct thru roof penetrations, expansion joints, etc.)

Exact sizes and exact locations of all openings are to be verified with the approved shop drawings issued for the installation. The exact sizes shall be coordinated prior to any fabrication and installation by any/all trades. (Sizes and locations indicated on contract drawings are diagrammatic and for information only.)

Any fabrication and/or installation which has not been properly coordinated with approved equipment manufacturer and must be repaired, relocated, altered, replaced, re-installed or modified in any manner will be done to the satisfaction of the Owner with no additional cost to the Owner or design professional.

1.8 FIRESTOPPING

A. Apply firestopping to cable and raceway penetrations of fire-rated floor and wall assemblies to achieve fire resistance of the assembly. Firestopping materials and installation requirements are specified in Division 7 Section "Firestopping".

1.9 NORMAL VOLTAGES (Unless Otherwise Noted)

A. Primary Distribution – 4800 volts.

B. Secondary Distribution – 480/277 Volt, three phase, 4 wire and/or 208/120 Volt, three phase, 4 wire.

1.10 MOUNTING HEIGHTS

A. Unless otherwise noted or required because of special conditions, locate outlets as indicated on the drawings:

1. Heights listed are from finished floor to center of device. Verify exact locations with the Architect/Engineer before installation.

1.11 CLEANING UP

A. Contractor shall take care to avoid accumulation of debris, boxes, crates, etc., resulting from the installation of his work. Contractor shall remove from the premises each day all debris, boxes, etc., and keep the premises clean, subject to the Architect/Engineer's instructions, which shall be promptly carried out.

B. Contractor shall clean all fixtures and equipment at the completion of the project.

C. All switchboards, panelboards, wireways, cabinets, enclosures, etc. shall be thoroughly vacuumed clean prior to energizing equipment and at the completion of the project. Equipment shall be opened for observation by the Architect/Engineer as required.

1.12 WATERPROOFING

A. Avoid, if possible, the penetration of any waterproof membranes such as roofs, machine room floors, basement walls, and the like. If such penetration is necessary, perform it prior to the waterproofing and furnish all sleeves or pitch-pockets required. Advise the Architect/Engineer and obtain written permission before penetrating any waterproof membrane, even where such penetration is shown on the Drawings.

B. If Contractor penetrates any walls or surfaces after they have been waterproofed, he shall restore the waterproof integrity of that surface as directed by the Architect/Engineer at his own expense, using workmen skilled in that trade.

1.13 SUPPORTS AND FASTENERS

A. Provide supports, hangers and auxiliary structural members required for support of the work according to Section 26 05 29 "Hangers and Supports for Electrical Systems" and Section 26 05 48 "Vibration and Seismic Control for Electrical Components."

B. Furnish and set all sleeves for passage of raceways through structural, masonry and concrete walls or floors and elsewhere as will be required for the proper protection of each raceway passing through building surfaces.

C. Wall mounted equipment may be directly secured to wall by means of steel bolts. Maintain at least 1" air space between equipment and supporting wall. Groups or arrays of equipment may be mounted on adequately sized steel angles, channels, or bars. Prefabricated steel channels providing a high degree of mounting flexibility, such as those manufactured by Kindorf, Glob-Strutt and Unistrut, may be used for mounting arrays of equipment.

1.14 PROHIBITED LABELS AND IDENTIFICATIONS

A. Prohibited Markings: In all public areas, tenant areas and similar locations within the project, the inclusion or installation of any item, element or assembly which bears on any exposed surface any name, trademark, or other insignia which is intended to identify the manufacturer, the vendor, or other source(s) from which such object has been obtained, is prohibited. Also prohibited is the inclusion or installation of any article which bears visible evidence that an insignia, name, label, or other device had been removed.

B. Exception: Required Underwriter's Laboratory labels shall not be removed nor shall identification specifically required under the various technical sections of the specifications be removed.

PART 2 - PRODUCTS

2.1 MATERIALS

A. If products and materials are specified or indicated on the Drawings for a specific item or system, use those products or materials. If products and materials are not listed in either of the above, use first class products and materials, subject to approval of Shop Drawings where Shop Drawings are required or as approved in writing where Shop Drawings are not required.

B. All equipment capacities, etc. are listed for job site operating conditions. All equipment sensitive to altitudes or ambient temperatures shall be derated and method of derating shown on Shop Drawings. Where operating conditions shown differ from the laboratory test conditions, the equipment shall be derated and the method of derating shown on Shop Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Follow manufacturer's instructions for installing, connecting, and adjusting all equipment. Provide one copy of such instructions to the Architect/Engineer before installing any equipment. Provide a copy of such instructions at the equipment during any work on the equipment. Provide all special supports, connections, wiring, accessories, etc.

B. Use mechanics skilled in their trade for all work.

C. Keep all items protected before and after installation. Clean up all debris.

D. Perform all tests required by local authorities in addition to tests specified herein, such as life safety systems.

E. Applicable equipment and materials to be listed by Underwriters' Laboratories and Manufactured in accordance with ASME, NEMA, ANSI or IEEE standards, and as approved by local authorities having jurisdiction as mentioned in Division 1.

F. Before commencing Work, examine all adjoining, underlying. Work on which this Work is in any way dependent for perfect workmanship and report any condition which prevents performance of first-class work. Become thoroughly familiar with actual existing conditions to which connections must be made or which must be changed or altered.

3.2 PROJECT MANAGEMENT AND COORDINATION

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

1. Schedule construction operations in sequence required to obtain the best results where installation of one part of the work depends on installation of other components, before or after its own installation.
2. Coordinate installation of different components with other contractors to ensure maximum accessibility for required maintenance, service, and repair.
3. Make adequate provisions to accommodate items scheduled for later installation.
4. Where availability of space is limited, coordinate installation of different components to ensure maximum performance and accessibility for required maintenance, service, and repair of all components, including mechanical and electrical.

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

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

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

1. Preparation of Contractor's Construction Schedule
2. Preparation of the Schedule of Values
3. Installation and removal of temporary facilities and controls
4. Delivery and processing of submittals
5. Progress meetings
6. Pre-installation conferences

7. Project closeout activities
8. Startup and adjustment of systems
9. Project closeout activities

D. Conservation: Coordinate construction activities to ensure that operations are carried out with consideration given to conservation of energy, water, and materials.

1. Salvage materials and equipment involved in performance of, but not actually incorporated into the work. Refer to other Sections for disposition of salvaged materials that are designated as Owner's property.

3.3 SUBMITTALS

A. Coordination Drawings: Prepare Coordination Drawings if limited space availability necessitates maximum utilization of space for efficient installation of different components or if coordination is required for installation of products and materials fabricated by separate entities.

1. Content: Project-specific information, drawn accurately to scale. Do not base Coordination Drawings on reproductions of the Contract Documents or standard printed data. Include the following information, as applicable:

a. Indicate functional and spatial relationships of components of architectural, structural, civil, mechanical, and electrical systems.
b. Indicate required installation sequence.
c. Indicate dimensions shown on the Contract Drawings and make specific note of dimensions that appear to be in conflict with submitted equipment and minimum clearance requirements. Provide alternate sketches to Architect/Engineer for resolution of such conflicts. Minor dimension changes and difficult installations will not be considered changes to the Contract.

2. All submittals shall be provided electronically.
3. Refer to individual Sections for Coordination Drawing requirements for work in those Sections.

B. Key Personnel Names: Within 15 days of starting construction operations, submit a list of key personnel assignments, including superintendent and other personnel in attendance at Project Site. Identify individuals and their duties and responsibilities; list addresses and telephone numbers, including home and office telephone numbers. Provide names, addresses, and telephone numbers of individuals assigned as standbys in the absence of individuals assigned to Project.

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

3.4 ADMINISTRATIVE AND SUPERVISORY PERSONNEL

A. General: In addition to Project Superintendent, provide other administrative and supervisory personnel as required for proper performance of the work.

END OF SECTION 26 05 00

SECTION 26 05 01 - SUMMARY OF WORK

PART 1 - GENERAL

1.1 SUMMARY

A. Provide the Work included in accordance with the Contract Documents.

B. Provide all labor, materials, equipment, tools, appliances, auxiliaries, services, hoisting, scaffolding, support, supervision, and Project Record Documents, and perform all operations for the furnishing and installing of the complete electrical system, including but not limited to the work described hereinafter. The work shall meet or exceed the latest codes, regulations and requirements required by the local Building Department (as mentioned in Division 01).

C. The electrical work is shown schematically on the Drawings to indicate the general system arrangement and configuration. The work of this Division shall include coordination with the work of other Divisions of the Specifications and the Contract Documents so as to provide a complete and operational system capable of being readily operated and maintained, including approved re-arrangement of the systems and equipment and re-routing of distribution services to enable the complete system to fit within the confines of the allotted electrical spaces, all to the satisfaction of the Architect/Engineer or as directed by the Architect/Engineer.

D. This specification encompasses work on two buildings within the School District. A separate summary of work for each follows. The work shall include but not limited to the following:

1. OFA High School / Middle School

    a. Panelboards (includes New or existing modifications).
    b. Electrical connections to new and replaced HVAC Equipment
    c. Feeder and branch circuits
    d. Wiring devices
    e. Fire alarm system modifications
    f. Grounding
    g. Identification
    h. Testing

1.2 SETTING OUT OF WORK

A. Layouts shown for mechanical equipment and elevator machine rooms are for estimating purposes only. Coordinate installation of conduit, outlets, luminaries, and equipment with final room equipment layout as supplied by equipment supplier.

B. Where switches, receptacles, fire alarm pull stations, are in the same general location, outlets shall be aligned vertically unless otherwise called for by the Architect. Comply with ADA mounting heights.

C. All equipment capacities, etc. are listed for job site operating conditions. All equipment sensitive to altitudes or ambient temperatures shall be derated and method of derating shown on the Shop Drawings.

D. Use mechanics skilled in their trade for all work.

E. Keep all items protected before and after installation. Clean up all debris.

F. Perform all tests required by local authorities in addition to tests specified herein, such as life safety systems.

G. Applicable equipment and materials shall be listed by Underwriters' Laboratories and manufactured in accordance with ASME, NEMA, ANSI or IEEE standards and as approved by local authorities having jurisdiction.

H. Before commencing work, examine all adjoining, underlying, etc., work on which this work is in any way dependent for perfect workmanship and report any condition which prevents performance of first-class work. Become thoroughly familiar with actual existing conditions to which connections must be made or which must be changed or altered.

1.3 MECHANICAL EQUIPMENT WIRING

A. Division 23 Contractor/s shall furnish all motor starters/variable frequency drives and disconnect switches for their equipment. Division 26 Contractor shall install these devices, including wiring between motors and starters and between starters and disconnects including terminations.

B. Starters and disconnects for equipment such as overhead doors or non-Division 23 equipment shall be furnished, installed, wired and terminated by Division 26 Contractor.

END OF SECTION 26 05 01

SECTION 26 05 03 - CODES, FEES

PART 1 - GENERAL

1.1 DESCRIPTION

A. General: Comply with Codes in accordance with the Contract Documents.

1.2 CODES

A. The electrical installation shall comply with the 2015 Edition of National Electrical Code (NFPA 70 2017), 2015 Edition of the International Building Code, IBC 2018, 2020 New York State Energy Code and any other agency or authority having jurisdiction in this area.

B. All equipment shall be equal to or exceed the minimum requirements of N.E.M.A., I.E.E.E., and UL.

C. Should any change in Drawings or Specifications be required to comply with governmental regulations, the Contractor shall notify Architect/Engineer prior to execution of the Work. The work shall be carried out according to the requirements of such code in accordance with the instruction of the Architect/Engineer and at no additional cost to the Owner.

D. The provisions of Standards, Codes, Laws, Ordinances, etc., shall be considered minimum requirements. In case of conflict between their published requirements, the Owner's Representative shall determine which is to be followed and his decision shall be binding. Specific requirements of this specification and/or the drawings which exceed the published requirements shall take precedence over them.

1.3 FEES

A. All local fees and permits and services of inspection authorities shall be obtained and paid for by the Contractor. The Contractor shall cooperate fully with local companies with respect to their services. Contractor shall include in his bid; any costs to be incurred relative to power service (primary and/or secondary) and telephone service.

PART 2 - PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

3.1 NOT USED

END OF SECTION 26 05 03

SECTION 26 05 10 - TESTING, INSPECTION AND CERTIFICATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. General – The Contractor shall completely test and inspect all systems in accordance with the specifications and drawings. The Contractor shall certify that all systems are in complete working order prior to turning over to the owner.

1.2 STANDARDS

A. Except as modified by governing codes and by the contract documents, comply with the latest applicable provisions and latest recommendations of the following:

1. NFPA
2. NEMA
3. NEC
4. IEEE
5. IPCEA
6. ANSI
7. UL
8. Local Fire Department

1.3 GENERAL TESTING

A. It shall be the responsibility of this Contractor to furnish all testing equipment and labor necessary to perform the following tests:

1. After wires or cables are in place, but before being connected to devices and equipment, the system shall be tested for shorts, opens, intentional and unintentional grounds. Wires or cables that are shorted or unintentionally grounded shall be replaced.
2. A voltage test shall be made on the last outlet of each branch circuit and the potential drop shall not exceed 2%. Voltage drops for panel and large feeders shall not exceed 3% hence the total voltage drop for a feeder and any branch circuit shall not exceed 5% of the service voltage. The test shall be made under design load or its equal.
3. Any wiring device or electrical apparatus in this contract, if grounded or shorted on an integral "line" part, shall be removed and the trouble corrected.
4. Complete test and inspection records shall be made and incorporated into a report for each piece of equipment tested. All readings taken shall be recorded. Four (4) copies shall be submitted to the Engineer for approval.
5. All tests must be conducted in the presence of Project Coordinator.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT AND MATERIALS

A. The Contractor shall provide all testing instruments, equipment and all materials, connections, etc., required to perform tests in accordance with these specifications.

PART 3 - EXECUTION

3.1 WIRING TEST

A. All wiring and cable tests shall be made before any circuits, main switch, motor, transformer or line is energized.

B. Tests shall be made for continuity, identification and absence of shorts and grounds for each conductor. Both ends of a given conductor shall be identified alike. Before circuit terminal connections are made, continuity and identification of wiring shall be checked by means of a DC test device using a bell, light, meter, or buzzer.

C. Insulation test shall be made at the following values:

480Y/277 Volt wiring at 1000 Volts DC
208Y/120 Volt wiring at 500 Volts DC

D. Insulation resistance between phase conductors and ground shall not be less than the minimum requirements of 2000 meg-ohms.

1. Wire terminations are not to be made to equipment (motors, VFD's, etc.), until that piece of equipment has been tested and verified as specified in this section.
2. Test motor feeders with motors disconnected, but with circuit breakers, switches or starters in the circuit opened so as to include only that portion of the feeder it is desired to test.
3. Test lighting feeders with the circuit breakers and panelboards connected but with lighting branch circuit breakers or switches open so as to include only the feeder circuit desired to test.

E. Contractor shall correct or replace any circuit which is defective or grounded and he shall also correct all other troubles encountered by these tests. All defects whether due to faulty workmanship or material furnished by the Contractor shall be corrected under this section at the Contractor's expense in a manner acceptable to the Engineer.

3.2 LIGHTING TEST

A. Check all lighting fixtures for proper operation. All Contractor supplied fixtures shall be 100% operable at no additional cost to the Owner. Repair cost to the Owner supplied fixtures shall not be the responsibility of the Contractor unless otherwise stated.

3.3 MOTOR TEST

A. All 460 volt motors shall be individually "spot tested" for insulation resistance using 1000V DC. All 208/120V motors shall be "spot tested" with 500V DC in a similar manner. The minimum resistance to ground shall be 2000 meg-ohm (corrected to 20 degrees C). The Contractor shall record the ambient temperature of the motor and submit this value along with insulation resistance value.

B. Make the following checks on all motors prior to start-up:

1. Check motor name plates for H.P., speed, phase and voltage. Verify proper wiring.
2. Check shaft for freedom of rotation.
3. Verify that the motor is properly lubricated prior to energizing.

C. Contractor shall furnish a proper sized heater for each overload relay, where applicable. Notify the Engineer prior to installation of the motor full-load current rating, the number of overload relays, the starter catalog number, and the heater catalog number.

D. Make the following tests on all motors during or immediately after start-up:

1. Check for proper shaft rotation.
2. Check motor for smooth operation (vibration).
3. Take a current reading using a clamp-on ammeter. (No-load readings and loaded readings).

E. Equipment shall be put into operation after certification by the Contractor that the installation is satisfactory.

3.4 PANELBOARD

A. "Spot Test" all equipment to be operated on the 208/120V system at 500V DC prior to connecting feeders. A minimum insulation resistance of 2000 meg-ohms shall be obtained between all phases and between phase and ground.

3.5 TRANSFORMER (POWER 600V OR LESS) TEST

A. Insulation tests on transformers shall be as follows:

1. 480 Volts High Sides:

   "Spot Test" with 1000V DC, high side winding to low side winding and high side winding to ground. 2000 meg-ohm shall be the minimum acceptable insulation resistance.
2. 208/120 Volts Low Side:

   "Spot Test" with 500V DC, low side to ground. 2000 meg-ohm shall be the minimum acceptable insulation resistance.

3.6 SPOT TEST

A. "Spot Test" mentioned in this section shall be interpreted as the specific test method of obtaining insulation resistance by applying indicated test voltage for 60 seconds to the equipment or wiring being tested.

3.7 CONTROL WIRING/OUTLET TEST

A. Control wiring shall perform the function as noted in operation methods and/or included schematics and single line diagrams.

B. All 120-volt outlets shall be tested with a Daniel Woodhead Cat. No. 1750 and 1760 tester under the supervision of the Coordinator. Minimum acceptable tension is 4 oz. for NEMA 1-15R, and 5-20R, 6-15R, 6-20R, 7-15R, 7-20R, 14-15R, 14-20R, 15-15R and 15-20R.

END OF SECTION 26 05 10

SECTION 26 05 15 - CEILING, FLOOR AND WALL ELECTRICAL PENETRATION FIRE SEALS

PART 1 - GENERAL

1.1 DESCRIPTION

A. General: Provide premixed putty sealant at ceiling and/or floor electrical penetration fire seals in accordance with the Contract Documents.

B. Related Work Specified in Division 26:

1.	Raceways and Boxes	Section 26 05 33
2.	Wires and Cable (0-1000V)	Section 26 05 21
3.	Penetration Firestopping	Section 07 84 13

1.2 STANDARDS

A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:

1. ASTM E119-73
2. UL 1479

1.3 SUBMITTALS

A. Submit manufacturer's data for fire seal compound

B. Submit proof of approval by local authorities.

PART 2 – PRODUCTS

2.1 APPROVED MANUFACTURERS

A. Hilti Inc.

B. Nelson Firestop Products

C. Grace Construction Products

2.2 The system shall provide an immediate fire seal, require no curing time, emit no hazardous or toxic fumes and be asbestos free.

2.3 The system shall be easy to use, require no special tools and shall be capable of being installed from one side.

2.4 The system shall not require derating whatsoever of the wiring systems passing through the seal.

2.5 The system shall be field modified for additions or deletions of raceways or cables.

2.6 Existing materials must be reusable to accommodate penetration changes.

2.7 The system shall maintain the fire rating of the structure it is protecting.

PART 3 – EXECUTION

3.1 GENERAL

A. Putty shall be installed no thinner than 0.75 inches.

D. A minimum of 0.5 inches of putty shall be placed around each penetrating item. When this is not possible, a cone shall be built up around the penetrating items, using a second layer of putty. Slope the cone at 30 degrees from wall or floor.

E. Wall openings must not have an unsupported space of putty greater than 4 inches and floor openings an unsupported opening of 1.5 inches.

F. Provide ceramic wool temperature rated 2300 degrees F. in conjunction with putty in accordance with the manufacturer's instructions

G. Provide ceramic fiberboard temperature rated 2000 degrees F. in conjunction with the putty in accordance with the manufacturer's recommendation

H. Penetrating items must be firmly anchored prior to the putty installation. Provide all necessary anchor bolts, fittings, etc., as necessary

3.2 INSTALLATION

A. Provide fire seals at all cable, conduit and bus duct penetrations through fire rated walls, floors and ceilings, and where noted on Drawings. Coordinate with architectural and structural drawings for location of fire rated walls.

B. Fire seal shall be installed in accordance with manufacturer's direction to provide a barrier rating equal to or greater than the barrier rating of the wall, floor or ceiling.

END OF SECTION 26 05 15

SECTION 26 05 21 - WIRES AND CABLES (0-1000V)

PART 1 - GENERAL

1.1 DESCRIPTION

A. General

1. Provide 600-volt wire and cable in accordance with the Contract Documents.

1.2 STANDARDS

A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:

1. General: Underwriters' Laboratories labeling of all insulations and jackets.
2. Rubber Insulated Wire and Cables

    a. ICEA pub. No. S-19-81 (NEMA Pub. No. WC 3): Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
    b. UL 44: Rubber-Insulated Wires and Cables

3. Thermoplastic Insulated Wire and Cables

    a. ICEA pub. No. 1 S-614-02 (NEMA Pub. No. WC3): Thermoplastic Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
    b. UL 83: Wires, Thermoplastic-Insulated

4. Cross Linked Thermosetting Polyethylene Insulated Wire and Cables

    a. ICEA pub. No. S-66-524: (NEMA Pub. No. WC7): Cross Linked Thermosetting Polyethylene Insulated Wire and Cable for Transmission and Distribution of Electrical Energy.
    b. UL 44: Rubber Insulated Wires and Cables
    c. UL 854: Service-Entrance Cables.

5. Annealed Copper Wire for Conductors

    a. ASTM B-3: Soft or Annealed Copper Wire

6. Terminal Blocks

    a. UL 1059

7. Insulation Thicknesses for Individual conductors

a. N.E.C. Table 310-13: Conductor Application and Insulations.

1.3 SUBMITTALS

A. Provide listing of manufacturers proposed for this project.

1.4 RELATED WORK SPECIFIED IN DIVISION 26

A. Section 26 05 10 – Testing, Inspection and Certification.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver wire and cable to job site on reels or coils marked in accordance with N.E.C. Section 310-11.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Wire and Cable:

1. Anaconda
2. The Okonite Company
3. Phelps Dodge Copper Products Corporation
4. Southwire Company
5. Or approved equal

B. Connectors (UL Approved):

1. Hand-Applied:

a. T&B "Piggy"
b. 3M Company "Scotchlok"
c. Ideal Industries "Wing Nut"
d. Buchanan "Squeeze On"
e. Or approved equal

2. Tool-Applied:

a. T&B "Stakon" or Series "54475" through "54490"
b. Ideal Industries "410 Crimp Connector"
c. Burndy "KA-U" or "YA"
d. ILSCO "TA", or "AU" or "D"

e. Buchannan "Wrap Cap"
f. Or approved equal

C. Electrical Tape

1. W.H. Brady "B-500+", "B-500"
2. T&B "E-Z" code Type WBC
3. 3M "Scotch 35" vinyl plastic, electrical
4. Johns-Manville
5. Or approved equal

2.2 WIRE AND CABLE

A. General

1. Provide wire with a minimum insulating rating of 600 volts, except for wire used in 50 volts or below applications for control of signal systems, use 300 volt minimum. Where permitted to be incorporated with other wiring systems, 600 volt wire shall be used for lower voltage wiring systems.
2. Conductor construction and application shall comply with N.E.C. article 310.104. Allowable ampacities shall comply with Table 310.15 (B) (16) or other applicable tables based on temperature and location. In general, wire shall be rated 90° C. Use the 75° C column for ampacities. For ambient temperatures other than 30° C, use the proper correction factor listed for each table.

B. Conductor

1. Electrical grade, annealed copper, tinned if rubber insulated and fabricated in accordance with ASTM standards. Minimum size number 12 for branch circuits; number 18 for control wiring.
2. The conductors illustrated on the drawings are copper. Except as otherwise noted, aluminum is not permitted.

C. Stranding and Number of Conductors

1. Number 12 and number 10 conductors shall be solid.
2. Cables larger than number 10, stranded in accordance with ASTM Class B stranding designations.
3. Control wires stranded in accordance with ASTM Class B stranding designations.
4. Cables, multi-conductor unless otherwise noted for low-tension systems.

D. Insulated Single Conductors

1. Type THHN – Flame retardant: Heat resistant thermoplastic insulation, nylon jacket rated for 90 C operation. Use for lighting branch circuit wiring installed and passing through the ballast channels of fluorescent fixtures, wiring in metal roof-decks in or near roof insulation in attic or joist spaces, or in raceways exposed to the sun.
2. Type THWN - 75°C: Use in dry or wet locations.

E. Color Coding

1. Provide consistent color coding of all feeders, sub feeders, motor circuits and the likes as follows:

a. 480/277 volts code

1) Phase A – Brown, Neutral-Gray
2) Phase B – Orange, Ground-Green with Yellow Stripes
3) Phase C - Yellow

b. 208/120 volts code

1) Phase A – Black
2) Phase B – Red
3) Neutral – White
4) Ground – Green

2. Color-code wiring for control systems installed in conjunction with mechanical and/or miscellaneous equipment in accordance with the wiring diagrams furnished with the equipment. Factory color code wire number 2 and smaller. Wire number 1 and larger may be color coded by color taping of the entire length of the exposed ends.

2.3 CONNECTORS

A. Make connections, splices and taps and joints with solderless devices, mechanically and electrically secure. Protect exposed wires and connecting devices with electrical tape or insulation to provide protection not less than that of the conductor.

B. Branch circuit wires (number 10 and smaller):

1. Hand-Applied

a. Coiled, tapered, spring wound devices with a conducting corrosion-resistant coating over the spring steel and a plastic cover and skirt providing full insulation for splice and wired ends. Screw connector on by hand.
b. Hydraulic tool of the same lug manufacturer shall be used and hydraulic tool shall emboss on the connector the proper die number for inspection.

2.4 ELECTRICAL TAPE

A. Specifically designed for use as insulating tape.

2.5 LUBRICANT

A. Use lubricant only where the possibility of damage to conductors exists. Use only a lubricant approved by the cable manufacturer and one, which is compatible with cable and raceways.

PART 3 - EXECUTION

3.1 WIRE AND CABLE

A. Provide a complete system of conductors in raceway system. Mount wiring through a specified raceway regardless of voltage application.

B. Drawings indicate the minimum size wiring for branch circuits. Use No. 12 AWG, minimum, use larger wire sizes for lighting and power branch circuits where indicated on the drawings to allow for voltage drop.

C. Do not install wire in incomplete conduit runs or until after the concrete work and plastering is completed and moisture is swabbed from conduits. Eliminate splices wherever possible. Where necessary, splice in readily accessible pull, junction or outlet box.

D. Flashover or insulation value of joints shall be equal to that of the conductor. Provide Underwriters' Laboratories listed connectors rated to 600 volts for general use.

E. Use terminating fittings, connectors, etc., of a type suitable for the specified cable furnished. Make bends in cable at termination prior to installing compression device. Make fittings tight.

F. Install wire in raceways and make up terminations in accordance with manufacturer's recommendations using special washers, nuts, etc., as required. Use an accepted wire pulling lubricant equivalent to "Yellow" (Ideal) for all wire number 4 and larger. Strip insulation so as to avoid nicking of wire.

G. Extend wire sizing for the entire length of a circuit, feeder, etc. unless specifically noted otherwise.

H. Where multiwire branch circuits (connected to multiple overcurrent devices) are installed in a single conduit, derating adjustments in accordance with NEC 310.15 shall apply. The neutrals shall be counted as current carrying conductors. Up to three single phase circuits may share a common neutral.

I. Where a three-phase circuit consisting of (3) three phase wires, (1) one neutral, and (1) one ground wire connected to a single over-current device is installed in a single conduit, derating adjustments outlined in NEC 310.15 shall not apply.

J. Conductors and Insulation Applications

1. Type THWN – THWN Shall be used for all feeders and branch circuits.
2. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway, Armored cable, Type AC Metal-clad cable or Type MC metal clad cable where permitted by N.E.C. articles 320 and 330.
3. Cord Drops and Portable Appliance Connections: Type SO, hard service cord.
4. Fire Alarm Circuits: Type THHN-THWN, in raceway or Power-limited, fire-protective, signaling circuit cable suitable for use in Plenums. Use metal raceways where required in Section 28 31 02 Multiplex Fire Alarm Systems.

5. Class 1 Control Circuits: Type THHN-THWN, in raceway.
6. Class 2 Control Circuits: Type THHN-THWN, in raceway Power-limited cable, concealed in building finishes Power-limited tray cable, in cable tray.
7. Use Type AC/MC cables for fixture whips not to exceed 6 ft. length.
8. The following cable types are not allowed in School Buildings in New York State: NM, NMC, NMS, SE, USE, UF, FC, FCC and TC Cables.

3.2 INSTALLATION

A. General

1. Provide tools, equipment and materials to pull all wire and cable into place and to make required splices and termination.

B. Wire and Cable in Conduit, Duct or Wireway

1. Utilize roller bearing swivel to prevent twisting of cable entering conduit or duct.
2. Take precautions to avoid entrance of dirt and water into conduit and ducts.
3. Clean existing conduits and ducts to remove any pulling compound prior to pulling new cables.
4. Do not damage conductor insulation, braid jacket or sheath.
5. Do not bend conductors to less than manufacturer's recommended radius.
6. Lubricate cable if required for pulling using powdered soapstone or pulling lubricants; do not use oils or greases.
7. Make splices only in pull boxes, junction boxes and outlet boxes.
8. Utilize cable reels on jacks for pulling through pull boxes, ducts and conduits so bends will not be excessive and conductors will not touch sharp edges; use feeding tube where required.
9. For large diameter cables, utilize properly sized pulling grips (open-ended woven basket, two to four feet long, of ductile steel).
10. Do not exceed maximum recommended pulling tension of wire and cable.

C. Splices, Terminations and Connections

1. General: Except where lugs are furnished with equipment, provide terminals and connectors suitable for quantity, conductor size temperature rating and direction of entry (top or bottom).
2. Insulated Flanged Terminals: Install for connection of conductors No. 12 AWG and smaller to device terminals; do not exceed three terminals at single connections.
3. Circumferential Compression Type Connectors: Install for splices and connections No. 4 AWG and larger.

    a. Use for incoming and outgoing cable connections at enclosures and for ground connections.
    b. Use manufacturer's approved tool and correct hex head which embosses die number on connector lug.
    c. Make crimped indentations parallel with conductor.
    d. Fill voids and irregularities with insulation putty.

e. Cover neatly with four (4) layers of vinyl plastic tape except where insulated covers are permitted; half-lap tape in two directions.
f. Use spring-held bakelite covers over splices or taps only with approval of Owner's representative.

4. Conductor Arcproofing

a. Cover two or more power feeder cables occurring in the same switchboard section, junction box or pull box (including pull boxes over switchboards) with arcproof and flameproof tape, except if boxes or compartments are barriered.
b. Provide tape "Scotch" Irvington Tape No. 7700 or Plymouth Rubber Co. Slipknot No. 30 to provide an insulation capable of withstanding a 200-amp arc for not less than 30 seconds.
c. Apply tape in a single layer, half-lapped, or as recommended by the manufacturer to conform to the above requirements. Apply with a random wrap of 1/2 inch (15mm) wide pressure sensitive, plastic film tape color coded as specified in the "conductor identification" paragraph.

D. Wire Marker Identification Labels

1. Utilize labels for all feeders and for those circuits where individual conductor identification is indicated on Drawings.
2. Apply to wires and cables at terminals and in all pull junction and splice boxes.
3. Do not cut and splice multi-conductor control cable for purpose of labeling.
4. Clean surfaces before applying labels.
5. Tag and tape all spare wiring.

3.3 FIELD QUALITY CONTROL

A. Testing

1. Test system wiring for continuity, grounds and short circuits prior to connection of any equipment.
2. Test final equipment connections for proper torque.
3. Insulation Resistance of Feeders and Subfeeders

a. Test with megger for insulation resistance.
b. Locate faults and replace sections found to have faulty insulation.
c. Demonstrate installation is free of grounds and short circuits and that insulation resistance complies with ICEA values.

END OF SECTION 26 05 21

SECTION 26 05 26 - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 DESCRIPTION

A. General: Provide a low impedance grounding system in accordance with the Contract Documents.

1. Purpose of grounding system:

a. Adequate path for ground fault currents.
b. Safety to personnel from accidental electric shock hazards.
c. Prevention of hazardous discharge of static electricity.

2. Whether or not indicated on Drawings, provide continuous ground path for all electrical circuits from point of utilization back to source through ground wires, bonded metallic conduit runs, grounded cable trays, and related items.

B. Electrical Equipment: Provide complete exterior and interior grounding system, including grounding provisions for low voltage switchboard, surge protective devices, motors, emergency generators and other equipment as indicated on Drawings or required by applicable standards.

C. Miscellaneous Equipment: Provide complete grounding for flag poles, metal lighting standards, metal antennas, steel framework of buildings, elevators, and other equipment as indicated on Drawings or required by applicable standards.

D. Related Work Specified in Division 26

1. Section 26 05 10 – Testing, Acceptances and Certifications
2. Section 26 05 14 – Equipment Connections and Coordination
3. Section 26 05 21 –Wires and Cables
4. Section 26 05 33 – Raceways and Boxes
5. Section 26 27 26 – Wiring Devices

E. Related Work Specified in Other Divisions of these Specifications.

1. Concrete
2. Metallic water piping

1.2 STANDARDS

A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:

1. Underwriters Laboratory Standard No. U.L. 467.

2. ANSI C-1 1978
3. IEEE Standards No. 142-1982 and No. 80
4. National Electrical Safety Code
5. NFPA
6. Federal Information Processing Standards, Publication #94

1.3 SUBMITTALS

A. Provide a complete set of shop drawings showing service grounding methods as called for on the Contract Documents.

B. Submit test reports certifying resistance values for buried or driven grounds and water pipe grounds.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Ground Connectors and Clamps; Grounding Bushings and Locknuts.

1. Electrical fitting Corp. (EFCOR)
2. Gedney Electric Company
3. Thomas & Betts
4. Or approved equal

B. Welding Type Ground Connectors:

1. Burndy Engineering Company (Thermoweld)
2. Erico Products, Inc. (Cadweld)
3. Or approved equal

C. Compression Type Grid Connectors:

1. Thomas & Betts Company – Series, 53,000
2. Burndy Corp. – Cat No. YGL-C
3. Or approved equal

D. Ground Rods and Clamps

1. Copperweld Steel Company
2. ITT Blackburn Corp.
3. J.A. Weaver Company
4. Or approved equal

E. Electrical Insulating Tapes:

1. Self-Fusing: 3M Company No. 23

2. Vinyl: 3M Company No. 33+

F. Compound for Compression Connectors:

1. Thomas & Betts Co. – Kopr/Shield
2. Brundy Engineering Company – Penetrox "E"
3. Or approved equal

2.2 MATERIALS

A. Ground Cables: Bare or green color coded, insulated, annealed stranded tinned copper wire as indicated on Drawings; insulated wire to conform to requirements of Section 26 05 21.

B. Mechanical Connectors: Tin-plated aluminum alloy, UL approved and stamped for use with aluminum or copper conductors.

C. Ground Rods:

1. Copper-clad steel fabricated by molten welding process
2. Diameter: 3/4 inch.
3. Length: 10 feet

2.3 GENERAL

A. Furnish and install electrical grounding systems as indicated on the construction documents and as specified herein.

B. Grounding systems shall be installed in accordance with the requirements of the local authorities, NEC Section 250, and subject to the approval of the Architect/Engineer.

C. Install equipment grounding conductors in all feeders and branch circuits.

D. Install insulated equipment grounding conductor with circuit conductors for the following items, in addition to those required by NEC:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Flexible raceway runs.
6. Armored and metal-clad cable runs.

E. All ground wires and bonding jumpers shall be stranded copper installed in conduit. All ground wires shall be without joints and splices over its entire length.

F. The system neutral shall be grounded at the service entrance only, and kept isolated from grounding systems throughout the building.

G. Each system of continuous metallic piping and ductwork shall be grounded in accordance with the requirements of the NEC Section 250.

H. Mechanical equipment shall be bonded to the building equipment grounding system. This shall include but is not limited to, fans, pumps, chillers, etc.

I. Metallic conduits and portions of metallic piping and duct systems which are isolated by flexible connections, insulated couplings, etc., shall be bonded to the equipment ground with a flexible bonding jumper, or separate grounding conductor.

J. Metal raceways, cable trays, cable armor, cable sheath, enclosures, frames, fittings and other metal noncurrent-carrying parts that are to serve as grounding conductors shall be effectively bonded where necessary to assure electrical continuity and the capacity to conduct safely any fault current likely to be imposed on them. Any non-conductive paint, enamel, or similar coating shall be removed at threads, contact points and contact surfaces or be connected by means of fittings so designed as to make such removal unnecessary.

2.4 RECEPTACLES

A. Receptacles shall be grounded to the outlet box by means of a bonding jumper between the outlet box and the receptacle-grounding terminal.

2.5 MDF/IDF/TELECOM ROOMS

A. In each MDF/Telecom room, provide a 1/4” x 2” x 2 ft. long copper ground bus, wall mounted on stand-offs and located near the main cable entrances. From each ground bus, run a #6 ground wire to the service entrance ground.

2.6 OUTDOOR EQUIPMENT

A. Outdoor enclosures shall be connected with No. 4 bare copper installed not less than 24 inches below grade, connecting to the indicated ground rods or ground grid. Equipment connections shall be bare copper No. 4.

2.7 CONCENTRIC KNOCKOUTS

A. Provide grounding type bushings for conduits terminated through multiple concentric knockouts not fully knocked out, on inside of electrical enclosures. Ground bushing with #12 bare copper to ground bus within enclosure or to enclosure proper where a ground bus is not present.

2.8 TOGGLE SWITCHES

A. Provide grounding clip on each toggle switch. Mount over device mounting strap such that contact is made between mounting strap, screw, faceplate and outlet box.

B. Provide devices with ground screw where required by local authorities and bond this with #10 conductor to associated outlet box.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Ground Conductors:

1. Size as shown on Drawings or as required by NEC Table 250-66 and 250.122.
2. Where ground cables are required, install insulated copper ground conductors in steel conduit, or as indicated.
3. Where ground cable is protected by metallic conduit, bond cable to conduit at both ends.
4. Connect ground conductors in cables and in conduit to appropriate ground buses (as in switchgear, motor control centers, and distribution panelboards) or directly to metallic enclosure if no ground bus is provided.

B. Conduit Attachment to Electrical Equipment:

1. Ground conduits to metal framework of electrical equipment with double locknuts or grounding bushings and bonding jumpers unless otherwise noted.
2. Install bonding jumpers at all electrical equipment to provide continuous ground return path through conduit.
3. Install NEC approved bonding jumpers across expansion fittings between conduit sections for ground path continuity.
4. Bond conduits to cable tray where conduit enters or exits tray.
5. Where motors or other utilization equipment are connected to electrical system with flexible conduit, ground by one of the following:

    a. Flexible metal conduit alone if length is 6 feet or less, conduit is terminated in fitting approved for purpose, and circuit conductors contained therein are protected by overcurrent devices rated 20 at amperes or less.
    b. External jumper across flexible conduit.
    c. Flexible conduit containing integral ground wire.
    d. Do not install external jumpers for flexible conduit connections to kitchen equipment.

C. Wiring Troughs:

1. Use metallic raceway system for principal ground return path, unless otherwise called for on the drawings.
2. Bond wiring troughs containing power circuits and tie to ground bus at switchboards and panelboards; install minimum No. 4/0 AWG copper conductors for bonding between cable system and switchboard ground buses.
3. Apply antioxidant compound to contact surfaces for all bonding connections to cable tray.
4. Install bonding jumpers across hinged joints.

D. Receptacles and Switches:

1. Install bonding jumpers between outlet box and receptacle grounding terminal except where contact device or yoke is provided for grounding purposes.

E. Wireways: Install grounding jumpers for bonding between wireway and other panelboards, conduit, switchboard, and at any other point where solid connection would otherwise not be provided in supporting system to insure continuous ground.

F. Panelboards: Install bonding jumpers inside (if possible) all panelboards to bond feeder conduit to panelboards, except ground panelboards containing branch circuits each having less than 150 amperes current carrying capacity, with two standard locknuts and bushings, one inside and one outside, run up wrench tight.

G. Sheet Metal Boxes:

1. Install bonding jumpers inside (if possible) all sheet metal boxes containing one or more feeders with current carrying capacity of 150 amperes or greater, to bond one conduit with another.
2. Ground boxes containing branch circuits only or feeders each less than 150 amperes current carrying capacity, with two standard locknuts and bushings, one inside and one outside, run up wrench tight.
3. Panelboards: Install bonding in sheet metal boxes in systems over 600 volts, regardless of current carrying capacity.

H. Floor Boxes: Install grounding jumpers where adequate ground connections are not provided through locking screws between high potential power service fittings, cover plates and conduit system.

3.2 FIELD QUALITY CONTROL:

A. Resistance Values for System and Equipment Grounds: For each ground rod and ground grid.

1. Acceptable Testing Equipment: Vibroground by Associated Research, Inc.; or Megger Earth Tester by James G. Biddle Co.
2. Method: Three (3) electrode fall of potential as prescribed by instrument manufacturer.
3. Drive additional ten-foot ground rods spaced eight feet apart, if necessary, until total resistance of system is measured at five ohms or less.

END OF SECTION 26 05 26

SECTION 26 05 29 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Shop Drawings: Show support details if different from methods specified or shown on the drawings.

B. Product Data: Catalog sheets, specifications and installation instructions.

PART 2 - PRODUCTS

2.1 ANCHORING DEVICES

A. Sleeve Anchors (FS FF-S-325 Group II, Type 3, Class 3): Molly/Emhart's Parasleeve Series, Phillips' Red Head AN, HN, FS Series, or Ramset's Dynabolt Series.

B. Wedge Anchors (FS FF-S-325 Group II, Type 4, Class 1): Hilti's Kwik Bolt Series, Molly/Emhart's Parabolt Series, Phillips' Red Head WS, or Ramset's Trubolt Series.

C. Self-Drilling Anchors (FS FF-S-325 Group III, Type 1): Phillips' Red Head Series S or Ramset's Ram Drill Series.

D. Non-Drilling Anchors (FS FF-S-325 Group VIII, Type 1): Hilti's Drop-In Anchor Series, Phillips' Red Head J Series, or Ramset's Dynaset Series.

E. Stud Anchors (FS FF-S-325 Group VIII, Type 2): Phillips' Red Head JS Series.

2.2 MISCELLANEOUS FASTENERS

A. Except where shown otherwise on the Drawings, furnish type, size, and grade required for proper installation of the Work, selected from the following: Furnish galvanized fasteners for exterior use, or for items anchored to exterior walls, except where stainless steel is indicated.

1. Standard Bolts and Nuts: ASTM A 307, Grade A, regular hexagon head.
2. Lag Bolts: FS FF-B-561, square head type.
3. Machine Screws: FS FF-S-92, cadmium plated steel.
4. Machine Bolts: FS FF-B-584 heads; FF-N-836 nuts.
5. Wood Screws: FS FF-S-111 flat head carbon steel.
6. Plain Washers: FS FF-W-92, round, general assembly grade carbon steel.
7. Lock Washers: FS FF-W-84, helical spring type carbon steel.
8. Toggle Bolts: Tumble-wing type; FS FF-B-588, type, class and style as required to sustain load.

B. Stainless Steel Fasteners: Type 302 for interior Work; Type 316 for exterior Work; Phillips head screws and bolts for exposed Work unless otherwise specified.

2.3 TPR (THE PEEL RIVET) FASTENERS

A. 1/4 inch diameter, threadless fasteners distributed by Subcon Products, 315 Fairfield Road, Fairfield, NJ 07004 (800) 634-5979.

2.4 POWDER DRIVEN FASTENER SYSTEMS

A. Olin Corp.'s Ramset Fastening Systems, or Phillips Drill Company Inc.'s Red Head Powder Actuated Systems.

2.5 HANGER RODS

A. Mild low carbon steel, unless otherwise specified; fully threaded or threaded each end, with nuts as required to position and lock rod in place. Unless galvanized or cadmium plated, provide a shop coat of red lead or zinc chromate primer paint.

2.6 "C" BEAM CLAMPS

A. With Conduit Hangers:

1. For 1 Inch Conduit Maximum: B-Line Systems Inc.'s BG-8, BP-8 Series, Caddy/Erico Products Inc.'s BC-8P and BC-8PSM Series, or GB Electrical Inc.'s HIT 110-412 Series.
2. For 3 Inch Conduit Maximum: Appleton Electric Co.'s BH-500 Series beam clamp with H50W/B Series hangers, Kindorf's 500 Series beam clamp with 6HO-B Series hanger, or OZ/Gedney Co.'s IS-500 Series beam clamp with H-OWB Series hanger.
3. For 4 Inch Conduit Maximum: Kindorf's E-231 beam clamp and E-234 anchor clip and C-149 series lay-in hanger; Unistrut Corp.'s P2676 beam clamp and P-1659A Series anchor clip with J1205 Series lay in hanger.

B. For Hanger Rods:

1. For 1/4 Inch Hanger Rods: B-Line Systems Inc.'s BC, Caddy/Erico Products Inc.'s BC, GB Electrical Inc.'s HIT 110, Kindorf's 500, 510, or Unistrut Corp.'s P1648S, P2398S, P2675, P2676.
2. For 3/8 Inch Hanger Rods: Caddy/Erico Products Inc.'s BC, Kindorf's 231-3/8, 502, or Unistrut Corp.'s P1649AS, P2401S, P2675, P2676.
3. For 1/2 Inch Rods: Appleton Electric Co. BH-500 Series, Kindorf's 500 Series, 231-1/2, OZ/Gedney Co.'s IS-500 Series, or Unistrut Corp.'s P1650AS, P2403S, P2676.
4. For 5/8 Inch Rods: Unistrut Corp.'s P1651AS beam clamp and P1656A Series anchor clip.

2.7 CHANNEL SUPPORT SYSTEM

A. Channel Material: 12 gage steel.

B. Finishes:

1. Phosphate and baked green enamel/epoxy.
2. Pre-galvanized.
3. Electro-galvanized.
4. Hot dipped galvanized.
5. Polyvinyl chloride (PVC), minimum 15 mils thick.

C. Fittings: Same material and finish as channel.

D. UL Listed Systems:

1. B-Line Systems Inc.'s B-22 (1-5/8 x 1-5/8 inches), B-12 (1-5/8 x 2-7/16 inches), B-11 (1-5/8 x 3-1/4 inches).
2. Grinnell Corp.'s Allied Power-Strut PS 200 (1-5/8 x 1-5/8 inches), PS 150 (1-5/8 x 2-7/16 inches), PS 100 (1-5/8 x 3-1/4 inches).
3. Kindorf's B-900 (1-1/2 x 1-1/2 inches), B-901 (1-1/2 x 1-7/8 inches), B-902 (1-1/2 x 3 inches).
4. Unistrut Corp.'s P-3000 (1-3/8 x 1-5/8 inches), P-5500 (1-5/8 x 2-7/16 inches), P-5000 (1-5/8 x 3-1/4 inches).
5. Versabar Corp.'s VA-1 (1-5/8 x 1-5/8 inches), VA-3 (1-5/8 x 2-1/2 inches).

2.8 MISCELLANEOUS FITTINGS

A. Side Beam Brackets: B-Line Systems Inc.'s B102, B103, B371-2, Kindorf's B-915, or Versabar Corp.'s VF-2305, VF-2507.

B. Pipe Straps:

1. Two Hole Steel Conduit Straps: B-Line Systems Inc.'s B-2100 Series, Kindorf's C-144 Series, or Unistrut Corp.'s P-2558 Series.
2. One Hole Malleable Iron Clamps: Kindorf's HS-400 Series, or OZ/ Gedney Co.'s 14-G Series, 15-G Series (EMT).

C. Deck Clamps: Caddy/Erico Products Inc.'s DH-4-T1 Series.

D. Fixture Stud and Strap: OZ/Gedney Co.'s SL-134, or Steel City's FE-431.

E. Supporting Fittings for Pendent Mounted Industrial Type Fixtures on Exposed Conduit System:

1. Ball Hanger: Appleton Electric Co.'s AL Series, or Crouse-Hinds Co.'s AL Series.
2. Flexible Fixture Hanger: Appleton Electric Co.'s UNJ-50, UNJ-75, or Crouse-Hinds Co.'s UNJ115.
3. Flexible (Hook Type) Fixture Hanger: Appleton Electric Co.'s FHHF, or Crouse-Hinds Co.'s UNH-1.

4. Eyelet: Unistrut Corp.'s M2250.
5. Eyelet with Stud: Kindorf's H262, or Unistrut Corp.'s M2350.
6. Conduit Hook: Appleton Electric Co.'s FHSN, or Crouse-Hinds Co.'s UNH-13.

F. Supporting Fasteners (Metal Stud Construction): Metal stud supports, clips and accessories as produced by Caddy/Erico Products Inc.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Where specific fasteners are not specified or indicated for securing items to in-place construction, provide appropriate type, size, and number of fasteners for a secure, rigid installation.

B. Install anchoring devices and other fasteners in accordance with manufacturer's printed instructions.

C. Make attachments to structural steel wherever possible.

3.2 FASTENER SCHEDULE

A. Material:

1. Use cadmium or zinc coated anchors and fasteners in dry locations.
2. Use hot dipped galvanized or stainless-steel anchors and fasteners in damp and wet locations.
3. For corrosive atmospheres or other extreme environmental conditions, use fasteners made of materials suitable for the conditions.

B. Types and Use: Unless otherwise specified or indicated use:

1. Anchoring devices to fasten items to solid masonry and concrete when the anchor is not subjected to pull out loads, or vibration in shear loads.
2. Toggle bolts to fasten items to hollow masonry and stud partitions.
3. TPR fasteners to fasten items to plywood backed gypsum board ceilings.
4. Metallic fasteners installed with electrically operated or powder driven tools for approved applications, except:

    a. Do not use powder driven drive pins or expansion nails.
    b. Do not attach powder driven or welded studs to structural steel less than 3/16 inch thick.
    c. Do not support a load, in excess of 250 lbs. from any single welded or powder driven stud.
    d. Do not use powder driven fasteners in precast concrete.

3.3 ATTACHMENT SCHEDULE

A. General: Make attachments to structural steel or steel bar joists wherever possible. Provide intermediate structural steel members where required by support spacing. Select steel members for use as intermediate supports based on a minimum safety factor of 5.

1. Make attachments to steel bar joists at panel points of joists.
2. Do not drill holes in main structural steel members.
3. Use "C" beam clamps for attachment to steel beams.

B. Where it is not possible to make attachments to structural steel or steel bar joists, use the following methods of attachment to suit type of construction unless otherwise specified or indicated on the drawings:

1. Attachment to Steel Roof Decking (No Concrete Fill):

a. Decking With Hanger Tabs: Use deck clamps.
b. Decking Without Hanger Tabs:

1) Before Roofing Has Been Applied: Use 3/8 inch threaded steel rod welded to a 4 x 4 x 1/4 inch steel plate and installed through 1/2 inch hole in roof deck.
2) After Roofing Has Been Applied: Use welding studs, or self-drilling/tapping fasteners. Exercise extreme care when installing fasteners to avoid damage to roofing.

2. Attachment to Concrete Filled Steel Decks (Total thickness, 2-1/2 inches or more):

a. Before Fill Has Been Placed:

1) Use thru-bolts and fish plates.
2) Use welded studs. Do not support a load in excess of 250 pounds from a single welded stud.

b. After Fill Has Been Placed: Use welded studs. Do not support a load in excess of 250 lbs from a single welded stud.

3. Attachment to Cast-In-Place Concrete:

a. Fresh Concrete: Use cast-in-place concrete inserts.

4. Attachment to Hollow Block or Tile Filled Concrete Deck:

a. New Construction: Use cast-in-place concrete inserts by having Construction Work Contractor omitting blocks and pouring solid blocks with insert where required.

5. Attachment to Metal Stud Construction: Use supporting fasteners manufactured specifically for the attachment of raceways and boxes to metal stud construction.

    a. Support and attach outlet boxes so that they cannot torque/twist. Either:

        1) Use bar hanger assembly, or:
        2) In addition to attachment to the stud, also provide far side box support.

3.4 CONDUIT SUPPORT SCHEDULE

A. Use pipe straps and specified method of attachment where conduit is installed proximate to surface of wood or masonry construction.

    1. Use hangers secured to surface with specified method of attachment where conduit is suspended from the surface.

B. Use "C" beam clamps and hangers where conduit is supported from steel beams.

C. Use deck clamps and hangers where conduit is supported from steel decking having hanger tabs.

    1. Where conduit is supported from steel decking which does not have hanger tabs, use clamps and hangers secured to decking, utilizing specified method of attachment.

D. Use channel support system supported from structural steel for multiple parallel conduit runs.

E. Where conduits are installed above ceiling, do not rest conduit directly on runner bars, T-Bars, etc.

    1. Conduit Sizes 2-1/2 Inches and Smaller: Support conduit from ceiling supports or from construction above ceiling.
    2. Conduit Sizes Over 2-1/2 Inches: Support conduit from beams, joists, or trusses above ceiling.

3.5 LIGHTING FIXTURE SUPPORT SCHEDULE

A. General: Do not support fixtures from ceilings or ceiling supports unless it is specified or indicated on the drawings to do so.

    1. Support fixtures with hanger rods attached to beams, joists, or trusses. Hanger rod diameter, largest standard size that will fit in mounting holes of fixture.

        a. Where approved, channel supports may span and rest upon the lower chord of trusses and be utilized for the support of lighting fixtures.
        b. Where approved, channel supports may span and be attached to the underside of beams, joists, or trusses and be utilized for the support of lighting fixtures.

2. Use 2 nuts and 2 washers on lower end of each hanger rod to hold and adjust fixture (one nut and washer above top of fixture housing, one nut and washer below top of fixture housing).

    a. Where specified that an adequately supported outlet box is to support a fixture or be utilized as one point of support, support the box so that it may be adjusted to bring the face of the outlet box even with surface of ceiling.

B. Number of Supports for Ceiling Mounted Lighting Fixtures: Provide at least the following number of supports. Provide additional supports when recommended by fixture manufacturer, or shown on the drawings.

1. Commercial and Industrial Fixtures:

    a. Support individual fixtures less than 2 feet wide at 2 points.
    b. Support continuous row fixtures less than 2 feet wide at points equal to the number of fixtures plus one. Uniformly distribute the points of support over the row of fixtures.
    c. Support individual fixtures 2 feet or wider at 4 corners.
    d. Support continuous row fixtures 2 feet or wider at points equal to twice the number of fixtures plus 2. Uniformly distribute the points of support over the row of fixtures.
    e. An adequately supported outlet box may be utilized as one point of support for fixtures weighing less than 50 pounds.

3.6 CHANNEL SUPPORT SYSTEM SCHEDULE

A. Use channel support system where specified or indicated on the drawings.

B. Channel supports may be used, as approved, to accommodate mounting of equipment.

C. Material and Finish:

1. Dry Locations: Use 12 gage steel channel support system having any one of the specified finishes.
2. Damp Locations: Use 12 gage steel channel support system having any one of the specified finishes except green epoxy/enamel.
3. Wet Locations: Use 12 gage steel channel support system having hot dipped galvanized, or PVC finish.

END OF SECTION 26 05 29

SECTION 26 05 33 - RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 SUMMARY

A. Provide raceways in accordance with the Contract Documents.

B. Related work in other sections:

1. Section 26 05 00 – Common Work Results for Electrical
2. Section 26 05 15 – Ceiling, Floor, and Wall Electrical Penetration Fire Seals
3. Section 26 05 26 – Grounding and Bonding
4. Section 26 05 29 – Hangers and Supports for Electrical Systems
5. Section 26 05 53 – Identifications for Electrical Systems
6. Section 26 27 26 – Wiring Devices

1.2 REFERENCES

A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:

1. Rigid Steel Conduit

   a. UL Standards UL-6
   b. A.N.S.I. C80-1
   c. Federal Specification WW-C-581E

2. Intermediate Metallic Conduit

   a. UL Standard UL-1242
   b. Federal Specification WW-C-581E

3. Electrical Metallic Tubing

   a. UL Standard UL-797
   b. A.N.S.I. C80-3
   c. Federal Specification WW-C-563

4. Flexible Steel Conduit

   a. UL Standard UL-1

5. Liquid Tight Flexible Conduit

   a. UL Standard UL-360

6. Non-Metallic Conduit

   a. UL Standard UL-651
   b. A.N.S.I. Standard F512
   c. N.E.M.A. Standard TC-2
   d. Federal Specification GSA-FSS and W-C-1094-A
   e. Corps of Engineers Specification CE-303:01

7. Wireways and Auxiliary Gutters

   a. UL Standard UL-870

1.3 SUBMITTALS

A. Provide listing of proposed manufacturers.

B. Provide manufacturer's catalog cuts of fittings.

C. Where wireways and/or auxiliary gutters are employed full erection drawings must be submitted. Drawings to include plan views, elevations, size of wireways, type and quantity of conductors, proposed to be installed therein, etc.

D. Submit shop drawings or catalog descriptive data on boxes exceeding twenty-four (24") inches for any one dimension.

E. Submit shop drawings or catalog descriptive for floor boxes and accessories.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by the following:

B. Conduit Bodies:

1. Appleton Electric Co.
2. Crouse-Hinds Division, Cooper Industries, Inc.
3. Killark Electric Mfg. Co.
4. Or approved equal

C. Fittings:

1. Appleton Electric Co.
2. O-Z/Gedney
3. Thomas and Betts
4. Or approved equal

D. Wireway:

1. GS Metals Corp.
2. Hoffman Engineering Co.
3. Keystone/Rees, Inc.
4. Square D Co.
5. Or approved equal

E. Surface Metal Raceway:

1. GS Metals Corp.
2. Square D Co.
3. The Wiremold Co.
4. Or approved equal

2.2 RACEWAY TYPES

A. Standard Threaded Rigid Steel Conduit

1. Rigid conduit, heavy wall, galvanized.
2. Threaded type fittings: "Erickson" couplings where threaded cannot be used.

B. Intermediate Metallic Conduit

1. Light weight, rigid steel conduit, galvanized.
2. Threaded type fittings: "Erickson" couplings where threaded cannot be used.

C. Electric Metallic Tubing

1. Continuous, seamless tubing, galvanized or sheradized on the exterior, coated on the interior with a smooth hard finish of lacquer, varnish, or enamel.
2. All couplings, connectors, etc., used in conjunction with this raceway, which are two (2") inches in size and smaller shall be steel compression gland fittings, "Tomic" tap-on or "Tomic" compression type. Conduits 2 1/2 inch size and larger may use set screw type which employ four (4) set screws per fitting.
3. EMT is not allowed in concrete.

D. Flexible Steel Conduit

1. Single strip, continuous, flexible interlocked, double-wrapped steel, galvanized inside and outside, forming smooth internal wiring channel.
2. Maximum length: Six (6) feet.
3. Each section of raceway must contain a bonding wire at each end and sized as required. Provide connectors with insulating bushings.
4. Squeeze-type fittings.

E. Liquid Tight Flexible Electrical Conduit

1. Same as flexible steel conduit except with tough, water-tight plastic outer jacket.

2. Fittings: Cast malleable iron body and gland nut, cadmium plated with one-piece brass grounding bushings which thread to interior of conduit. Spiral molded vinyl sealing ring between gland nut and bushing and nylon insulated throat.

F. Non-Metallic Raceway

1. Composed of polyvinyl chloride suitable for 90 degrees C.
2. Raceway, fittings, and cement must be produced by the same manufacturer who must have had a minimum of ten (10) years experience in manufacturing the products.
3. Materials must have a tensile strength of 7,000-7,200 psi at 73.4 degrees F, flexural strength of 12,000 psi and compressive strength of 9,000 psi.
4. All joints shall be solvent cemented in accordance with the recommendations of the manufacturer.

G. Wireways and Auxiliary Gutters

1. Of sizes and shapes indicated on the drawings and as required.
2. Provide all necessary elbows, tees, connectors, adaptors, etc.
3. Hinged cover secured with captive screws.
4. Wire retainers not less than twelve (12") inches on center.

2.3 OUTLET, JUNCTION, AND PULL BOXES

A. Cast Type Conduit Boxes, Outlet Bodies and Fittings

1. Provide surface mounted outlet and junction boxes, in indoor locations, where exposed to moisture and all outdoor locations.
2. Requirements:

Type Conduit	Box Material	Type Hubs
Rigid Steel & IMC	Ferrous Alloy	Inside Thread
Electrical Metallic Tubing	Ferrous Alloy or Inside Thread with Adapter	Compression

3. Covers: Cast or sheet metal unless otherwise required.
4. Tapered threads for hubs.

B. Galvanized Pressed Steel Outlet Boxes

1. General

a. Pressed steel galvanized or cadmium-plated, minimum of four (4") inches octagonal or square, with galvanized cover or extension ring as required.

2. Concrete Box

a. Four (4") inch octagons with a removable backplate and 3/8" fixture stud, if required. Depth of box shall allow for a minimum of one (1") inch of concrete to be poured above the backplate.

3. Switch and Receptacle Box, Indoors

    a. Nominal four (4") inches square, 1-1/2" or 2-1/8" deep as required, with adaptor covers as required unless otherwise indicated on drawings.

4. Lighting Fixture Box

    a. Four (4") inch octagon with 3/8" fixture stud.
    b. For suspended ceiling work, four (4") inch octagon with removable backplate where required, and two (2) parallel bars for securing to the cross-furring channels and extend flexible conduit to each fixture.

5. Plug any open knockouts not utilized.

C. Sheet Steel Boxes Indoors

1. No. 12 USS gauge sheet steel for boxes with maximum side less than forty (40") inches, and maximum area not exceeding 1,000 square inches; riveted or welded 3/4 inch flanges at exterior corners.
2. No. 10 USS gauge sheet steel for boxes with maximum side forty (40") to sixty (60") inches, and maximum area 1,000 to 1,500 square inches; riveted or welded 3/4 inch flanges at exterior corners.
3. No. 10 USS gauge sheet steel riveted or welded to 1-1/2" by 1-1/2" by 1/4" welded angle iron framework for boxes with a maximum side exceeding sixty (60") inches and more than 1,500 square inches in area.
4. Covers

    a. Same gauge steel as box.
    b. Subdivided single covers so no section of cover exceeds fifty (50) pounds.
    c. Machine bolts, machine screws threaded into tapped holes, or sheet metal screws as required; maximum spacing twelve (12") inches.

5. Paint

    a. Rust inhibiting primer; ANSI No. 61 light gray finish coat.

6. Where size of box is not indicated, size to permit pulling, racking and splicing of cables.

D. Pull and Splice Boxes, Outdoors

1. Aluminum reinforced, with removable covers secured by brass machine screws.
2. Where size of box is not indicated, size to permit pulling, racking, and splicing of the cables.
3. Braze a ground connector suitable for copper cables to the inside of the box.

E. Identification Labels

1. Acceptable Manufacturers

    a. W.H. Brady Company (Style A)

b. Thomas & Betts Company (T&B), Style A

2. Plasticized Cloth

a. Non-conductive
b. Waterproof
c. Capable of withstanding continuous temperatures of 235 degrees F and intermittent temperatures to 300 degrees F.
d. Over-coating for protection against oil, solvents, chemicals, moisture, abrasion and dirt.

3. Heavy, thermo-resistant industrial grade adhesive, for adhesion of label to any surface without curling, peeling or falling off.
4. Legends

a. Sharp, bold face, two-inch black letters on "Alert" orange background.

5. Label Designations: Nominal System Voltages Applied to the covers of all low voltage pull, splice and junction boxes.

PART 3 - EXECUTION

3.1 APPLICATION OF RACEWAYS

A. The following applications must be adhered to except as otherwise required by Code. Raceways not conforming to this listing must be removed by this Contractor and replaced with the specified material at this Contractor's expense.

B. Raceway Types	Application
Rigid Steel	Application: Where installed in concrete within the building, in or under slabs within the building, where exposed to mechanical injury, where specifically required, indoors where exposed to moisture and where required by codes and for all circuits in excess of 600 volts.
I.M.C.	Application: Same as standard threaded rigid steel conduit.
E.M.T.	Application: Use in every instance except where another material is specified. Strictly prohibited in concrete or in contact with earth or fill.
Flexible Steel	Applications: Use in dry areas for connections to lighting fixtures in hung ceilings, connections to equipment installed in removable panels of hung ceilings at bus duct takeoffs, at all transformer or equipment raceway connections where sound and vibration isolation is required. Maximum length: 6'-0".

Liquid-Tight Flexible Conduit	Applications: Use in areas subject to moisture where flexible metal conduit is permitted, at connections to all motors.

3.2 RACEWAY SYSTEM IN GENERAL

A. Provide raceways for all wiring systems. All wiring shall be installed in EMT unless otherwise noted or required by Code. Emergency system wiring must be kept independent of the normal system wiring. Where non-metallic raceways are utilized, provide sizes as required with the grounding conductor considered as an insulated additional conductor. Minimum size, 3/4 inch for branch circuits, and one (1") inch minimum for feeders. Wiring of each type and system must be installed in separate raceways.

B. Install capped bushings on raceways as soon as installed and remove only when wires are pulled. Securely tie embedded raceway in place prior to embedment. Raceways installed below or in floor slabs must extend a minimum of four (4") inches above the finished slab to the first connector. Lay out the work in advance to avoid excessive concentrations of multiple raceway runs.

C. Locate raceways so that the strength of structural members is unaffected and they do not conflict with the services of other trades. Install one (1") inch or larger raceways, in or through structural members (beams, slabs, etc.) only when and in the manner accepted by the Architect/Engineer. Draw up couplings and fittings full and tight. Protect threads from corrosion with one (1) coat red lead or zinc chromate after installation.

D. Above Grade-Defined as the area above finished grade for a building exterior and above top surface of any slabs (or other concrete work) on grade for a building interior. Above-grade raceways shall comply with the following:

1. Install raceways concealed except at surface cabinets and for motor and equipment connection in electrical and mechanical rooms. Install a minimum of six (6") inches from flues, steam pipes, or other heated lines.
   Provide flashing and counter-flashing for waterproofing of raceways, outlets, fittings, etc., which penetrate the roof. Route exposed raceways parallel or perpendicular to building lines with right-angle turns and symmetrical bends. Run raceways in or under slabs in a direct line and, where possible, with long sweep bends and offsets. Provide sleeves in forms for new concrete walls, floor slabs, and partitions for passage of raceways. Waterproof sleeved raceways where required.
2. Provide raceway expansion joints for exposed and concealed raceways with necessary bonding conductor at building expansion joints and between buildings or structures and where required to compensate for raceway or building thermal expansion and contraction. Provide expansion fittings every 200 feet on outdoor conduit.
3. Provide one (1) empty 3/4 inch raceway for each three (3) spare unused poles or spaces of each flush-mounted panelboard. Terminate empty 3/4 inch conduit in a junction box, which after completion, is accessible to facilitate future branch circuit extension.
4. Provide raceway installation (with appropriate seal-offs, explosion-proof fittings, etc.) in special occupancy area, as required. Provide conduit seal-offs where portions of an interior raceway system pass through walls, ceiling, or floors which separate adjacent

rooms having substantially different maintained temperatures, as in refrigeration or cold storage rooms.

5. Protect metal raceways in earth or fill with two (2) coats of asphalt base paint. Touch up abrasions and wrench marks after conduit is in place.
6. In lieu of the above, protect raceways with a minimum of twenty (20) mil tape approved for the purpose and overlapped a minimum of one half tape width.
7. Provide drag wire in spare or empty raceways. Allow five (5) feet of slack at each end and in each pull box. Tag both ends of wire denoting opposite end termination location with black India ink on flameproof linen tag.
8. Install pull-wire in empty raceways. Use polypropelene on monofilament plastic line with not less than 200 lb. tensile strength. Leave at least 12 inches of slack at each end of pull-wire. Conduits designated as “spare” shall be capped.
9. All conduits stubbed above the floor for voice/data or signal systems in the main electrical room shall be stubbed 6” AFF and provided with insulating bushings.

E. Raceways in hung ceiling shall be run on and secured to slab or primary structural members of ceiling, not to lathing channels or T-bars, Z-bars, or other elements which are the direct supports of the ceiling panels. Secure conduit firmly to steel by clips and fittings designed for that purpose. Install as high as possible, but not less than 1'-0" above hung ceilings.

F. Conduit above accessible ceilings and exposed raceways shall be run parallel or at right angles with building lines. Secure raceway clamps or supports to masonry materials by toggle bolts, expansion bolts, or steel inserts. Install raceways on steel construction with approved clamps which do not depend on friction or set screw pressure alone.

G. Clear raceway of all obstructions and dirt prior to pulling in wires or cables. This shall be done with a ball mandrel (diameter approximately 85% of conduit inside diameter) followed by a close fitting wire brush and wad of felt, or similar material. This assembly may be pulled in together with, but ahead of, the cable being installed. All empty raceways shall be similarly cleaned. Clear any raceway which rejects ball mandrel.

H. Support less than two (2") inches trade size, vertically run, raceways at intervals no greater than eight (8) feet. Support such raceways, two (2") inches trade size or larger and made up with threaded couplings, at intervals no greater than the story height, or fifteen (15) feet, whichever is smaller.

I. Support less than (1") inch trade size, horizontally run, raceways at intervals no greater than seven (7) feet. Support such raceways, one (1") inch trade size or larger, at intervals no greater than ten (10) feet.

3.3 WIREWAYS AND AUXILIARY GUTTER

A. Wireways installed in hung ceilings shall be placed such that the cover will hinge upward from the side.

B. Twelve (12") inches clear shall be provided from wireway cover when it is in the open position.

C. Routing of wireways, shown on plans, is diagrammatic. Provide a complete system including corners, elbows, and angle sections to clear the work of other trades and other obstructions.

3.4 OUTLET, JUNCTION, AND PULLBOXES

A. Provide outlet, junction, and pullboxes as indicated on the drawings and as required for the complete installation of the various electrical systems, and to facilitate proper pulling of wires and cables. J-boxes and pullboxes shall be sized per electrical code minimum. Boxes on empty conduit systems shall be sized as if containing conductors of #4 AWG.

B. The exact location of outlets and equipment is governed by structural conditions and obstructions, or other equipment items. When necessary, relocate outlets so that when fixtures or equipment are installed, they will be symmetrically located according to the room layout and will not interfere with other work or equipment. Verify final location of outlets, panels, equipment, etc., with Architect.

C. Back-to-back outlets in the same wall, or "thru-wall" type boxes, are not permitted. Provide twelve (12") inch (minimum) spacing for outlets shown on opposite sides of a common wall to minimize sound transmission.

D. Fit outlet boxes in finished ceiling or walls with appropriate covers, set flush with the finished surface. Where more than one switch or device is located at one point, use gang boxes and covers unless otherwise indicated. Sectional switch boxes or utility boxes will not be permitted. Provide Series "GW" (Steel City) tile box, or as accepted, or a four (4") inch square box with tile ring in masonry walls, which will not be plastered or furred. Where drywall materials are utilized, provide plaster ring. Provide outlet boxes of the type and size suitable for the specific application.

E. Pull Box Spacing

1. Provide pull boxes so no individual conduit run contains more than the equivalent of four (4) quarter bends (360 degrees total).
2. Conduit Sizes 1-1/4" and larger.

    a. Provide boxes to prevent cable or wire from being excessively twisted, stretched, or flexed during installation.
    b. Provide boxes for medium voltage cables so that maximum pulling tensions do not exceed cable manufacturer's recommendations.
    c. Provide support racks for boxes with multiple sets of conductors so that the conductors do not rest on any metal work inside box.

3. Conduit sizes one (1") inch and smaller, low voltage wire and cable (maximum distances).

    a. 150 feet straight runs.
    b. 100 feet runs with one 90 degree bend or equivalent.
    c. 75 feet runs with two 90 degree bends or equivalent.
    d. 50 feet runs with three or four 90 degree bends or equivalent.

F. Sheet Steel Boxes

1. Size and shape (if not on drawings) to avoid exceeding manufacturer's minimum bending radius recommendations for conductors.
2. Access for removal and replacement of conductors, splices, and equipment.
3. Minimum dimensions of boxes in runs of 1-1/2" or larger conduit.

a. Straight Pulls

1) Sizes length eight (8) times nominal diameter of largest conduit.

b. Angle or U Pulls

1) Size such that distance between conduit entry and opposite wall of box is six (6) times nominal diameter of largest conduit.

4. Covers

a. Fasten to flange or framework of box with machine bolts, machine screws threaded into tapped holes, or sheet metal screws as required.

G. Identification labels for all low voltage and medium voltage pull, splice and junction boxes in main feeder and subfeeder runs, indicating nominal system voltage.

1. Apply labels after painting of boxes, conduits, and surrounding areas have been completed.
2. Clean surfaces before applying labels; clean aluminum surfaces with solvent wipe.
3. Apply labels on cover and minimum of one (1) fixed side: one (1) label viable from floor where boxes are installed exposed.

3.5 SLEEVES

A. Where sleeves are required for the installation of electrical work, passing through walls or floors, they shall be furnished and installed under this Section of the specification unless indicated otherwise on the drawings. Such sleeves shall be galvanized or black enameled rigid steel conduit or Schedule 40 black steel pipe. Aluminum conduit sleeves shall not be used. Where specific sizes are not indicated on the drawings, sleeves shall be sized to provide 1/2 inch clearance around the outside surface of the item for which they are installed. They shall be cut flush with wall surfaces and shall extend two (2") inches above finished floor level, or as indicated on the drawings.

B. For interior walls and for floors, the space between conduit, ground cable, or similar items and sleeves shall be packed to the full depth of wall or slab thickness with products manufactured by HILTI or equal:

END OF SECTION 26 05 33

SECTION 26 05 53 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Provide fixed identification of all distribution equipment and conductors in accordance with the Contract Documents.

B. Related work in other sections:

1. Section 26 05 21 – Wires and Cables
2. Section 26 24 13 – Switchboards
3. Section 26 24 16 – Panelboards
4. Section 26 28 23 – Disconnect Switches – Fused and Non-Fused
5. Section 26 29 13 – Enclosed Controllers
6. Section 26 51 00 – Interior Lighting

1.2 REFERENCES

A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:

1. Industry standards shall apply.

1.3 SUBMITTALS

A. Identification procedures shall be noted and scheduled on the applicable shop drawings.

PART 2 - PRODUCTS

2.1 Unless otherwise noted, nameplates shall be black lamacoid plates with white engraved upper case letters enclosed by white border on beveled edge.

2.2 Nameplates for equipment, supplied by the emergency system, shall be red lamacoid with white lettering.

2.3 All nameplates must be engraved and must be secured with rivets, brass or cadmium plate screws. The use of Dymo tape or the like is unacceptable.

2.4 Lettering heights unless otherwise noted must be as follows:

Item	Lettering Height
Panelboards	1/2"
Feeder Switches	1/4"
Remote Smoke Detector Lamps	1/8"
Wall Plates	1/8"
Motor Controllers	1/4"
Fire Alarm Control Panels	1/2"

2.5 Cable tags must be flameproof secured with flameproof non-metallic cord.

2.6 Nameplate inscriptions must bear the name and number of equipment to which they are attached as indicated on the Drawings. The engineer reserves the right to make modifications in the inscriptions as necessary.

2.7 The Engineer reserves the right to request additional nameplates at time of review of shop drawings and upon site observations. These shall be furnished at no additional cost to the Owner.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Panelboards

1. Furnish and install a nameplate for each panelboard and load center engraved with the identification indicated on the Drawings. Mount at top of panel.
2. After installations are complete, provide and mount under sturdy transparent shield in the directory frame of each panel door, a neat, accurate, and carefully typed directory properly identifying the lighting, receptacles, outlets and equipment each overcurrent device controls.
3. Include on directory the panel or load center identification, the cable and raceway size of panel feeder, and the feeder origination point.

B. Disconnect Switches

1. Furnish and install a nameplate for each disconnect switch engraved with the equipment designation which the disconnect serves.

C. Motor Controllers

1. Furnish and install a nameplate for each motor controller or combination motor controller for both individual motor controllers and those in a motor control center, etc. Engraving must indicate the motor served and the type of service (e.g., AC-8 – 1st floor supply, EF-2 electric closet exhaust).

D. Feeder Switches

1. Furnish and install for each circuit breaker a nameplates with the following:

a. Indicate the load served, the size and type of cable and raceway example:

1) LP-4, LP-5, LP-6
2) 4#500 MCM-THW-CU-3-1/2"C

E. Remote Smoke Detector Lamps and Test Stations

1. Furnish and install a nameplate on each remote smoke detector lamp and/or test station. Engraving must indicate the location of the devise to which the lamp is connected, as approved by the Engineer.

F. Switches

1. Furnish and install an engraved nameplate for each switch, controlling loads which are not local to the switch. Engraving shall be as directed by the Engineer.

G. Pullboxes, Enclosures and Cable Terminations

1. Furnish and install cable tags on each cable, which enters a pullbox, enclosure, switchboard, and at terminations. Mark tags with type written inscription noting the load served, type and size of cable, and the overcurrent device protecting the cable.

H. Fire Alarm Control Panels

1. Furnish and install on each fire alarm terminal cabinet an approved nameplate.
2. Nameplates shall indicate floor and where multiple panels cabinets are installed a prime designation for each cabinet (e.g. FATC-1A, FATC-1B).

I. Capping and Staking

1. Wherever raceways are for future use and are terminated outside of the structure, stake the location with a 2'-0" long, 1" x 1" wooden stake having a conspicuous colored flag.
2. Provide metal markers inserted into 8" D x 12" concrete ballast at all raceway terminations exterior to the structure. Inserts must state the date the raceway was installed, the size of the raceway, and the point of the raceway termination.

J. Generator Control Panel

1. Furnish and install a red nameplate for each generator control panel. Engraving shall indicate the generator controlled by the panel.

K. Painting and Finishing

1. All electrical fitting, supports, hanger rods, pullboxes, channel frames, conduit racks, outlet boxes, brackets clamps, etc., shall be galvanized finished or have enamel paint finish over corrosion-resistant primer.
2. All panelboards, etc., shall be factory finished in alkyd high gloss enamel applied over corrosion-resistant primer. Matte or flat type finish paint not acceptable. Factory finished units that are scratched or marked during installation shipping shall be touched up with matching spray-on air dry lacquer or, if required, to provide a satisfactory job, shall be completely refinished.
3. Fire alarm pullboxes and junction boxes to be finished in red.
4. Telecommunications terminal panel and junction boxes to be finished in yellow.
5. Low voltage switching terminal cabinets and pullboxes to be finished in black.
6. Security terminal panel and junction boxes to be finished in yellow.

END OF SECTION 26 05 53

SECTION 26 05 83 - ARC FLASH HAZARD STUDY

PART 1 - GENERAL

1.1 DESCRIPTION

A. Provide an Arc Flash Hazard Study for the electrical distribution system shown on the one line drawings. The intent of the Arc Flash Hazard Study is to determine hazards that exist at each major piece of electrical equipment shown on the one-line drawing. This includes switchgear, switchboards, panelboards, and ATSs. The study will include creation of Arc Flash Hazard Warning Labels. These labels serve as a guide to assist technicians and others in the selection of proper Personal Protective Equipment when working around exposed and energized conductors. The electrical contractor will install the labels.

Example of Arc Flash Warning Label

B. The arc flash hazard study shall include the electrical distribution system equipment shown on the one-line drawing. Specification Section 26 05 73 requires an overcurrent protective device coordination and short circuit study be completed as part of this project. The arc flash hazard study shall consider operation during normal conditions alternate operations, emergency power conditions, and any other operations, which could result in maximum arc flash hazard.

1.2 QUALIFICATIONS

A. The Contractor shall have the study prepared by qualified engineers of an independent consultant. The consultant shall be a Registered Professional Electrical Engineer (licensed in the state where the project is completed) who has at least ten (10) years of experience and specializes in performing power system studies.

B. The arc flash hazard study shall be performed using SKM PowerTools for Windows computer software packages. No substitutions.

C. Pre-approved: Power Systems Engineering, P.S. - Covington, WA.

1.3 SUBMITTALS

A. The contractor shall submit the arc flash hazard study and arc flash warning labels at least 30 days prior to energizing the electrical equipment.

B. Submit three (3) copies of the power systems study and (1) set of warning labels.

PART 2 - EXECUTION

2.1 SHORT CIRCUIT STUDY

A. Utilize the short circuit study specified in Section 26 05 73.

2.2 PROTECTIVE DEVICE COORDINATION STUDY

A. Utilize the protective device coordination study specified in Section 26 05 73.

2.3 ARC FLASH HAZARD STUDY

A. Perform an arc flash hazard study after the short circuit and protective device coordination study has been completed.

B. The study shall be calculated by means of the SKM PowerTools for Windows computer software package. Pertinent data, rationale employed, and assumptions in developing the calculations shall be incorporated in the introductory remarks of the study.

C. The study shall be in accordance with applicable NFPA 70E, OSHA 29-CFR, Part 1910 Sub part S and IEEE 1584 Standards.

D. Determine the following

1. Flash Hazard Protection Boundary
2. Limited Approach Boundary

3. Restricted Boundary
4. Prohibited Boundary
5. Incident Energy Level
6. Required Personal Protective Equipment Class
7. Type of Fire Rated Clothing

E. Produce an Arc Flash Warning label listing items 1 – 7 above. Also include the bus name and voltage. Labels shall be printed in color and be printed on adhesive backed Avery Labels. See example above.

F. Produce Bus Detail sheets that lists the items D 1 – 7 from above and the following additional items:

1. Bus Name
2. Upstream Protective Device Name, Type, and Settings
3. Bus Line to Line Voltage

G. Produce Arc Flash Evaluation Summary Sheet listing the following additional items:

1. Bus Name
2. Upstream Protective Device Name, Type, and Settings
3. Bus Line to Line Voltage
4. Bus Bolted Fault
5. Protective Device Bolted Fault Current
6. Arcing Fault Current
7. Protective Device Trip / Delay Time
8. Breaker Opening Time
9. Solidly Grounded Column
10. Equipment Type
11. Gap
12. Arc Flash Boundary
13. Working Distance
14. Incident Energy
15. Required Protective Fire Rated Clothing Type and Class

PART 3 - ANALYSIS

3.1 Analyze the short circuit, protective device coordination, and arc flash calculations and highlight any equipment that is determined to be underrated or causes an abnormally high incident energy calculation. Propose approaches to reduce the energy levels. Proposed major corrective modifications will be taken under advisement by the Engineer, and the Contractor will be given further instructions.

PART 4 - REPORT

4.1 The results of the power system study shall be summarized in a final report. The report shall include the following sections:

A. Introduction, executive summary and recommendations, assumptions, reduced copy of the one-line drawing.

B. Arc Flash Evaluations Summary Spreadsheet

C. Bus Detail Sheets

D. Arc Flash Hazard Warning Labels printed in color on adhesive backed labels.

END OF SECTION 26 05 83

SECTION 26 07 00 - ELECTRICAL DEMOLITION

PART 1 - GENERAL

1.1 GENERAL

A. The work of this section includes furnishing of all labor, tools, materials, and equipment necessary to complete all the demolition required for the project as specified herein and shown on the drawings.

B. Cooperation with contractors under separate contracts is required, and the work described herein and shown on the drawings shall be coordinated as required to fulfill the intent of the contract.

1.2 INTENT

A. It is the intent of this specification and accompanying drawings to describe and indicate the demolition work to be performed. It is not intended that the specifications and drawings describe and indicate every piece of equipment required to be removed for where items are intended to be removed or as required for the satisfactory completion of the project or is considered to be the accepted practice of the trade, they shall be considered to be specified and indicated.

B. The contractor shall disconnect and remove all lighting fixtures, conduit, wire and related electrical items as indicated on the drawings, or as required by the project. This includes all abandoned low voltage signal and communication cables.

C. The contractor shall seal floor, wall and ceiling openings with thermo setting fire resistive compound after removal of conduits.

D. The contractor is cautioned that when performing demolition work circuitry servicing areas of the building outside the work area must remain in operation. The contractor is responsible, at his own expense, to repair any services or damages caused by his demolition work.

E. When disconnecting equipment from existing circuits, if equipment is connected to the circuit which must remain active, the circuit continuity shall be maintained as required. Wiring from circuits becoming completely inactive shall be removed back to the source of supply.

PART 2 - SCOPE OF WORK

2.1 DEMOLITION/ALTERATION

A. Prior to start of demolition, check to determine that power, communication services, etc., such as electricity and telephone in the work area, have been disconnected at the source of supply.

B. The Contractor shall furnish and erect barriers, and maintain approved danger, warning, and "Keep Out" signs at locations where the placing of such signs is warranted for safety of all personnel not working in this area.

C. Demolition shall be performed in such a manner as to avoid hazards to persons and property, interference with the use of adjacent properties, and interruption of free passage to and from such property. Work shall be performed in strict accordance with all Municipal, State and Federal Rules, Regulations, Codes, and Laws which may govern and apply to this work.

D. During the demolition work in the effected areas, the building non-work areas must be protected from dust, dirt and possible water damage, to the Owner's satisfaction.

E. All areas shall be cleaned and free of all debris resulting from the demolition work on a daily basis.

F. Remove all equipment shown to be removed; however, all changes cannot be detailed completely on the drawings, some removals and relocations of existing electric work will be necessary for satisfactory performance of this and other trades. Take into consideration in proposal all required changes.

G. Maintain continuous service on feeders, circuits or partial circuits, and outlets affected by this work, except where Architect gives written permission for outage for specified time. All work requiring shut down of existing systems shall be performed on overtime at hours as approved by the Architect and at no additional cost to the Owner. Submit schedule of required outages to the Owner for approval. Perform work in a manner to minimize shutdown time.

H. Provide reconnections and temporary installations as required; remove at job completion.

I. Take possession and remove from the premises all abandoned materials and equipment unless specified as returnable to the Owner; in which case, remove without damage all such equipment and turn over and deliver to Owner at location designated by the Owner.

J. Cut back to floor, wall, or ceiling and plug ends of concealed conduits made obsolete by alterations to permit refinishing surfaces. Remove exposed conduits, wireways, outlet boxes, hangers and devices made obsolete by this work unless designated specifically to remain.

K. Existing concealed conduits not interfering with the work of this or any other trade may remain; however, wiring shall be removed from panelboards or source of power and ends taped. No unused live wiring shall be left in place.

L. Provide blank plates on all unused outlet boxes that are unable to be removed.

M. Wherever extensions of wires or cables are shown on the drawings, check and verify wire and cable sizes and capacities. Secure Architect's acceptance of this data before new cables are ordered or installation started.

N. Remove all unused data/voice/TV cables installed above existing ceilings.

PART 3 - SALVAGE

3.1 SALVAGE

A. The contractor shall be responsible for all damage to existing materials not affected by the demolition work. The contractor shall repair or replace damaged material or equipment as directed at no additional cost to the owner. Repairing and patching of areas shall be done by the respective trade involved with the demolition, utilizing workmen skilled in the trade involved with the repair or replacement of the material in question.

B. All equipment removed during demolition shall remain on the site, unless otherwise noted. The Owner reserves all rights to claiming material removed during demolition. The contractor is responsible to remove from the site all material not claimed by the Owner. In addition, the contractor is responsible to deliver to the Owner's storage facilities, equipment claimed by the Owner.

END OF SECTION 26 07 00

SECTION 26 24 16 – PANELBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

A. General – provide panelboards in accordance with the Contract Documents.

B. Related Work Specified in Division 26

1. Section 26 05 26 – Grounding and Bonding
2. Section 26 05 53 – Identification for Electrical Systems
3. Section 26 28 14 – Fuses – Low Voltage

C. Related Work Specified in other Divisions of these Specifications.

1. Finish Painting

1.2 STANDARDS

A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and recommendations of the following:

1. Panelboards

a. U.L. Standards #50 & #67
b. Federal Standard W-P-115A Type II, Class I and W-C-375B
c. NEMA Standard PB-1-1971

2. Circuit Breakers

a. U.L. Standard #489
b. Federal Standard W-C-375A Amendment No. 4
c. NEMA Standard AB-1-1969

1.3 SUBMITTALS

A. Refer to Section 26 05 05 concerning the procedures and additional documents for submittals in concert with panelboard submittals. Submittals failing to meet the following criteria will be returned without a review or acceptance.

B. With each panelboard drawing the following is required:

1. Show main devices and lug sizes; branch circuit device sizes and arrangement; bus ampacities; withstandability and short circuit rating; dimensions and construction; gutter

and backbox dimensions; nameplate and legend; protective coating; and all pertinent details of panel, enclosure, cover, and method of securing cover and lock.

1.4 QUALITY ASSURANCE

A. Each panelboard as a complete and finished product shall receive a single integrated equipment rating by the manufacturer. The integrated equipment short circuit wiring shall certify that all equipment is capable of withstanding the thermal and magnetic stress of a fault equal to the value specified on the Drawings. Such rating shall be established by actual tests by the manufacturer on similar equipment. This certification shall be permanently affixed to each panelboard. Test data shall be submitted to the Engineer at time of submission of Acceptance Drawings.

PART 2 - PRODUCTS

2.1 APPROVED MANUFACTURERS

A. All panelboards are to be Square D or General Electric Co.

2.2 PANELBOARDS IN GENERAL

A. Provide panelboards consisting of an assembly of branch circuits switching and protective devices (circuit breakers) mounted inside a dead front enclosure. Provide the number and size of these branch circuit devices as indicated by the circuiting, on the drawings, and in the schedules. Locations of circuit breakers shall be as indicated in the schedules.

B. Provide the following modifications and additional equipment as shown on the Drawings:

1. Main circuit breakers, as indicated
2. Shunt trip circuit breakers, where indicated
3. Feed through lugs and/or bus, where indicated
4. Ground fault interrupting circuit breakers, where indicated
5. Oversized gutters
6. Door in door construction for power panels wider than 20” or higher than 63”

C. Interiors

1. Rigid removable assembly of copper bus bars and interchangeable bolted branch circuit devices.
2. Bus bars drilled to permit branch circuit devices of all sizes and number of poles to be interchangeable and installed in any spare space of sufficient size, without disturbing adjacent units; without removing main bus or branch circuit connectors and without machining, drilling, or tapping in the field.
3. Arrange bus in sequence or distributed phasing so that multipole circuit breaker can replace any group of single circuit breakers of the same size.

D. Enclosure

1. Code gauge steel box galvanized.
2. Provide a bolt-on ground connector to inside of enclosure.
3. Flush mounted in finished areas and where indicated. Surface mount elsewhere.

E. Front

1. Doors must be provided on all lighting and power panels.
2. Heavy code gauge steel as required to maintain panel face flat.
3. Hold front closed with trim clamps.
4. Factory finished in medium gray enamel or two coats of air-drying lacquer over a rust inhibitor.
5. Provide directory for total number of poles.
6. Provide approved lock. All panels keyed alike. Furnish four (4) sets matching keys to the Owner.
7. Welded angle rest at the bottom of the door to facilitate cover installation.
8. Door over 48" in height shall have auxiliary fasteners at top and bottom of door in addition to lock and catch.

F. Multiple Section Panelboards

1. Each section of multiple section panelboards shall be the same height.
2. Multiple sections shall each contain the same number of poles (e.g. 72 poles equal 2-36 pole panels).

G. Terminal Lugs

1. Bolted type, labeled for either copper or aluminum conductors.
2. Locate main lugs properly at top or bottom, depending where main feeder enters.

H. Electrical Ratings

1. Panelboards are to be rated 208/120 or 480/277 volts, three phase, four (4) wire, full neutral with ampacities as indicated on the Drawings (unless otherwise noted).
2. Short circuit withstand ratings shall be as indicated on the Drawings.
3. Where indicated, provide panelboards having a “service entrance” Type UL label with neutrals factory bonded to frame or enclosure.

I. Circuit Breaker Devices

1. Plastic molded case bolt-on type. Plug-on or plug-in type breakers are unacceptable. Completely sealed enclosure. Toggle type operating handle. Trip ampere rating and ON/OFF indication clearly visible.
2. Thermal-magnetic trip-free, trip-indicating, quick-make, quick-break, with inverse time delay characteristics. Single handle and common tripping multipole breakers.
3. Silver alloy contacts with auxiliary arc-quenching devices.
4. Panelboard must be of the type which will accept the field installation of shunt trip devices of 60 amperes or less on the branch devices.

5. Interrupting capacities shall be "fully rated" with AIC ratings as indicated on the Drawings. As a minimum, 120/208-volt devices shall be not less than 10,000 AIC and 480/277-volt devices shall be not less than 14000A.1.6.
6. Bolted type terminals U.L. listed for either aluminum or copper 75 degrees C cables.
7. Locate next to each breaker or space unit the number/s indicated on the schedules.
8. Shunt trip breakers shall be supplied with 120-volt coils. Provide 120-volt circuit from nearest 120-volt panel to coil. Where shunt trip breakers are in emergency panels provide emergency 120-volt source for same from nearest 120-volt emergency panel.
9. Provide locking device for designated breakers.
10. For HVAC equipment, provide UL listed: HACR type devices.

J. Ground Fault Interrupters

1. Ground fault interrupter branch circuit breakers shall be as indicated on the Drawings. Circuit breakers shall be circuit interrupting which will operate manually for normal switching functions and automatically under overload, short circuit, and 0.005-amp line-to-ground fault conditions. The operating mechanism shall be entirely trip-free so that contact cannot be held close against an abnormal overcurrent, short circuit, or ground fault condition. The device shall be bolt-on type with case construction and shall be interchangeable with standard 1P breakers utilized in the panelboard.
2. All snow melting equipment or pipe heat trace shall be served from GFI breakers.

K. Future Devices

1. Any space within breaker mounting area where a breaker may be mounted, shall be bussed and fully equipped to accept a breaker without any further modifications to the panelboard.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mount all panels at a maximum height of 6 feet 6 inches to top unless otherwise noted.

B. Mount surface type panels a minimum one (1) inch off wall on channels.

C. Connect feed through panels to main feeder by insulated parallel gutter taps (O.Z. Electrical Manufacturing Co. – Type PMX or PMX-C). Full size tap for two panels on a common feeder, half the main cable capacity for three or more panels per feeder.

D. Where flushed mounted, the fire integrity of the wall in which it is installed must be maintained.

E. Neatly arrange branch circuit wires and tie together in each gutter with Thomas & Betts nylon "Ty-Raps", or approved equal at minimum (4) four-inch intervals.

F. Plug all knockouts removed and not utilized.

G. Provide nameplate and fill out panel directory per Section 26 05 53.

H. Provide grounding and bonding jumpers per Section 26 05 26 and as indicated on the Drawings.

I. Where panelboards are indicated to be replaced, provide backbox enclosure complete with all bussing and breakers. Do not use existing backbox. If new panel cannot be located in the same space as the existing panel, utilize the existing backbox for splicing existing branch circuits to extend to new panel.

J. Where panelboards are flush mounted, provide three (3) - 1" empty conduits stubbed to 12" above accessible ceiling.

3.2 TOUCH UP AND CLEANING

A. Vacuum all backboxes clean of debris after installation and prior to final payment.

B. Touch up scratch marks, etc. with matching paint.

3.3 OBSERVATIONS

A. All panel fronts shall be removed by the Contractor for observation of the panel interiors by the Engineers.

B. Panel fronts shall be removed when directed by the Engineer/Architect for observation (either by floor, or by group of floors on all panels on the project as required by the Engineer/Architect) and reinstalled immediately thereafter the observations.

END OF SECTION 26 24 16

SECTION 26 27 26 - WIRING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

A. General: Provide wiring devices in accordance with the Contract Documents.

B. Related Work Specified in other Divisions of these Specifications.

1. Finish painting.

C. Color: The numbers shown are for white devices and stainless-steel cover plates.

1.2 STANDARDS

A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:

1. Switches

a. Federal Specifications Standard WS-896E.

2. Receptacles

a. N.E.M.A. Standard WD-1, 3.2 through 3.10.
b. U.L. Standard 498 Federal Specification WC596-D.
c. ANSI.

1.3 SUBMITTALS

A. Submit manufacturer's catalog cuts and specifications for all wiring devices and plates.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The following manufacturers, shortened versions (shown in parentheses), are approved for submission of their products. Other manufacturers may be used, only with approval by the Owner (other). Hubbell catalog numbers have been shown as basis of design.

1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).

3. Leviton Mfg. Company Inc. (Leviton).
4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).
5. Arrow-Hart (AH)
6. General Electric (GE)
7. Or approved equal

2.2 STRAIGHT BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

1. Hubbell; HBL5361W (single), HBL5362W (duplex).

B. Hospital-Grade, Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498 Supplement SD.

1. Hubbell; HBL8310W (single), HBL8300W (duplex).

C. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

1. Hubbell; HBL8300SGWA.
2. Description: Labeled to comply with NFPA 70, "Health Care Facilities" Article, "Pediatric Locations" Section.

D. Convenience Receptacle with two (2) USB ports.

1. Hubbell: USB 202X 2 W

2.3 GFCI RECEPTACLES

A. General Description: Straight blade, non-feed through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

1. Hubbell; GF5362WA

2.4 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.

1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.

2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.5 SNAP SWITCHES

A. Comply with NEMA WD 1 and UL 20.

B. Switches, 120/277 V, 20 A:

1. Hubbell; HBL1221W (single pole), HBL1222W (two pole), HBL1223W (three way), HBL1224W (four way).

C. Pilot Light Switches, 20 A:

1. Hubbell; HBL1221PLC for 120 V and 277 V.
2. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."

D. Dimmer switches shall be of the type identified in the symbol’s legend.

2.6 WALL PLATES

A. Single and combination types to match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 302 stainless steel with satin finish.
3. Material for Unfinished Spaces: Smooth, high-impact thermoplastic.
4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover and listed and labeled for use in "wet locations."

B. Wet-Location, Weatherproof In-Use Cover Plates: NEMA 250, complying with type 3R weather-resistant, thermoplastic with lockable cover.

2.7 MULTIOUTLET ASSEMBLIES

A. Manufacturers:

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Wiremold Company (The).
3. Or approved equal

B. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

C. Raceway Material: Metal, with manufacturer's standard “ivory” finish.

D. Wire: No. 12 AWG.

2.8 FINISHES

A. Color: Wiring device catalog numbers in Section Text a reference to the rating or style of device required. Final color selection shall be by the Owner or Architect.

1. Wiring Devices Connected to Normal Power System: White, unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Power System: Red.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise required by ADA and as shown on the drawings.

B. Coordination with Other Trades:

1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

a. Cut back and pigtail, or replace all damaged conductors.
b. Straighten conductors that remain and remove corrosion and foreign matter.
c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors online and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Division 16 Section "Electrical Identification."

1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with white-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

END OF SECTION 26 27 26

SECTION 26 28 14 - FUSES-LOW VOLTAGE

PART 1 - GENERAL

1.1 SUMMARY

A. General

1. Provide fuses in accordance with the Contract Documents.

B. Related Work in Specification Division 26

1. Section 26 28 23 – Disconnect Switches – Fused and Non-Fused

1.2 STANDARDS

A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:

1. UL Standard #198
2. UL Standard #977

1.3 SUBMITTALS

A. Provide a complete set of shop drawings to include let-through curves for each type of fuse.

B. Submit listing of all types, sizes and quantity of fuses which will be installed including the location of each.

C. Submit listing of all spare fuses by types, sizes and quantities, which will be furnished for placement in the respective fuse cabinets.

D. Submit dimensioned drawings of each fuse cabinet by type and size.

E. Short circuit current analysis is based upon Bussman fuse characteristics for let-through currents. If Reliance, Cefco or Gould-Shawmut fuses are to be utilized, it is the Electrical Contractor's responsibility to provide the appropriate fuse curves and let-through values which correspond to the Bussman values shown on the Drawings. Submit comparative chart of fuse substitutions for Architect/Engineer and for respective Building Department review prior to acceptance of same substitutions. Comparative chart shall include the following:

1. Cross reference of fuses to be used in place of Bussman fuse type designation indicated on the drawings or specified herein.

F. Submit proof of coordination with the power company for any fuses associated with electric service.

G. Fuses shall comply with the recommendations of the Fault Current and Coordination Study.

PART 2 - PRODUCTS

2.1 APPROVED MANUFACTURERS

A. Fuses

1. Bussman
2. Cefco
3. Gould-Shawmut
4. Reliance
5. Or approved equal

B. Spare Fuse Cabinet

1. By fuse supplier.

2.2 MATERIALS

A. Branch Circuits

1. General

a. All fuses shall be labeled as UL Class L or UL Class R, current limiting and rated for up to 200,000 amperes. Time delay Class R fuses shall be so labeled.

2. Branch Circuits (where indicated on the drawings)

a. Unless noted otherwise on the drawings, all fuses up to 600A shall be UL Class RK5 labeled Time-delay.

3. All fuses shall be so selected as to provide a selectively coordinated system.
4. All fuses shall be of the same manufacturer.

B. Spares

1. Upon completion of the building, the contractor shall provide the Owner with spare fuses as indicated below:

a. 10 percent (minimum of 3) of each type and rating of installed fuses shall be supplied as spare.
b. Spare fuse cabinets shall be provided to store the above spares.
c. Spare fuse cabinets shall be provided as a minimum in the following locations.

1) Main electric room.
2) Each major mechanical equipment room.

C. Labels

1. Paste-on labels for building standard fuses of 600A and below to read:

EXAMPLE:

"WARNING: INSTALL CLASS RK1 FUSES ONLY."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fuses shall not be installed until equipment is ready to be energized. Verify the proper fuse size before ordering, regardless of sizes shown on drawings.

B. Provide and install fuses of proper type, voltage and ampere ratings for all fusible devices furnished under this section and all other sections of this specification.

C. Labels

1. Paste appropriate label within each switch, motor starter, or panelboard door or at location next to fuse clips, where fuses shall be furnished and installed by this Contractor. Fill-in, ink blank spaces on labels for non-standard fuses with appropriate fuse data.

END OF SECTION 26 28 14

SECTION 26 28 23 - DISCONNECT SWITCHES - FUSED AND NON-FUSED

PART 1 - GENERAL

1.1 DESCRIPTION

A. Division 23 Contractor shall furnish all disconnects for Division 23 HVAC and Division 22 Plumbing equipment. As indicated on the drawings and in the Mechanical/Electrical responsibility schedule. Division 26 Contractor shall install disconnect, conduit and wire and terminate all power wiring.

B. Division 26 Contractor shall furnish and install disconnect switches, wire and terminate power wiring for other equipment such as overhead doors, etc.

C. Disconnects protecting the primary side of remote dry type transformers shall be fused to protect the transformer for 100,000 amps RMS symmetrical.

D. Related Work Specified in Division 26

1. Section 26 28 14 – Fuses – Low Voltage
2. Section 26 05 26 – Grounding and Bonding
3. Section 26 05 53 – Identification for Electrical Systems

E. Related Work Specified in other Divisions of these Specifications.

1. Setting of motors and other equipment.

1.2 STANDARDS

A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and the latest applicable recommendations of the following:

1. U.L. Standards #98 (File #4776) and #508.
2. Federal Specifications W-S-865C.
3. NEMA Standard KS1-1975.
4. U.L. 20 and Federal Specification Test Standards for Toggle Switches.

1.3 SUBMITTALS

A. Submit manufacturer's data for all disconnect switches.

B. Identify motor or equipment served by each switch; indicate nameplate inscription.

PART 2 - PRODUCTS

2.1 APPROVED MANUFACTURERS

A. Safety switches.

1. Shall be of the same manufacturer as the panelboard.

B. Toggle type manual control switches. Shall be of the same manufacturer of the panelboards.

2.2 SAFETY SWITCHES

A. Heavy-duty, horsepower rated, single-throw knife switch with quick-make, quick-break mechanism, capable of full-load operations. Meet NEMA and U.S. Government specifications for Class A switches.

B. Provide with contact arc-quenching devices, such as magnetic blowouts or snuffing plates. Provide self-aligning switchblades with silver alloy contact areas and designed so that arcing upon making and breaking does not occur on the final contact surfaces. Provide with high-pressure, spring-loaded contact. Mount switch parts on high-grade insulating base.

C. Enclosure – NEMA 1 with hinged door and defeat-able interlock when switch is in "ON" position and can be positively padlocked in "ON" and "OFF" positions. Utilize NEMA 3R (rain-tight) enclosure for exterior installations.

D. Size, fusing and number of poles as shown or as required. Where fused, the devices must be provided with UL listed rejection feature to reject all but Class R fuses. Provide horsepower rated switch to match motor load if no size is shown. Use 3 pole plus solid neutral switches on four wire circuits and 3 pole switches on all other circuits, unless otherwise noted.

E. Lugs must be UL listed for aluminum and/or copper conductors and be front removable.

2.3 TOGGLE TYPE MANUAL CONTROL SWITCHES

A. Provide switches that operate at their full rating with resistance loads, and at 80% of their rated capacity with motor loads.

B. Switches to be heavy duty and have:

1. Arc-resisting bodies.
2. Slow make-and-break mechanisms
3. Silver alloy contact buttons
4. Side or back wiring with up to No. 10 AWG solid conductors

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Each motor over 1/2 HP (except for 120V-1Ø) shall be provided with a horsepower-rated safety-type disconnect switch.

B. Each piece of equipment utilizing multi-phase power shall be supplied with a safety-type disconnect switch.

C. Each piece of equipment utilizing single-phase power but protected at over 30 amperes shall be supplied with a safety-type disconnect switch.

D. Equipment other than that mentioned above may utilize a toggle-type manual control switch properly sized and rated for the equipment it disconnects.

E. Factory installed disconnect switches may be used to satisfy the above requirements with the Architect/Engineer's prior approval.

3.2 MOUNTING

A. Provide connections and wiring to and from each disconnect switch. Support conduit feeder from ceiling or floor.

B. Disconnect switches shall be mounted at adjacent wall or from the floor with independent supports. Switches shall not be mounted on fan housings.

C. Mount switch enclosure rigidly and with proper alignment on building structure or steel supports with centerline of operating handle not more than 5’ – 6” above finished floor unless otherwise required. Use steel supports fabricated from standard rolled structural steel shapes or framing channel to provide one-inch separation between enclosure and building wall for vertical flow of air.

D. Install fuses as specified in Section 26 28 14.

E. Completed installation shall contain no extraneous openings.

3.3 IDENTIFICATION

A. Provide identification of all disconnect switches in accordance with Section 26 05 53 of these specifications.

END OF SECTION 26 28 23

SECTION 26 51 00 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 DESCRIPTION

A. General: Provide luminaires and accessories in accordance with the Contract Documents.

B. Related Work Specified in Division 26

1. Section 26 05 10 – Testing, Inspection and Certification
2. Section 26 05 14 – Equipment Connections and Coordination
3. Section 26 05 21 – Wires and Cables
4. Section 26 05 29 – Hangers and Supports for Electrical Systems
5. Section 26 05 33 – Raceways and Boxes
6. Section 26 05 53 – Identification for Electrical Systems
7. Section 26 09 24 – Distributed Digital Lighting Controls
8. Section 26 27 26 – Wiring Devices

1.2 STANDARDS

A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:

1. Luminaires – UL 57, UL 1570, UL 1571, UL 1572, UL 676.
2. Exit and Egress Luminaires – NFPA 70 and 101, UL 924.
3. Hazardous Locations – UL 1225, UL 1203, UL 506, UL 844, UL 886.
4. Cords – UL 62.
5. IES-SPI-NEMA Joint Standards for Class A and Class C acrylic compounds for plastic enclosures.
6. L.E.D. Light Sources – UL 8750-09
7. Local code requirements.

1.3 SUBMITTALS

A. Submit shop drawings and manufacturers' data for the following items in accordance with the conditions of the contract and as specified below.

1. Major luminaires and special luminaires shall show full-size cross sections. Indicate finished dimensions, metal thicknesses, and materials.
2. Show mounting details, including hung ceiling construction.
3. For each fixture indicate type of LED driver and quantity. Include information as to power factor, input watts and lumens.

4. Indicate drivers to be utilized and quantity and submit photometry. Where the drivers to be utilized are other than ones which published photometric data is available for, additional test data shall be submitted to the engineer. These tests shall be performed by a certified independent testing laboratory or equal as approved.
5. Shop drawings shall include a complete listing of all luminaires on a single sheet. This listing shall contain the luminaire type, manufacturers catalog number, applied voltage and drivers.
6. The Owner reserves the right to require submittal of a complete sample fixture for any fixture type.

PART 2 - PRODUCTS

2.1 APPROVED MANUFACTURERS

A. Luminaires

1. Fixtures shall be as per specified in the lighting fixture schedule as shown on the Drawings. Substitutions to specified fixtures shall be made to architect/engineer 10 days prior to bid due date for prior approval. Acceptable manufacturers are listed in the lighting fixture schedule.
2. The designations indicated on the lighting fixture schedule are a design series reference (not necessarily a complete catalog number) and do not necessarily represent the number, size, voltage, wattage, finish trim, ceiling type, mounting hardware of special requirements as specified hereinafter on as required by the particular installation(s) and code. Contractor shall verify these requirements and order fixtures as required to give proper installation per the contract documents and per code.

2.2 FIXTURE QUALITY AND DESCRIPTION

A. Manufacture luminaires to the specifications described herein and on the drawings.

2.3 FABRICATION

A. Provide luminaires, completely factory-assembled and wired and equipped with necessary lamps, wiring, shielding, reflectors, channels, lenses, etc., and deliver to job ready for installation.

2.4 MATERIALS

A. Plastic Lenses and Diffusers:

1. Virgin methyl methacrylate unless otherwise noted. De-staticize after cleaning. Install and leave with no fingerprints or dirt marks on the lens or diffuser. Use white gloves if necessary.

2. Minimum nominal thickness for flat acrylic lens: .156 inch unless otherwise specified in the Fixture Schedule on the drawings.

B. Finish: Porcelain or baked enamel finish, matte white on interiors with minimum tested reflectance of 90 percent. Matte white finish or as specified for visible portions of exterior. Thoroughly clean base metal and bonderize after fabrication.

C. Luminaire Wiring: Minimum individual luminaire wiring – number 18 gauge with insulation at rated operating temperature of 105 degrees Centrigrade or higher. Terminate wiring for recessed luminaires, except fluorescent units, in an external splice box.

D. Where utilized as raceways, luminaires shall be suitable for use as raceways. Provide feed through splice boxes where necessary.

2.5 LED LIGHT FIXTURES

A. General:

1. LED light fixtures shall be in accordance with IES, NFPA, UL, as shown on the drawings, and as specified.
2. LED light fixtures shall be Reduction of Hazardous Substances (RoHS) – compliant.
3. LED drivers shall include the following features unless otherwise indicated:

   a. Minimum efficiency: 85% at full load.
   b. Minimum Operating Ambient Temperature: -20° C. (-4°F)
   c. Input Voltage: 120-277V (+/-10%) at 60 Hz.
   d. Integral short circuit, open circuit, and overload protection.
   e. Power Factor: ≥ 0.95
   f. Total Harmonic Distortion: $\leq 20\%$
   g. Comply with FCC 47 CFR Part 15

4. LED modules shall include the following features unless otherwise indicated:

   a. Comply with IES LM-79 and LM-80 requirements.
   b. Minimum CRI 90 and color temperature 3500° K unless otherwise specified in LIGHTING FIXTURE SCHEDULE.
   c. Minimum Rated Life: 50,000 hours per IES L70.
   d. Light output lumens as indicated in the LIGHTING FIXTURE SCHEDULE.

B. LED Downlights:

1. Housing, LED driver, and LED module shall be products of the same manufacturer.

C. LED Troffers:

1. LED drivers, modules, and reflector shall be accessible, serviceable, and replaceable from below the ceiling.
2. Housing, LED driver, and LED module shall be products of the same manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Architect's and/or interior designers reflected ceiling plans show actual location of luminaires. Report to the Architect/Engineer any conflict between these plans and the electrical documents. Perform the work in accordance with the Architects/Engineers instructions. At the time of bid, include the most stringent requirement.

B. Spaces for luminaire insertion will be provided by the trade that installs the ceiling. Furnish plaster and other frames for setting and installing under another section of these specifications.

C. Install luminaires in mechanical and unfinished areas after ductwork and piping installation. Locate fixtures within space on walls but not lower than 7'-0" AFF. Where mounted lower than 8'-6" luminaires shall be chain or pendant hung and protected by an approved wire guard.

D. The Contractor is required to protect luminaires from damage during installation of same and up to time to acceptance by the Architect/Engineer and any broken luminaires, glassware, plastics, lamps, etc., must be replaced by the contractor with new parts, without any additional expense to the Owner.

E. Where LED luminaires are surface mounted, they shall be labeled for such and a minimum of one-half (1/2) inch air space shall be maintained between top of luminaire and mounting surface by an approved means.

F. Pendant mounted units shall comply with the following:

1. Where 8' and 4' luminaires are mounted in a continuous row, luminaires, eight feet in length, shall have stems placed within 2'-0" apart. Stems shall be spaced symmetrically with a minimum of two (2) stems per eight-foot fixture and one (1) stem per four foot fixtures so as to provide a uniform appearance throughout.
2. Individual luminaires, four feet or three feet in length, shall have two stems placed approximately 3 inches from each end.
3. Individual luminaires, eight feet in length shall have two stems placed approximately 4'-0" apart.
4. Each stem shall have a brass or steel swivel of other self-aligning device. The entire luminaire mounting (hickey, aligner, swivel, stem, etc.) shall be approved and provided by the fixture manufacturer.
5. A malleable iron bushing shall be placed at luminaire end of stem through which wire passes.
6. A pendant support using an approved sliding clevis bracket which firmly grips an indentation in rigid sides of the wiring channel will be acceptable.
7. Connections between outlet boxes and luminaires shall be by means of approved flexible raceways.

G. Where luminaires are mounted upon surface-mounted outlet boxes in surface mounted conduit runs, this Contractor shall furnish and install a luminaire canopy sufficiently deep to permit exposed conduits to pass through. Canopy shall have proper openings cut by luminaire

manufacturer through which conduits may pass. Submit sample of canopy for approval before installation.

H. Where required by the local Building Department, provide approved wire guards over luminaires.

I. Prior to final payment this contractor shall clean all luminaires and replace all expended LED lamps. He shall also touch up all scratch marks, etc. in an approved manner.

J. Except as otherwise noted as a minimum procedure, support surface or pendant mounted luminaires:

1. Where weight is less than five pounds, from its outlet box by means of an interposed metal strap.
2. Where weight is from five to fifty pounds, from its outlet box by means of a hickey or other direct threaded connection.
3. Whose weight exceeds fifty pounds, directly from structural slab, deck or framing member.

K. Except as otherwise noted as a minimum procedure, support recessed luminaires:

1. Where weight is eighty pounds or less ceiling suspension members, as described above.
2. Where weight is more than eighty pounds directly from structural slabs, decks or framing members.
3. Where luminaires and ceilings are such as to require luminaire support from ceiling opening frames, include in the electric work the members necessary to tie back the ceiling opening frames to ceiling suspension members or slabs so as to provide actual support for the luminaires as noted above.

L. In conjunction with luminaires weighing less than fifty pounds the above restriction against supporting from suspended ceiling splines, runners or bars in the plane of the ceiling will be waived for ceilings which have been specifically approved for the weight and arrangement of luminaires being applied. Any support members, or other appurtenances, however, required to tie in or adapt the luminaires and their ceiling opening frames (if any) to the ceiling in the approved manner shall be included as part of the electric work.

M. In stairwells provide at minimum a luminaire of the type specified at each landing and at each intermediate landing.

N. Install exit lights as indicated on the drawings but not higher than 10'-0" AFF. All exit lights shall be installed with the downlight component fully operational.

O. Track luminaires, adjustable luminaires, floodlights, and accent lights shall be aimed as directed by the Architect/Engineer. Outdoor lighting shall be aimed in periods of darkness.

P. Recessed luminaires to be installed in metal pan or acoustic modular ceilings shall be modified as required to fit into openings in ceiling construction. This contractor shall coordinate and verify this work with the General Construction Contractor. Shop drawings showing details shall be submitted for approval. Provide 1C rated fixtures in music/band room, etc. being provided with insulated ceilings for sound attenuation.

3.2 COORDINATION WITH MOUNTING CONDITIONS

A. This contractor is responsible for coordinating the mounting accessories and luminaire trims with the ceiling conditions for which each luminaire will be installed. No extra compensation will be permitted for failure to coordinate.

B. All luminaires in hung ceilings are to be installed with earthquake clips.

3.3 COORDINATION WITH AMBIENT CONDITIONS

A. This contractor is responsible for coordinating the characteristics and the U.L. labeling of the luminaires and their components with the ambient conditions which will exist when the luminaires are installed. No extra compensation will be permitted for failure to coordinate the luminaires with their ambient conditions. These areas of coordination include but are not limited to the following:

1. Wet location labels
2. Damp location labels
3. Plenums and air handling spaces
4. Fire rated ceilings
5. Insulated ceilings

3.4 FINAL ADJUSTMENTS

A. Adjust lamp position, reflector/refractor position and aim fixtures as required.

END OF SECTION 26 51 00