PROJECT MANUAL
Volume 2

McKinley High School Major Renovations

CSRS|Tillage Program Management PROJECT NOS. 920.007

OWNER:

EAST BATON ROUGE PARISH SCHOOL BOARD

Shashonnie Steward	President
Michael Gaudet	Vice President
Lamont Cole	Superintendent of Schools

SCHOOL BOARD MEMBERS

Mark Bellue, District 1	Nathan Rust, District 6
Dadrius Lanus, District 2	Michael Gaudet, District 7
Carla Powell, District 3	Emily Soulé, District 8
Shashonnie Steward, District 4	Patrick Martin, District 9
Cliff Lewis, District 5	

Addition and Renovation Package
Design Development Submittal

DATE:
August 8, 2025

PROGRAM MANAGER:

ARCHITECT:

Domain Architecture, APAC / CHASM Architecture, LLC
A Joint Venture
11130 Industriplex Blvd Suite 200, Baton Rouge, LA 70809

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SECTION 210100 - FIRE PROTECTION OPERATING AND MAINTENANCE MANUALS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Compilation product data and related information appropriate for Owner's operation and maintenance of products furnished under Contract. Prepare operating and maintenance data as specified.

B. Instruct Owner's personnel in operation and maintenance of equipment and systems.

C. Submit three copies of complete manual in final form.

1.2 SUBMITTALS

A. Thirty (30) days after the Contractor has received the final scheduled identified submittals bearing the Architect / Engineer's stamp of acceptance (including resubmittals), submit for review one copy of the first draft of the Operating and Maintenance Manual. This copy shall contain as a minimum:

1. Table of Contents for each element.
2. Contractor information.
3. All submittals, coordination drawings and product data, reviewed by the Architect / Engineer; bearing the Architect / Engineer's stamp of acceptance. (When submittals are returned from Engineer "Correct as Noted", corrected inserts shall be included.)
4. All parts and maintenance manuals for items of equipment.
5. Warranties (without starting dates)
6. Certifications that have been completed. Submit forms and outlines of certifications that have not been completed.
7. Operating and maintenance procedures.
8. Form of Owner's Training Program Syllabus (including times and dates).
9. Control operations/equipment wiring diagrams.
10. Other required operating and maintenance information that are complete.

B. Copy will be returned to the Contractor within 15 days with comments for corrections.

C. Submit three (3) completed manuals in final form to the Architect / Engineer one day after substantial completion, and prior to Owner's instructions. Include all specified data, test and balance reports, drawings, dated warranties, certificates, reports, along with other materials and information.

D. The Architect / Engineer will review the manuals for completeness within fifteen (15) days.

E. The Contractor shall be notified of any missing or omitted materials. The Manuals shall be reworked by the Contractor, as required, in the office of the Architect / Engineer. The manuals will not be retransmitted.

F. Two (2) complete Manuals will be delivered to the Owner.

PART 2 - PRODUCTS

2.1 BINDERS

A. Commercial quality black three-ring binders with clear overlay plastic covers.

B. Minimum ring size: 1".
Maximum ring size: 3".

C. When multiple binders are used, correlate the data into related groupings.

D. Label contents on spine and face of binder with full size insert. Label under plastic cover.

PART 3 - EXECUTION

3.1 OPERATION AND MAINTENANCE MANUAL

A. Form for Manuals:
1. Prepare data in form of an instructional manual for use by Owner's personnel.
2. Format:
    a. Size: 8-1/2" x 11".
    b. Text: Manufacturer's printed data or neatly typewritten.
3. Drawings:
    a. Provide reinforced punched binder tab and bind in text.
    b. Fold larger drawings to size of text pages.
4. Provide flyleaf indexed tabs for each separate product or each piece of operating equipment.
5. Cover: Identify each volume with typed or printed title "Operating and Maintenance Instructions". List:
    a. Title of Project
    b. Identity of separate structures as applicable.
    c. Identity of general subject matter covered in the manual.
6. Binder as specified.

B. Content of Manual:
1. Neatly typewritten Table of Contents for each volume arranged in systematic order as outlined in the specifications.
    a. Contractor, name of responsible principal, address and telephone number.

b. A list of each product required to be included, indexed to content of the volume.
c. List with each product, name, address and telephone number of:
1) Subcontractor or installer
2) Maintenance contractor as appropriate
3) Identify area of responsibility of each
4) Local source of supply for parts and replacement
d. Identify each product by product name and other identifying symbols as set forth in Contract Documents.

2. Product Data:
a. Include those sheets pertinent to the specific product
b. Annotate each sheet to:
1) Identify specific product or part installed
2) Identify data applicable to installation
3) Delete references to inapplicable information. (All options not supplied with equipment shall be marked out indicated in some manner.

3. Drawings:
a. Supplement product data with drawings as necessary to illustrate:
1) Relations of component parts of equipment and systems
2) Control and flow diagrams
b. Coordinate drawings with information in Project Record Documents to assure correct illustration of completed installation.
c. Do not use Project Record Documents as maintenance drawings.

4. Written text, as required to supplement product data for the particular installation:
a. Organize in consistent format under separate headings for different procedures.
b. Provide logical sequence of instructions for each procedure.

5. Copy of each warranty, bond and service contract issued.
a. Provide information sheet for Owner's personnel, giving:
1) Proper procedures in event of failure
2) Instances that might affect validity of warranties or bonds

6. Shop drawings, coordination drawings and product data as specified.

C. Sections for Equipment and Systems.

1. Content for each unit of equipment and system as appropriate:
a. Description of unit and component parts
1) Function, normal operating characteristics, and limiting conditions
2) Performance curves, engineering data and tests
3) Complete nomenclature and commercial number of replaceable parts.
b. Operating procedures:
1) Start up, break-in, routine and normal operating instructions.
2) Regulation, control, stopping, shut down and emergency instructions.
3) Summer and winter operating instructions.
4) Special operating instructions.
c. Maintenance procedures:

1) Routine operations
2) Guide to trouble-shooting.
3) Disassembly, repair and reassembly.
4) Alignment, adjusting and checking.
5) Routine service based on operating hours.

d. Servicing and lubrication schedule. List of lubricants required.
e. Manufacturer's printed operating and maintenance instructions.
f. Description of sequence of operation by control manufacturer.
g. Original manufacturer's parts list, illustrations, assembly drawings and diagrams required for maintenance.
   1) Predicted life of part subject to wear.
   2) Items recommended to be stocked as spare parts.
h. As installed control diagrams by controls manufacturer.
i. Complete equipment internal wiring diagrams.
j. Each Contractor's coordination drawings.
k. As installed color coded piping diagrams.
l. Charts of valve tag number, with location and function of each valve.
m. List of original manufacturer's spare parts and recommended quantities to be maintained in storage.
n. Other data as required under pertinent sections of the specifications.

2. Prepare and include additional data when the need for such data becomes apparent during instruction of Owner's personnel.
3. Additional requirements for operating and maintenance data as outlined in respective sections of specifications.
4. Provide complete information for products specified in Division 21.
5. Provide certificates of compliance as specified in each related section.
6. Provide start up reports as specified in each related section.
7. Provide signed receipts for spare parts and material.
8. Provide training report and certificates.
9. Provide backflow preventer certified test reports.

END OF SECTION 210100

SECTION 210500 - FIRE PROTECTION GENERAL PROVISIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Except as modified in this Section, General Conditions and Supplementary Conditions, applicable provisions of the General Requirements, and other provisions and requirements of the contract documents apply to work of Division 21 Fire Sprinkler Systems.

B. Applicable provisions of this section apply to all sections of Division 22, Plumbing.

1.2 CODE REQUIREMENTS AND FEES

A. Perform work in accordance with applicable statutes, ordinances, codes and regulations of governmental authorities having jurisdiction.

B. Plumbing work shall comply with applicable inspection services:
1. Underwriters Laboratories
2. National Fire Protection Association
3. State Health Department
4. Local Municipal Building Inspection Department
5. Texas Department of Licensing & Regulations (TDLR)
6. Texas Accessibility Standards (TAS Based on ADA)

C. Resolve any code violations discovered in contract documents with the Engineer prior to award of the contract. After Contract award, any correction or additions necessary for compliance with applicable codes shall be made at no additional cost to the Owner.

D. This Contractor shall be responsible for being aware of and complying with asbestos NESHAP regulations, as well as all other applicable codes, laws and regulations.

E. Obtain all permits required.

1.3 CONTRACTOR'S QUALIFICATIONS

A. An approved contractor for the work under this division shall be:
1. A licensed specialist in this field and have the personnel, experience, training, skill, and organization to provide a practical working system
2. Able to furnish evidence of having contracted for and installed not less than 3 systems of comparable size and type that has served their Owners satisfactorily for not less than 3 years

1.4 REFERENCE SPECIFICATIONS AND STANDARDS

A. Materials which are specified by reference to Federal Specifications; ASTM, ASME, ANSI, or AWWA Specifications; Federal Standards; or other standard specifications must comply with latest editions, revisions, amendments or supplements in effect on date bids are received. Requirements in reference specifications and standards are minimum for all equipment, material, and work. In instances where specified capacities, size, or other features of equipment, devices, or materials exceed these minimums, meet specified capacities.

1.5 CONTRACT DRAWINGS

A. Contract drawings are diagrammatic only and do not give fully dimensioned locations of various elements of work. Determine exact locations from field measurements.

1.6 PROJECT RECORD DOCUMENTS

A. Maintain at the job site a separate set of white prints (blue line or black line) of the contract drawings for the sole purpose of recording the "as-built" changes and diagrams of those portions of work in which actual construction is at variance with the contract drawings. Mark the drawings with a colored pencil. Prepare, as the work progresses and upon completion of work, reproducible drawings clearly indicating locations of various lines, valves, ductwork, traps, equipment, and other pertinent items, as installed. Include flow-line elevation of sewer lines. Record existing and new underground and under slab piping with dimensioned locations and elevations of such piping.

B. At the conclusion of project, obtain without cost to the Owner, erasable mylars of the original drawings and transfer as-built changes to these. Prior to transmittal of corrected drawings, obtain 3 sets of blue-line prints of each drawing, regardless of whether corrections were necessary and include in the transmittal (2 sets are for the Owner's use and one set is for the Architect/Engineer's records). Delivery of these as-built prints and reproducibles is a condition of final acceptance. Provide record drawings on one set each (reproducible Dayrex mylar film positives) and AutoCad 2012 / Revit CAD files on disk (CD Rom).

C. As-Built drawings should indicate the following information as a minimum:
  1. Indicate all addendum changes to documents.
  2. Remove Engineer’s seal, name, address and logo from drawings.
  3. Mark documents RECORD DRAWINGS.
  4. Clearly indicate: DOCUMENT PRODUCED BY
  5. Indicate all changes to construction during construction. Indicate actual routing of all piping, etc. that were deviated from construction drawings.
  6. Correct schedules to reflect (actual) equipment furnished and manufacturer.
  7. During the execution of work, maintain a complete set of drawings and

specifications upon which all locations of equipment, ductwork, piping, devices, and all deviations and changes from the construction documents in the work shall be recorded.

8. Location and size of all ductwork and mechanical piping above ceiling including exact location of isolation of domestic and plumbing valves.
9. Exact location of all electrical equipment in and outside of the building.
10. Fire Protection System documents revised to indicate exact location of all sprinkler heads and zone valves.
11. Exact location of all roof mounted equipment, wall, roof and floor penetrations.
12. Cloud all changes.

1.7 SPACE REQUIREMENTS

A. Consider space limitations imposed by contiguous work in selection and location of equipment and material. Do not provide equipment or material that is not suitable in this respect.

1.8 RELATION WITH OTHER TRADES

A. Carefully study all matters and conditions concerning the project. Submit notification of conflict in ample time to prevent unwarranted changes in any work. Review other Divisions of these specifications to determine their requirements.

B. Because of the complicated relationship of this work to the total project, conscientiously study the relation and cooperate as necessary to accomplish the full intent of the documents.

C. Provide sleeves and inserts in forms as required for the work. Stub up and protect open ends of pipe before any concrete is placed. Furnish sizes of required equipment pads. Furnish and locate bolts and fittings required to be cast in them.

D. Locate and size openings required for installation of work specified in this Division in sufficient time to prevent delay in the work.

E. Refer to other Divisions of the specifications for the scope of required connections to equipment furnished under that Division. Determine from the Contractor for the various trades, the Owner, and by direction from the Architect/Engineer, the exact location of all items.

1.9 CONCEALED AND EXPOSED WORK

A. When the word "concealed" is used in connection with insulating, painting, piping, ducts and the like, the work is understood to mean hidden from sight as in chases, furred spaces or above ceilings. "Exposed" is understood to mean open to view.

1.10 GUARANTEE

A. Guarantee work for 1 year from the date of substantial completion of the project. During that period make good any faults or imperfections that may arise due to defects or omissions in material, equipment or workmanship. At the Owner's option, replacement of failed parts or equipment shall be provided.

1.11 MATERIAL AND EQUIPMENT

A. Furnish new and unused materials and equipment meeting the requirements of the paragraph specifying acceptable manufacturers. Where two or more units of the same type or class of equipment are required, provide units of a single manufacturer.

1.12 NOISE AND VIBRATION

A. Select equipment to operate with minimum noise and vibration. If objectionable noise or vibration is produced or transmitted to or through the building structure by equipment, piping, ducts or other parts of work, rectify such conditions at no additional cost. If the item of equipment is judged to produce objectionable noise or vibration, demonstrate at no additional cost that equipment performs within designated limits on a vibration chart.

1.13 ACCEPTABLE MANUFACTURERS

A. Manufacturers names and catalog number specified under sections of Division 21 are used to establish standards of design, performance, quality and serviceability and not to limit competition. Equipment of similar design, equal to that specified, manufactured by a named manufacturer will be acceptable on approval. A request for prior approval of equipment not listed must be submitted ten (10) days before bid due date. Submit complete design and performance data to the Engineer.

1.14 OPERATING TESTS

A. After all plumbing systems have been completed and put into operation, subject each system to an operating test under design conditions to ensure proper sequencing and operation throughout the range of operation. Tests shall be made in the presence of the Architect/Engineer. Make adjustments as required to ensure proper functioning of all systems. Special tests on individual systems are specified under individual sections. Submit 3 copies of all certifications and test reports adequately in advance of completion of the work to allow for remedial action as required to correct deficiencies discovered in equipment and systems.

1.15 WARRANTIES

A. Submit 3 copies of all warranties and guarantees for systems, equipment, devices and materials. These shall be included in the Operating and Maintenance Manuals.

1.16 BUILDING CONSTRUCTION

A. It shall be the responsibility of each sub-contractor to consult the Architectural and Engineering drawings, details, and specifications and thoroughly familiarize himself with the project and all job related requirements. Each sub-contractor shall cooperate with the General Contractor to verify that all piping and other items are placed in the walls, furred spaces, chases, etc., so there will be no delays in the job.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 OPENINGS

A. Framed, cast or masonry openings for ductwork, equipment or piping are specified under other divisions. Drawings and layout work for exact size and location of all openings are included under this division.

3.2 HOUSEKEEPING PADS

A. Provide equipment housekeeping pads under all floor mounted and ground mounted plumbing equipment, and as shown on the drawings.

B. Concrete work as specified in Division 3.

C. Concrete pads:
   1. 4" high, rounded edges, minimum 2500 psi unless otherwise indicated on the drawings
   2. Chamfer strips at edges and corner of forms.
   3. Smooth steel trowel finish.
   4. Doweled to existing slab

D. Install concrete curbs around multiple pipe penetrations.

3.3 VANDAL RESISTANT DEVICES

A. Provide a handle for each loose keyed operated valve and hose bibb on the project.

B. Where vandal resistant screws or bolts are employed on the project, deliver to the Owner 2 suitable tools for use with each type of fastener used.

C. Proof of delivery of these items to the Owner shall be included in the Operating and Maintenance Manuals.

3.4 INSTRUCTION OF OWNER'S PERSONNEL

A. Prior to final inspection, conduct an on-site training program to instruct the Owner's operating personnel in the operation and maintenance of the plumbing systems.
   1. Provide the training during the Owner's regular working day.
   2. The Instructors shall each be experienced in their phase of operation and maintenance of building plumbing systems and with the project.

B. Time to be allocated for instructions.
   1. Minimum of 4 hours dedicated instructor time.
   2. 2 hours on each of 2 days.

C. Before proceeding with the on-site training program, submit the program syllabus; proposed time and dates; and other pertinent information for review and approval.
   1. One copy to the Owner.
   2. One copy to the Architect/Engineer.

D. The Owner will provide a list of personnel to receive instructions, and will coordinate their attendance at the agreed upon times.

E. Use the operation and maintenance manuals as the basis of instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.

F. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shut down of each item of equipment.

G. Demonstrate equipment functions (both individually and as part of the total integrated system).

H. Prepare and insert additional data in the operating and maintenance manuals when the need for additional data becomes apparent during instructions.

I. Submit a report within one week after completion of the training program that instructions have been satisfactorily completed. Give time and date of each demonstration and hours devoted to the demonstration, with a list of people present.

J. At the conclusion of the on-site training program, have the person designated by the Owner sign a certificate to certify that he/she has a proper understanding of the system, that the demonstrations and instructions have been satisfactorily completed, and the scope and content of the operating and maintenance manuals used for the training program are satisfactory.

K. Provide a copy of the report and the certificate in an appropriately tabbed section of each Operating and Maintenance Manual.

3.5 EQUIPMENT IDENTIFICATION

A. Provide a laminated engraved plastic nameplate on each piece of equipment and starter.
   1. Designation approved by Architect/Engineer.
   2. Equipment includes, but is not limited to, water heaters, pumps, boilers and utility controllers.
   3. Submit schedule of equipment to be included and designations.

B. Provide nameplates with 1/2" high letters and fastened with epoxy or screws.

3.6 OBSTRUCTIONS

A. The drawings indicate certain information pertaining to surface and subsurface obstructions which has been taken from available drawings. Such information is not guaranteed, however, as to accuracy of location or complete information.
   1. Before any cutting or trenching operations are begun, verify with Owner's representative, utility companies, municipalities, and other interested parties that all available information has been provided.
   2. Should obstruction be encountered, whether shown or not, alter routing of new work, reroute existing lines, remove obstruction where permitted, or otherwise perform whatever work is necessary to satisfy the purpose of the new work and leave existing services and structures in a satisfactory and serviceable condition.

B. Assume total responsibility for and repair any damage to existing utilities or construction, whether or not such existing facilities are shown.

3.7 PROTECTION

A. Protect work, equipment, fixtures, and materials. At work completion, work must be clean and in original manufacturer's condition.

END OF SECTION 210500

SECTION 210510 - FIRE PROTECTION CONTRACT QUALITY CONTROL

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Contract quality control including workmanship, manufacturer's instructions and demonstrations.

1.2 QUALITY CONTROL PROGRAM

A. Maintain quality control over supervision, subcontractors, suppliers, manufacturers, products, services, site conditions and workmanship to produce work in accordance with contract documents.

1.3 WORKMANSHIP

A. Comply with industry standards except when more restrictive tolerances or specified requirements indicate more rigid standards or more precise workmanship.

B. Perform work by persons qualified to produce workmanship of specified quality.

C. Secure products in place with positive anchorage devices designed and sized to withstand stresses, vibration, and racking. Under no conditions shall material or equipment be suspended from structural bridging.

D. Provide finishes to match approved samples. All exposed finishes shall be approved by the Architect. Submit color samples as required.

1.4 MANUFACTURER'S INSTRUCTIONS

A. Comply with instructions in full detail, including each step in sequence.

B. Should instruction conflict with Contract Documents, request clarification from Architect / Engineer before proceeding.

1.5 MANUFACTURER'S CERTIFICATES

A. When required in individual Specification Sections, submit manufacturer's certificate in duplicate, certifying that products meet or exceed specified requirements.

1.6 MANUFACTURER'S FIELD SERVICES

A. When required in individual Specification Sections, manufacturer shall provide qualified personnel to observe:
   1. Field conditions.
   2. Condition of installation.
   3. Quality of workmanship.
   4. Start-up of equipment.
   5. Testing, adjusting, and balancing of equipment.

B. Representative shall make written report of observations and recommendations to Architect / Engineer.

PART 2 - PRODUCTS

2.1 REFERENCE APPLICABLE SPECIFICATION SECTIONS.

PART 3 - EXECUTION

3.1 PROTECTION OF EQUIPMENT

A. Do not deliver equipment to the project site until progress of construction has reached the stage where equipment is actually needed or until building is closed in enough to protect the equipment from weather. Equipment allowed to stand in the weather will be rejected, and the Contractor is obligated to furnish new equipment of a like kind at no additional cost to the Owner.

B. Adequately protect equipment from damage after delivery to the project. Cover with heavy tarpaulins, drop cloths or other protective coverings as required to protect from plaster, paint, mortar and/or dirt. Do not cover with plastic materials and trap condensate and cause corrosion.

END OF SECTION 210510

SECTION 21 05 12 - FIRE PROTECTION SHOP DRAWINGS, COORDINATION DRAWINGS & PRODUCT DATA

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Prepare submittals as required by Division 1.

B. The term submittal, as used herein, refers to all:
1. Shop Drawings
2. Coordination Drawings
3. Product data

C. Submittals shall be prepared and produced for:
1. Distribution as specified
2. Inclusion in the Operating and Maintenance Manual, as specified, in the related section

1.2 SHOP DRAWINGS

A. Present drawings in a clear and thorough manner. Identify details by reference to sheet and detail, schedule, or room numbers shown on Contract Drawings.

B. Show all dimensions of each item of equipment on a single composite Shop Drawing. Do not submit a series of drawings of components.

C. Identify field dimensions; show relationship to adjacent features, critical features, work, or products.

D. Submit shop drawings in plan, elevation and sections, showing equipment in mechanical equipment areas.

1.3 COORDINATION DRAWINGS

A. Present in a clear and thorough manner. Title each drawing with project name. Identify each element of drawings by reference to sheet number and detail, or room number of contract documents. Minimum drawing scale: ¼” = 1’-0”.

B. Prepare coordination drawings to coordinate installations for efficient use of available space, for proper sequence of installation, and to resolve conflicts. Coordinate with work specified in other sections and other divisions of the specifications.

C. For each mechanical room and for each outside equipment pad where equipment is located, submit plan and elevation drawings. Show:
   1. Actual mechanical equipment and components to be furnished
   2. Service clearance
   3. Relationship to other equipment and components
   4. Roof drains and leader piping
   5. Fire protection piping and equipment

D. Identify field dimensions. Show relation to adjacent or critical features of work or products.

E. Related requirements:
   1. Ductwork shop drawings
   2. Coordination drawing specified in Division 26

F. Submit shop drawings in plan, elevation and sections, showing equipment in mechanical equipment areas.

G. Gas piping sketch indicating proposed location of piping prior to proceeding with the installation.

1.4 PRODUCT DATA AND INSTALLATION INSTRUCTION

A. Submit only pages which are pertinent to the project. All options which are indicated on the product data shall become part of the contract and shall be required whether specified are not.

B. Mark each copy of standard printed data to identify pertinent products, referenced to specification section and article number.

C. Show reference standards, performance characteristics and capacities; wiring and piping diagrams and controls; component parts; finishes; dimensions and required clearances.

D. Modify manufacturer's standard schematic drawings and diagrams to supplement standard information and to provide information specifically applicable to the work. Delete information not applicable.

F. Provide a separate transmittal for each submittal item. Transmittals shall indicate product by specification section name and number. Separate all submittals into appropriate specification section number. Do not combine specification sections.

1.5 MANUFACTURERS INSTRUCTIONS

A. Submit Manufacturer's instructions for storage, preparation, assembly, installation, start-up, adjusting, calibrating, balancing and finishing.

1.6 CONTRACTOR RESPONSIBILITIES

A. Review submittals prior to transmittal.

B. Determine and verify:
   1. Field measurements
   2. Field construction criteria
   3. Manufacturer's catalog numbers
   4. Conformance with requirements of Contract Documents

C. Coordinate submittals with requirements of the work and of the Contract Documents.

D. Notify the Architect / Engineer in writing at time of submission of any deviations in the submittals from requirements of the Contract Documents.

E. Do not fabricate products, or begin work for which submittals are specified, until such submittals have been produced and bear contractor's stamp. Do not fabricate products or begin work scheduled to have submittals reviewed until return of reviewed submittals with Architect / Engineer's acceptance.

F. Contractor's responsibility for errors and omissions in submittals is not relieved whether Architect / Engineer reviews submittals or not.

G. Contractor's responsibility for deviations in submittals from requirements of Contract Documents is not relieved whether Architect / Engineer reviews submittals or not, unless Architect / Engineer gives written acceptance of the specific deviations on reviewed documents.

H. Submittals shall show sufficient data to indicate complete compliance with Contract Documents:
   1. Proper sizes and capacities
   2. That the item will fit in the available space in a manner that will allow proper service
   3. Construction methods, materials and finishes

I. Schedule submissions at least 15 days before date reviewed submittals will be needed.

1.7 SUBMISSION REQUIREMENTS

A. Make submittals promptly in accordance with approved schedule, and in such sequence as to cause no delay in the Project or in the work of any other Contractor.

B. Number of submittals required:
   1. Shop Drawings and Coordination Drawings: Submit one reproducible transparency and three opaque reproductions.

2. Product Data: Submit the number of copies which the contractor requires, plus those which will be retained by the Architect / Engineer.

C. Accompany submittals with transmittal letter, in duplicate, containing:
   1. Date
   2. Project title and number
   3. Contractor's name and address
   4. The number of each Shop Drawing, Project Datum and Sample submitted
   5. Other pertinent data

D. Submittals shall include:
   1. The date of submission
   2. The project title and number
   3. Contract Identification
   4. The names of:
      a. Contractor
      b. Subcontractor
      c. Supplier
      d. Manufacturer
   5. Identification of the product
   6. Field dimensions, clearly identified as such
   7. Relation to adjacent or critical features of the work or materials
   8. Applicable standards, such as ASTM or federal specifications numbers
   9. Identification of deviations from contract documents
   10. Suitable blank space for General Contractor and Architect / Engineer stamps
   11. Contractor's signed and dated Stamp of Approval

E. Coordinate submittals into logical groupings to facilitate interrelation of the several items:
   1. Finishes which involve Architect / Engineer selection of colors, textures or patterns
   2. Associated items which require correlation for efficient function or for installation

1.8 SUBMITTAL SPECIFICATION INFORMATION

A. Every submittal document shall bear the following information as used in the project manual:
   1. The related specification section number
   2. The exact specification section title

B. Submittals delivered to the Architect / Engineer without the specified information will not be processed. The Contractor shall bear the risk of all delays, as if no submittal had been delivered.

1.9 RESUBMISSION REQUIREMENTS

A. Make re-submittals under procedures specified for initial submittals.
   1. Indicate that the document or sample is a re-submittal
   2. Identify changes made since previous submittals

B. Indicate any changes which have been made, other than those requested by the Architect / Engineer.

1.10 CONTRACTOR'S STAMP OF APPROVAL

A. Contractor shall stamp and sign each document certifying to the review of products, field measurements and field construction criteria, and coordination of the information within the submittal with requirements of the work and of Contract Documents.

B. Contractor's stamp of approval on any submittal shall constitute a representation to Owner and Architect / Engineer that Contractor has either determined and verified all quantities, dimensions, field construction criteria, materials, catalog numbers, and similar data or assumes full responsibility for doing so, and that Contractor has reviewed or coordinated each submittal with the requirements of the work and the Contract Documents.

C. Do not deliver any submittals to the Architect / Engineer that do not bear the Contractor's stamp of approval and signature.

D. Submittals delivered to the Architect / Engineer without Contractor's stamp of approval and signature will not be processed. The Contractor shall bear the risk of all delays, as if no submittal had been delivered.

1.11 ARCHITECT / ENGINEER REVIEW OF IDENTIFIED SUBMITTALS

A. The Architect / Engineer will:
   1. Review identified submittals with reasonable promptness and in accordance with schedule
   2. Affix stamp and initials or signature, and indicate requirements for re-submittal or approval of submittal
   3. Return submittals to Contractor for distribution or for resubmission

B. Review and approval of submittals will not extend to design data reflected in submittals which is peculiarly within the special expertise of the Contractor or any party dealing directly with the Contractor.

C. Architect / Engineer's review and approval is only for conformance with the design concept of the project and for compliance with the information given in the contract.
   1. The review shall not extend to means, methods, sequences, techniques or procedures of construction or to safety precautions or programs incident thereto.

2. The review shall not extend to review of quantities, dimensions, weights or gauges, fabrication processes or coordination with the work of other trades.

D. The review and approval of a separate item as such will not indicate approval of the assembly in which the item functions.

1.12 SUBSTITUTIONS

A. Do not make requests for substitution employing the procedures of this Section.

B. The procedure for making a formal request for substitution is specified in Div. 1.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION - NOT USED

END OF SECTION 210512

SECTION 210513 - ELECTRICAL PROVISIONS OF FIRE PROTECTION WORK

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Electrical provisions to be provided as fire protection work are indicated in other Division 21 sections, on drawings, and as specified.

B. Types of work, normally recognized as electrical but provided as fire protection, specified or partially specified in this Section, include but are not necessarily limited to the following:
1. Motors for fire protection equipment.
2. Starters for motors of fire protection equipment, but only where specifically indicated to be furnished integrally with equipment.
3. Wiring from motors to disconnect switches or junction boxes for motors of fire protection equipment, but only where specifically indicated to be furnished integrally with equipment.
4. Wiring of field-mounted float control switches, flow control switches, and similar fire protection-electrical devices provided for fire protection systems, to equipment control panels.
5. Pipe heat tracing.

C. Refer to Division 21 sections for specific individual fire protection equipment electrical requirements.

F. Refer to Division 26 sections for motor starters and controls not furnished integrally with fire protection equipment.

G. Refer to Division 26 sections for junction boxes and disconnect switches required for motors and other electrical units of fire protection equipment.

1.2 RELATED WORK

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

1.3 QUALITY ASSURANCE

A. Wherever possible, match elements of electrical provisions of fire protection work with similar elements of electrical work specified in Division 26 sections for electrical work not otherwise specified.

B. For electrical equipment and products, comply with applicable NEMA standards, and refer to NEMA standards for definitions of terminology. Comply with National Electrical Code (NFPA 70) for workmanship and installation requirements.

1.4 SUBMITTALS

A. Include in listing of motors, voltage, notation of whether motor starter is furnished or installed integrally with motor or equipment containing motors.

PART 2 - PRODUCTS

2.1 MOTORS

A. Provide motors for fire protection equipment manufactured by one of the following:
1. Baldor Electric Company.
2. Century Electric Div., Inc.
3. General Electric Co.
4. Louis Allis Div.; Litton Industrial Products, Inc.
5. Lincoln Electric
6. Marathon Electric Mfg. Corp.
7. Reliance Electric Co.
8. Westinghouse Electric Corp.

B. Motor Characteristics. Except where more stringent requirements are indicated, and except where required items of fire protection equipment cannot be obtained with fully complying motors, comply with the following requirements for motors of fire protection work:

C. Temperature Rating. Rated for 40°C environment with maximum 50°C temperature rise for continuous duty at full load (Class A Insulation).

D. Provide each motor capable of making starts as frequently as indicated by automatic control system, and not less than 5 starts per hour for manually controlled motors.

E. Phases and Current Characteristics. Provide squirrel-cage induction polyphase motors for 3/4hp and larger, and provide capacitor-start single-phase motors for 1/2hp and smaller, except 1/6hp and smaller may, at equipment manufacturer's option, be split-phase type. Coordinate current characteristics with power specified in Division 26 sections, and with individual equipment requirements specified in other Division 21 requirements. For 2-speed motors provide 2 separate windings on polyphase motors. Do not purchase motors until power characteristics available at locations of motors have been confirmed, and until rotation directions have been confirmed.

F. Service Factor. 1.15 for polyphase motors and 1.35 for single-phase motors.

G. Motor Construction. Provide general purpose, continuous duty motors, Design "B" except "C" where required for high starting torque.
1. Frames. NEMA #56.
2. Bearings are to be ball or roller bearings with inner and outer shaft seals, regreasable except permanently sealed where motor is inaccessible for regular maintenance. Where belt drives and other drives produce lateral or axial thrust in motor, provide bearings designed to resist thrust loading. Refer to individual section of Division 21 for fractional-hp light-duty motors where sleeve-type bearings are permitted.
3. Except as indicated, provide open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation, and provide guarded drip-proof motors where exposed to contact by employees or building occupants. Provide weather-protected Type I for outdoor use, Type II where not housed. Refer to individual sections of Division 21 for other enclosure requirements.
4. Provide built-in thermal overload protection and, where indicated, provide internal sensing device suitable for signaling and stopping motor at starter.
5. Noise Rating: Provide "Quiet" rating on motors.

H. All motors shall be premium efficiency.

2.2 EQUIPMENT FABRICATION

A. Fabricate fire protection equipment for secure mounting of motors and other electrical items included in work. Provide either permanent alignment of motors with equipment, or adjustable mountings as applicable for belt drives, gear drives, special couplings and similar indirect coupling of equipment. Provide safe, secure, durable, and removable guards for motor drives. Arrange for lubrication and similar running-maintenance without removal of guards.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install motors on motor mounting systems in accordance with motor manufacturer’s instructions, anchored to resist torque, drive thrusts, and other external forces inherent in fire protection work. Secure sheaves and other drive units to motor shafts with keys and Allen set screws on flat surface of shaft. Unless otherwise indicated, set motor shafts parallel with machine shafts.

B. Verify voltage with Electrical Plans.

END OF SECTION 210513

SECTION 210514 - FIRE PROTECTION ALTERATIONS PROJECT PROCEDURES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Inspect and service existing equipment and materials that are to remain or to be reused.

B. Disposal of equipment, materials, or housekeeping pads to be abandoned. Prior to disposal, the Contractor shall verify with the Owner what is to be salvaged by the Owner and what is to become the property of the Contractor.

C. Handling of equipment and materials to be removed.

1.2 QUALITY ASSURANCE

A. Coordination with the Owner prior to the disconnection or shutdown of existing equipment, or to the modification of existing operational systems.

1.3 CONTRACT DRAWINGS

A. There is the possibility that existing conditions and devices are affected by the work indicated on the drawings and called for in the specifications (project manual) that do not appear on the drawings. It is the Contractor’s responsibility to visit the site and determine all of the existing conditions and to consider these existing conditions when making and presenting a proposal, to have a complete proposal.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Material used to upgrade and repair existing equipment shall conform to that specified.

B. Material used to upgrade and repair existing equipment shall not void existing warranties or listings of the equipment to be upgraded or repaired.

C. Material used to upgrade and repair existing equipment shall be new and shall be of the same manufacturer of the existing equipment, shall be acquired through the existing original equipment manufacturer’s approved distribution channels, shall have manufacturer’s warranties for the new material being used, and shall be listed for the use intended.

PART 3 - EXECUTION

3.1 INSPECTION

A. Existing materials and equipment indicated on the drawings or in the specifications to be reused shall be inspected for damaged or missing parts. Contractor shall notify the Architect/Engineer, in writing, accordingly.

B. If using materials specified or shown on the drawing voids or diminishes the warranty or operation of remaining equipment or systems, the Contractor shall notify the Architect/Engineer, in writing.

C. Verify field measurements, above and underground piping connections and flows.

D. Demolition Drawings are based on casual field observation, and when available, existing record documents. Report discrepancies to Architect before disturbing existing installation, and immediately after such discrepancies are discovered.

E. Field verify existing conditions and actual utility uses prior to final connections. Existing drawings may not have been available for all required information.

3.2 APPLICATION

A. Existing materials and equipment indicated on the drawings or in the specifications to be reused shall be cleaned and reconditioned, including cleaning of piping systems prior to installation and reuse, or abandon.

B. Material and equipment removed that is not to be salvaged for Owner's use or for reuse on the project shall become the property of the Contractor and be removed from the site.

C. Material or equipment salvaged for Owner's use shall be carefully handled and stored where directed by the Owner or the Architect / Engineer. Relocate material and / or equipment as directed by Owner.

D. Materials and equipment not indicated to be removed or abandoned shall be reconnected to the new system.

E. Materials, equipment and housekeeping pads not to be reused or reconnected shall be removed for Owner’s review and salvaged by Contractor.

F. Prior to start of construction, Contractor shall walk areas to be renovated with Owner to identify and document items to be salvaged for Owner’s use.

G. Clean and repair existing materials and equipment that remain or are to be reused.

H. Contractor shall utilize spaces efficiently to maximize accessibility for other installations, for maintenance, and for repairs.

3.3 SEQUENCE AND SCHEDULE

A. Coordinate utility service outages with Utility Company, Architect and Owner.

B. Provide additional or temporary valves, piping and connections to maintain existing systems in service during construction.

C. Existing Fire Protection Service: Refer to drawings for work in remodeled areas. Where facilities in these areas are to remain in service, any related work to keep the facilities in operation is specified in this Division. Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Obtain permission from Owner at least 48 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area. Maintain acceptable temperature and humidity control within existing building during renovation activities.

D. Remove and replace existing fire protection systems and appurtenances as occasioned by new or remodeled construction. Re-establish service that may be interrupted by remodeled construction.

E. Refer to other drawings series for work in remodeled areas. Where facilities in these areas are required to remain in service, any related work required to keep these facilities in operation is specified in this Division.

F. Remove and replace existing piping coincident with the construction.

3.4 DEMOLITION AND EXTENSION OF EXISTING FIRE PROTECTION WORK

A. The Contractor shall modify, remove, and/or relocate all materials and items so indicated on the drawings or required by the installation of new facilities. All removals and/or dismantling shall be conducted in a manner as to produce maximum salvage. Salvage materials shall remain the property of the Owner, and shall be delivered to such destination as directed by the Owner's representative unless they are not wanted, then it will be the responsibility of this Contractor to remove such items and properly dispose of them. Materials and/or items scheduled for relocation and which are damaged during dismantling or reassembly operations shall be repaired and restored to good operative condition. The Contractor may, at his discretion, and upon approval of the Owner's representative substitute new materials and/or items of like design and quality in lieu of materials and/or items to be relocated.

B. All items to be relocated shall be carefully removed in reverse to original assembly or placement and protected until relocated. The Contractor shall clean, repair, and provide all new materials, fittings, and appurtenances required to complete the relocations and to restore them to good operative order. All relocations shall be performed by workmen skilled in the work and in accordance with standard practice of the trades involved.

C. When items scheduled for relocation and/or reuse are found to be in damaged condition before work has been started on dismantling, the Contractor shall call the attention of the Owner's representative to such items and receive further instructions before removal. Items damaged in repositioning operations are the contractor's responsibility and shall be repaired or replaced by the contractor as approved by the owner's representative, at no additional cost to the Owner.

D. Fire protection piping and appurtenances to be removed, salvaged, or relocated shall be removed to points indicated on the drawings, specified, or acceptable to the Owner's representative. Piping not scheduled for reuse shall be removed to the points at which reuse is to be continued or service is to remain. Such services shall be sealed, capped, or otherwise tied-off or disconnected in a safe manner acceptable to the Construction Inspector. All disconnections or connections into the existing facilities shall be done in such a manner as to result in minimum interruption of services to adjacent occupied areas. Services to existing areas or facilities that must remain in operation during the construction period shall not be interrupted without prior specific approval of the Owner's representative hereinbefore specified.

E. Repair adjacent construction and finishes damaged during demolition and extension work.

F. Maintain access to mechanical installations that remain active. Modify installation or provide access panel as appropriate.

G. Extend existing installations using materials and methods compatible with existing fire protection installation, or as specified.

H. Existing fire protection piping and devices found to need additional hangers installed should be added at no additional cost to the Owner.

3.5 PROTECTION OF THE WORK

A. Provide adequate temporary support and auxiliary structure as necessary to ensure structural value or integrity of affected portion of work.

B. Provide devices and methods to protect other portions of work from damage.

C. Execute fitting and adjustment of products to provide a finished installation to comply with specified products, functions, tolerances and finishes.

3.6 IDENTIFICATION OF EQUIPMENT IN RENOVATED AREAS

A. Identification of Equipment: Provide new identification of all existing equipment to be reused and located within the renovated areas. Do not include the description "existing". Provide new nameplates for all existing equipment in renovated areas as specified in Section 21 05 00 Fire Protection General Provisions.

END OF SECTION 210514

SECTION 211000 - FIRE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Design coordination of sprinkler work with the installations of other trades as shown on their drawings; all mechanical, electrical, plumbing and sprinkler work must fit the space requirements. The sprinkler work shall comply with other Sections of this specification; and fit the structure finishes. The Sprinkler Contractor will comply with all the codes and underwriter authorities, and the requirements for the installation of inside and outside piping; including sprinkler heads, valves, tamper switches, flow switches, hangers and supports, sleeves, fire department connections, inspector test connections, main drain and accessories, signs and any other component parts reasonably incidental to providing a complete protection system. Provide 100 percent coverage for the entire building.

B. A wet system shall be installed in heated areas and dry pipe systems in areas subject to freezing. When heated areas are not available and dry pipe system not used, provide heat tracing and / or insulation installed per NFPA and per local Fire Marshall Requirements, or as indicated on drawings.

C. Furnish all articles of a completed sprinkler system including all materials, labor, tools, equipment, transportation services and supervision fees.

D. The plans provide a riser assembly location at water entry into building for flow switch locations, valve locations (with tamper switches), fire department test assemblies and fire department Siamese connections. These are a guide for subsequent preparation of the Contractor's detailed installation drawings of the complete fire protection sprinkler system which shall be submitted to the Architect / Engineer for review. Submit only drawings and calculations bearing the approval of the authority having jurisdiction.

E. Do not exceed 52,000 square feet of building for each individual sprinkler system.

F. Install fire protective system identification signs in accordance with NFPA-13, NFPA-14, and NFPA-20

G. It shall be the fire protection installer's responsibility to verify pressure at the project site by performing a flow test. Determine if the available static pressure, residual pressure and flow rate will adequately provide the fire extinguishing system with the necessary operating requirements or if a fire pump, storage tank and necessary appurtenances are required. Notify Architect and Engineer if low water flow / pressure condition exist and inform them of all options prior to proceeding.

H. The installation of the entire Sprinkler Systems shall comply with all rules and regulations of the National Board of Fire Underwriters, the Local Building Code, Local Fire Marshall, and Requirements of NFPA Pamphlet 13, and other local authorities exercising jurisdiction.

I. Study the general, structural, electrical and mechanical drawings and specifications, in order to become familiar with the building and details as they apply to the work of this Section. Cooperate with all Trades so that there will be no conflict of space. Plumbing flow lines, large ductwork HVAC piping and electrical service feeders shall take precedence over Fire Protection work, except where it is absolutely necessary to maintain coverage protection.

J. Provide a water curtain sprinkler system along glazing to create a 1-hour rating, as outlined in NFPA 13. Refer to Architecture plans for locations. Water demand for water curtain shall be added to the ceiling sprinkler water demand at the point of connection, per NFPA 13. Sprinkler heads shall be spaced at 6’-0” o.c., minimum 6 inches and maximum 12 inches from glazing.

1.2 BASIS OF DESIGN

A. National Fire Protection Association (NFPA), latest edition of NFPA 13, Standard for the Installation of Sprinkler Systems.

B. Vertical zone valves installed in horizontal position are not acceptable. All zone valves are to be located at water entry into building and mounted in the vertical riser.

1.3 QUALITY ASSURANCE

A. Sprinkler equipment and installation to be in accordance with recommendations of and approved by local, state and federal fire authorities.

B. Equipment and installation to meet requirements of NFPA No. 13, 24, 25, 70 and 72.

C. Use materials and equipment that are new and of unused, approved by NFPA and as listed in the UL list of "Inspected Fire Protection Equipment and Materials."

1.4 SHOP DRAWINGS

A. Make complete shop drawings and working drawings of equipment furnished, including detailed drawings of piping and sprinkler head locations. Drawings shall show construction details and dimensions of each piece of equipment and work to be installed. The location of all heads shall be as approved. Where additional heads are required to meet NFPA 13, provide at no additional cost.

B. Before the shop drawings are submitted to Architect / Engineer, submit drawings to the jurisdictions for approval. All approvals shall be noted on the drawings or by letter from the departments.

C. The Architect's approval of shop drawings shall not relieve the responsibility of correctly figured dimensions or any errors that may be contained in these drawings. The omission of any material shown on the contract drawings, or specified from the shop drawings, even though approved, shall not relieve the responsibility to furnish and erect them.

D. Provide ¼ scale drawings to show the location of the water entry into building with all zone valves, and shut-off valves, with alarms and drains at this location. Prepare the sprinkler drawings under the work of this Section.

E. Submit samples of all sprinkler types for approval.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Johnson Controls (Tyco Fire Products)
   1. Gem/Grinnell
   2. Central
   3. Star Sprinkler

B. Automatic Sprinkler Company of America

C. Potter Roemer, Inc.

D. The Reliable Automatic Sprinkler Company

E. Viking Corporation

F. Victaulic Company of America

G. Globe Fire Sprinkler Corporation

2.2 PIPING AND FITTINGS

A. Above Slab Inside Building
   1. Pipe 2" and Smaller: Schedule 40, black steel pipe conforming to ASTM A 795 or ASTM A135 joined with threaded fittings.
   2. Pipe 2-1/2" and larger, provide ASTM A795 or ASTM A135 UL and FM listed.
      a. Light wall having a minimum corrosion resistance ratio (CRR) or 1.00 or greater.

B. Underground within five feet of building. Provide ductile iron pipe, Class 200 conforming to ASTM, and ring-tite fittings. Provide concrete thrust blocks at changes in direction, according to the pipe manufacturer's recommendations.

C. All piping shall be black carbon steel, except in dry systems where pipe shall be galvanized per ASTM A53.

D. Fittings used to join pipe shall be listed fabricated fittings or manufactured in accordance to the material and dimension standards listed in table 6.4.1 NFPA 13 and 2.2.1 NFPA 14.

2.3 SPRINKLER HEAD

A. All sprinklers shall comply with the latest requirements of NFPA 13 with respect to orifice size.

B. All heads shall be UL listed and/or FM approved, and comply with the latest requirements of NFPA 13 with respect to orifice size unless otherwise noted. Sprinkler heads with “O” ring design shall not be acceptable.

C. Exposed areas:
1. Standard upright type with brass finish and escutcheon. Provide temperature rating per NFPA 13 and UL/FM approvals.
2. Tyco Model B, FRB, Globe Model GL-QR, GL-SR, or approved equal

D. Sidewall applications:
1. Horizontal sidewall type with brass finishes and chrome escutcheon.
2. Unfinished areas and recessed with chrome plated escutcheon. Provide temperature rating per NFPA 13 and UL/FM approvals.
3. Tyco Model B, FRB, Globe Model GL-QR/SW, GL-SR/SW, or approved equal.

E. Suspended ceilings:
1. Adjustable drop down deflector type concealed heads with manufacturer painted white cover plate with glass bulb fusible link. Provide temperature rating per NFPA 13 and UL/FM approvals.
2. Color of plate, selected by Architect
3. Tyco Series RFII; Series ELOC, Globe Concealed Models GL-QR/INCH, GL-SW/INCH and GL-INCH/ECLH or approved equal.
4. Easy-Flex or Flexhead Industries flexible sprinker fittings. Provide Victaulic VicFlex

F. Dry sprinklers heads at freezers and coolers
1. Tyco Model DS-1, DS-2, or approved equal.

G. Sprinklers subject to mechanical injury shall be protected with fusible solder type sprinklers and listed heavy duty bolt on guards. Bulb type sprinklers will not be acceptable for these locations.

1. Storage rooms with exposed structure.
2. Gymnasiums.
3. Mechanical and Electrical rooms.
4. Below exposed stairs.
5. Exposed structure areas.

H. Systems serving walk-n freezers shall utilize Tyco Model DS-1 or DS-C dry pendent sprinklers. A Model DSB-1 dry sprinkler boot shall be utilized in conjunction with the dry sprinkler to eliminate the requirement for insulation and to stop potential air interchange. Length of dry pendent shall be determined by manufacturer's recommendation with respect to freezer ambient temperatures expected.

2.4 INSPECTOR'S TEST CONNECTION

A. Provide inspector's test connection as required by NFPA 13.
   1. Ductile iron module housing with combination sight glass, orifice and bonnet assembly
   2. UL listed
   3. Victaulic No. 718
   4. Globe Model UTD
   5. Tyco, or approved equal

2.5 TAMPER SWITCH / SUPERVISORY SWITCH

A. Tamper switch on each valve
   1. Controlling or shutting off sprinkler system or any portion thereof.
   2. Tamper switch with either one single pole, double throw switch or two single pole, double throw switches as required.
   3. Switch shall be compatible with installed valve for standard mounting.
   4. Potter-Roemer Fig. 6220, 6221, 6222, 6223 or approved equal.

2.6 FLOW SWITCH

A. Vane type flow switch.
   1. Self-contained pneumatic, adjustable retard.
   2. Two, single pole, double throw switches.
   3. Red enamel tamper proof switch housing with flow paddle.
   4. Potter Roemer Model No. 6200, or approved equal.

2.7 FLOORS AND CEILING PLATES

A. Provide chrome-plated floor and ceiling plates around pipes exposed to view when passing through walls, floors, partitions, or ceilings in finished areas; size plates to fit pipe or insulation and lock in place.

2.8 DRY PIPE SYSTEM

A. General: Provide a UL listed and FM approved dry pipe system at the dock area. System shall consist of a dry pipe valve, air compressor, fusible link type sprinkler heads and all associated trim and piping for a complete operating system.

B. Dry Pipe Valve: Rated for a working pressure of 175 psi, factory hydrostatic tested at 350 psi, supplied with all gauges, valves, strainer, electrical alarm switch, ball drip valve, and drip cup assembly, manufactured by Victaulic Model 756, Globe Model RCW.

C. Air Compressor: Oilless, permanently lubricated, pipe mounted, direct drive, complete with safety relief valve manufactured by Reliable Model A or approved equal. Size of air compressor is determined by volume of dry pipe system. Coordinate power requirement with electrical contractor. Coordinate all wiring required with Fire Alarm System.

D. If the dry pipe system is not used in conjunction with a wet pipe system containing the necessary check valves or backflow preventer, a check valve shall be installed in the dry pipe system at the connection to the water supply.

E. If the dry pipe system is not used in conjunction with a wet pipe system containing a control valve such as a post indicator (PIV) or outside screw & yoke valve (OS&Y), a PIV or OS&Y shall be installed in the system.

F. The dry pipe valve and pipe to the wet supply shall be protected from freezing.

G. Provide an automatic or manual compressed air system capable of restoring normal air pressure to a system in 30 minutes or less.

H. Provide an accelerator when system capacity exceeds 500 gallons.

I. Provide a water motor alarm or electric pressure switch.

J. Provide dry pipe valve trim and pressure gauges.

K. Dry pipe system shall be hydraulically calculated for the hazard being protected.

L. Provide dry pendent type sprinkler heads only when the piping and sprinklers are not in a heated area.

M. Provide a test drain valve sized per NFPA. An inspector's test shall be provided at each system.

N. Slope all piping toward a drain per NFPA 13. A drain shall be provided at all low points.

O. The following accessories shall be provided where required:

1. Victaulic Series 756.
2. Viking Model E dry pipe valve with conventional trim.
3. Viking Model D-1 accelerators.
4. Globe Model RCW dry pipe valve with conventional trim package, and Model C Accelerator.

2.9 GASKETS

A. Use 1/16-inch thick preformed synthetic rubber bonded.

2.10 COUPLINGS

A. Use listed rolled grooved mechanical couplings to engage and lock grooved or shouldered pipe ends and to allow for some angular deflection, contraction and expansion. Coupling consists of ductile iron housing, c-shaped composition sealing gasket and steel bolts. Gasket Material for dry pipe systems shall be silicone and listed for dry pipe service.

2.11 VALVES

A. Use valves suitable for 175 psig WOG.

B. Valves to be UL listed and FM approved.

C. Valve Connections:
1. Provide valves suitable to connect adjoining piping as specified for pipe joints. Use full line size valves unless noted otherwise.
2. Screwed ends for pipe sizes 2 inches and smaller.
3. Flanged ends for pipe sizes 2-1/2 inches and larger.
4. Solder or screw to solder adapters for copper tubing.
5. Use grooved body valves with mechanical grooved jointed piping.

D. Gate Valves:
1. Up to 2 inches, bronze, outside screw and yoke, rising stem, solid wedge, screwed ends, manufactured by: Mueller, or approved equal.
2. Over 2 inches, iron body, bronze trim, outside screw and yoke, rising stem, solid wedge, flanged ends; manufactured by Mueller, or approved equal.

E. Check Valves:
1. Up to 2 inch, bronze, regrind bronze swing disk, solder or screwed ends; 200 WOG, manufactured by Mueller, or approved equal.
2. Over 2 inch, iron body bronze trim, swing disk, regrind – renew bronze disk and seat, flanged ends; 200 WOG, manufactured by Mueller, Globe Model RCV, or approved equal.

F. Butterfly Valve: Lug body style, bubble-tight shutoff, cast iron body, ASTM B 148 bronze disk, with integral tamper switch, manufactured by Anvil Model No. 8000 FP, or approved equal.

G. Freestanding Indicating Post: Install adjustable indicating post and valve outside building where shown on Civil drawings, consisting of UL/FM, non-rising stem gate valve and indicating post. Gate valve shall be iron body, non-rising stem, bronze mounted. Indicator flange, 175-psi non-shock rating, flanged end. Indicator shall be UL/FM approved cast iron body, Plexiglas window and 18-inch adjustment span with handle and tamper switch wired to main fire alarm control panel, manufactured by Mueller, Valve No. A-2052, Indicating Post No. A20800, or approved equal.

H. Wall post-adjustable indicating valve: Outside building at water entry location into building, consisting of UL/FM, non-rising stem gate valve and indicator. Gate valve shall be iron body, non-rising stem, bronze mounted. Indicator flange, 175-psi non-shock rating, flanged end. Indicator shall be UL/FM approved cast iron body, Plexiglas window and 18-inch adjustment span with handle and tamper switch wired to main fire alarm control panel, manufactured by Mueller, Valve No. A-2052, Indicating Post No. A20800, or approved equal.

2.12 ELECTRIC ALARM BELL

A. 10-inch round red enamel steel bell with electrically operated vibrating outdoor alarm bell, UL listed, red enamel steel, manufactured by Simplex, or approved equal.

2.13 GAUGES

A. Gauges shall be bourdon tube type with minimum 4-1/2 inch dial and die cast aluminum case with screwed ring and black enamel finish. The movement shall be all stainless steel with Grade A phosphor bronze bourdon tube, brazed at socket and tip. The accuracy of the gauge shall be within one-half of one percent of the scale range. The pointer shall be the micrometer adjustment type recalibrated from the front. Pressure and compound gauges shall have suitable scale ranges and graduations. Suitable for temperatures up to 120 degrees F.

B. Gauges shall have ¼ inch connections and be mounted with combination stop / snubber needle valve with suitable pressure rating. Scale ranges: 0-200 psi.

C. Gauge range shall be such that system normal operating pressure falls with 25 percent and 75 percent of the full-scale range.

D. Pressure scale graduations shall read in psig. Figure intervals shall be in – 20 psig increments, with minor divisions in 2 psig increments.

E. The accuracy of the gauge shall be at least 0.5 percent of the scale range. Gauge shall be made in accordance with ASME B40.1 accuracy grade 2A.

F. Manufactured by:
   1. Trerice Model No. 4500 Series
   2. Ashcroft
   3. Marsh
   4. Weksler

2.14 SPARE SPRINKLER HEAD BOX

A. Provide baked enamel steel box to store 36 sprinkler heads (Minimum of 3 of each type used) for emergency replacement. Provide sprinkler wrench.

2.15 ALARM CHECK VALVE

A. Provide UL listed check valve.
   1. Variable for City Supplied systems pressure trim set.
   2. Tyco AV-1, Globe Model H, or approved equal.

2.16 WATER MOTOR ALARM

A. Provide a red enamel motor alarm for installation on exterior wall.
   1. Tyco Model WMA-1, Globe Model WM, or approved equal.

2.17 SIAMESE FIRE DEPARTMENT CONNECTION

A. Siamese Wall mounted chrome-plated Siamese. Include caps, sillcock, chain, and a plate lettered AUTO-SPKR.
   1. Provide a 4" X 2-1/2" x2-1/2".
   2. Potter-Roemer #5751

PART 3 - EXECUTION

3.1 DESIGN

A. Design, spacing of sprinkler heads and selection sizes shall conform to the requirements of NFPA 13 for the indicated occupancy.

B. Uniform discharge density design shall be based on hydraulic calculations using the method outlined in NFPA 13. Density of discharge from sprinkler heads shall conform to NFPA 13.

C. Friction losses in pipe will be based on a value of “C” = 120 in the Hazen and Williams formula.

D. Design and install the system so that no part will interfere with doors, windows, heating, mechanical, lighting or electrical equipment. Do not locate sprinkler heads closer than 3 feet to lighting fixtures or other obstructions.

3.2 LOCATION

A. Heads shown, if indicated on reflected ceiling plans, are an integral part of the ceiling design. Where heads are not shown or indicated, locate them in the exact center of acoustical ceiling tile unless noted otherwise. In rooms with monolithic plaster or gypsum drywall ceilings, locate the sprinkler heads symmetrically arranged with respect to both axes of the room. Locate sprinkler heads in relation to specialty ceiling elements such as slats, ribs, panels, grids, etc., if not shown on the drawings. Generally, locate heads in the exact center of, or spaced between, such elements. Center heads in corridors.

B. Locate heads as may be required for coordinated ceiling pattern, even through number of heads exceed minimum code requirements.

C. Sprinkler heads located in utility or mechanical rooms, penthouses, service corridors, or other such spaces not subject to public view need not be centered in ceiling patterns and may use a straight drop from branch line.

D. Install a water curtain sprinkler system along glazing to create a 1-hour rating, as outlined in NFPA 13. Refer to plans for locations. Water demand for water curtain shall be added to the ceiling sprinkler water demand at the point of connection, per NFPA 13. Sprinkler heads shall be spaced at 6’-0” on center, minimum 6 inches and maximum 12 inches from glazing.

E. Where glazing shall be installed in 2-hour fire rated assemblies, the Tyco Window sprinkler shall be utilized as outlined in the ICC Legacy report equivalency requirements. Any glazing requiring fire exposure protection shall also utilize the Tyco window sprinklers.

3.3 PREPARATION

A. Ream pipes and tubes, clean off scale, rust, oxide and dirt, inside and outside, before assembly. Remove welding slag or other foreign material from piping.

B. Pipe beveled each end, per approved procedures.

C. Hammer clean and flush out piping after welding to remove scale, welding slag and other debris.

3.4 CONNECTION

A. Make screwed joints with square, clean full cut standard taper pipe threads. Ream after cutting and threading. Red lead and linseed oil or other approved non-toxic joint compound applied to male threads only.

B. Nipples: Shoulder type; extra heavy where less than 1-1/2 inch is unthreaded.

C. Clamp cast iron water pipe at fittings with ¾ inch rods and properly anchor and support.

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

3.5 COORDINATION

A. Coordinate the installation schedule for this work with the construction schedule for the Work to ensure orderly progress with minimum delay.

B. Coordinate interface of fire sprinkler system with the work of other trades to ensure proper and adequate provision for the installation and connection of this system.

C. Coordinate location and quantity of Siamese connections required for fire department connection with Architect and local fire officials.

3.6 SURFACE CONDITIONS

A. Before starting each stage of the fire sprinkler systems installation, inspect the installed work of other trades and determine that work is complete enough to allow installation to begin. Ensure that work of other trades has been installed in a manner to permit work of this Section in accordance with approved design.

3.7 INSTALLATION

A. Run piping concealed above furred ceilings and in joists to minimize obstructions. Expose only heads.

B. Protect sprinkler heads against mechanical injury with heavy duty bolt-on guards.

C. Locate system drains and inspector’s test connections in utility rooms, mechanical rooms or other readily accessible areas not requiring access through ceiling. Coordinate sprinkler system drain flow rates with plumbing system drainage capacities.

D. Where low points or drains occur above ceilings or in otherwise finished spaces, furnish drain valve with brass cap and chain.

E. Locate outside alarms on wall of building and coordinate with Architect.

F. Fire pump and all accessories shall be tested in accordance with NFPA 20 and the local Fire Marshall and/or all other authorities having jurisdiction.

G. Provide on interior wall near sprinkler valve, cabinet containing extra sprinkler heads of each type and wrench suitable for each head type.

H. Provide a minimum 18-inch radius swing joint for each drop to sprinkler heads located in ceilings.

I. Provide Easy-Flex or Flexhead Industries sprinkler hose fittings for each sprinkler head installation for hydraulically designed wet, pre-action, deluge or dry pipe sprinkler connections per NFPA 13. Allow a 3” minimum bend radius per UL Guidelines and a 7” minimum bend radius per FM Guidelines. Hose assembly length shall be 2’-0”, 3’-0” or 4’-0” minimum for 1/2” or 3/4” outlet size.

J. Install pipe markers to identify fire protection.

K. Provide shield or deflector for sprinklers or equipment where electrical switchgear, switchboards and motor control centers are in sprinkler protected spaces.

L. Install fire 2-1/2 inch department valve, maximum 5 feet above floor, complying with NFPA 14.

M. During construction, make one standpipe outlet available on each floor without delay, for fire department use.

N. Provide 3-way standpipe outlets above roof.

O. Provide pressure gauges at the top of each standpipe as detailed on the drawings.

P. Provide drain for each standpipe.

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

R. Sprinkler heads shall be installed above and below ductwork over 48 inches wide, in exposed areas, per NFPA 13.

S. Install the complete fire sprinkler system in accordance with the approved shop drawings.

T. Perform piping installation in accordance with the provisions of the specifications, including furnishing of required sleeves for fire sprinkler system pipes passing through rated walls, floors, and other parts of the building. Provide scheduled 40 galvanized pipe sleeve for concrete or CMU penetrations. Furnish size required for fireproofing and or insulation. Furnish and install split wall plates and chrome plated escutcheons for exposed fire sprinkler system pipes. Where pipes pass through concrete floors, furnish and install wrought iron or steel pipe sleeves made flush with the ceiling below and extending 2" above the finished floor.

U. Do not cut or make holes in any part of the building except where shown on the approved shop drawings.

V. Furnish and install, next to the sprinkler riser main, a print sheet protected by glass or a transparent plastic cover, giving brief instructions regarding control, emergency procedure, and other data required by NFPA #13. For hydraulically designed sprinkler systems, a placard is to be permanently attached to the riser indicating the location, and the basis of design (discharge density and system demand).

W. Do not install exposed piping below structure in public area.

X. Provide heat tracing and insulation on wet piping systems exposed to freezing when not installed in a heated space or installed by other acceptable methods of maintaining the piping from freezing. Installation of heat tracing and insulation shall be in accordance with the latest edition of NFPA 13 and the local code authorities. Coordinate electrical requirements with Division 26.

3.8 SECURING AND SUPPORTING

A. Support piping to maintain line and grade, with provision for expansion and contraction. Use approved clevis-type or trapeze-type hangers connected to structural members of the building. Single pipe runs to be supported by approved clevis type hangers. Multiple pipe runs to be supported by approved trapeze type hangers. Do not support piping from other piping or structural joist bridging.

B. Provide supports both sides of elbows for pipe 6" and larger.

C. Support vertical risers with steel strap pipe clamps of approved design and size, supported at each floor. Support piping assemblies in chases so they are rigid and self-supported before the chase is closed.

D. Support spacing: As recommended by the project structural engineer and support manufacturer, but not more than listed below. Not to exceed spacing requirements of smallest pipe.

Pipe Size	Steel Max. Support Spacing, Feet	Minimum Rod Diameter, Inches
1" & smaller	6	1/4
1-1/4" & 1-1/2"	8	1/4

2"	10	1/4
3"	10	3/8
4" & 5"	10	1/2
6" and above	10	5/8

3.9 PIPE SUPPORTS

A. Provide P1001 or P 5000 Unistrut metal framing members and appurtenances for pipe support. Hot-dip galvanize members and appurtenances when located outside. Sagging of pipes or supports is not acceptable.

B. Adjustable clevis hangers shall be used for single pipe supports; Anvil Fig. 260. When oversized clevis is used, a nipple shall be placed over the clevis bolt as a spacer to assure that the lower U-strap will not move in on the bolt. Ring type clevis hangers are not acceptable. All parts shall be zinc plated carbon steel, or galvanized.

3.10 PIPE SLEEVES

A. Sleeves through masonry and concrete construction:
   1. Fabricate sleeves of Schedule 40 galvanized steel pipe.
   2. Size sleeve large enough to allow for movement due to expansion and to provide continuous insulation.

B. Sleeves through gypsum wall construction.
   1. Fabricate sleeves of 16 gauge galvanized sheet metal.

C. Sleeves through elevated slab construction.
   1. Fabricate sleeves of Schedule 40 galvanized steel pipe with welded center flange in floor.

D. Extend each sleeve through the floor or wall. Cut the sleeve flush with each wall surface. Sleeves through floors shall extend 2” above floor lines for waterproofing purposes. Slab on grade floors shall not be sleeved except where penetrating waterproofing membrane or insect control is required.

E. Caulk sleeves water and airtight. Seal annular space between pipes and sleeves with mastic compound to make the space water and air tight.

F. For sleeves below grades in outside walls, provide Thunderline Link-Seal or Advance Product and System Interlynx, with 316 stainless steel nuts and bolts, with cast iron pressure plate.

G. Provide chrome plated escutcheon plates on pipes passing through walls, floors or ceilings exposed to view. At exterior walls, stainless steel sheet metal is to be used.

H. For sleeves through fire and smoke rated walls, seal with a UL through-penetration firestop, rated to maintain the integrity of the time rated construction. Install in accordance with the manufacturer's installation instructions. Comply with UL and NFPA standards for the installation of firestops. Refer to Architectural drawings for all fire and smoke rated partitions, walls, floors, etc.

3.11 CLEANING OF PIPING SYSTEMS

A. General cleaning of piping systems. Purge pipe of construction debris and contamination before placing the systems in service. Provide and install temporary connections as required to clean, purge and circulate.

3.12 FLUSHING AND TESTING

A. Testing and flushing of installation of sprinkler system shall be in accordance with NFPA 13, and NFPA 25.

B. Flush sprinkler piping in accordance with NFPA 13. Additionally, flush all alarm valves, and all main piping up to valve.

C. In addition to NFPA 13 required tests, provide flow switch test and tamper switch test for each device, and verify alarm valve operation.

D. All tests shall be witnessed by Architect / Engineer. Contractor shall notify Architect / Engineer 7 working days in advance.

3.13 EXCAVATING, TRENCHING, AND BACKFILLING

A. Perform excavation, trenching, and backfilling for this portion of the work in accordance with the specifications.

3.14 PIPE MARKERS

A. Identify interior exposed piping and piping in accessible chases or plenums with Opti-Code Brady Pressure Sensitive Adhesive Pipe Markers, consisting of pipe marker and direction of flow arrow tape. Clean pipe prior to installation. Background colors of markers, arrows and tape for each type of system shall be the same. Meet ANSI/OSHA standards and clearly identify each system. Provide minimum 2-1/4-inch letters through 4-inch pipe and 4-inch letters for 5-inch pipe and larger.

B. Identify exterior and mechanical room piping with Snap Around pipe markers through 4-inch pipe and Strap Around markers 5-inch pipe and larger. Pipe markers consisting of pipe marker and direction of flow arrow tape; background colors of markers, arrows and type for each type of system shall be the same.

Meet ANSI / OSHA standards and clearly identify each system. Provide minimum 2-1/4-inch letters through 4-inch pipe and 4-inch letters for 5-inch pipe and larger.

C. Install identification in the following locations:
   1. Both sides of penetrations through walls, floors and ceilings.
   2. Close to valves or flanges.
   3. Intervals on straight pipe runs not to exceed 50 feet
   4. Apply marker where view is obstructed.

D. Pipe markers shall meet or exceed the specifications of the ASME A13.1 “Scheme for Identification of Piping Systems”.

3.15 TESTING AND ACCEPTANCE

A. Prior to connecting to the overhead sprinkler piping, flush the underground main. Secure required approvals of the flushing operations.

B. Upon completion of the fire sprinkler system installation, test and retest the complete installation and make corrections as necessary to obtain acceptance by the Fire Marshall and/or any other authority having jurisdiction. Furnish test equipment and personnel required.

3.16 TRAINING

A. At a time mutually agreed upon, provide 4 hours of instruction to the Owner’s designated personnel on the operation and maintenance of the automatic sprinkler system and associated equipment. Owner’s Operation and Maintenance Manual prepared for this project shall be used during the instruction.

END OF SECTION 211000

SECTION 220100 - PLUMBING GENERAL PROVISIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Except as modified in this Section, General Conditions, Supplementary Conditions, applicable provisions of the General Requirements, and other provisions and requirements of the contract documents apply to work of Division 22 Plumbing.

B. Applicable provisions of this section apply to all sections of Division 22, Plumbing.

1.2 CODE REQUIREMENTS AND FEES

A. Perform work in accordance with applicable statutes, ordinances, codes and regulations of governmental authorities having jurisdiction.

B. Plumbing work shall comply with applicable inspection services:
1. Underwriters Laboratories
2. National Fire Protection Association
3. State Health Department
4. Local Municipal Building Inspection Department

C. Resolve any code violations discovered in contract documents with the Engineer prior to award of the contract. After Contract award, any correction or additions necessary for compliance with applicable codes shall be made at no additional cost to the Owner.

D. This Contractor shall be responsible for being aware of and complying with asbestos NESHAP regulations, as well as all other applicable codes, laws and regulations.

E. Obtain all permits required.

1.3 CONTRACTOR'S QUALIFICATIONS

A. An approved contractor for the work under this division shall be:
1. A licensed specialist in this field and have the personnel, experience, training, skill, and organization to provide a practical working system
2. Able to furnish evidence of having contracted for and installed not less than 3 systems of comparable size and type that has served their Owners satisfactorily for not less than 3 years

1.4 REFERENCE SPECIFICATIONS AND STANDARDS

A. Materials which are specified by reference to Federal Specifications; ASTM, ASME, ANSI, or AWWA Specifications; Federal Standards; or other standard specifications must comply with latest editions, revisions, amendments or supplements in effect on date bids are received. Requirements in reference specifications and standards are minimum for all equipment, material, and work. In instances where specified capacities, size, or other features of equipment, devices, or materials exceed these minimums, meet specified capacities.

1.5 CONTRACT DRAWINGS

A. Contract drawings are diagrammatic only and do not give fully dimensioned locations of various elements of work. Determine exact locations from field measurements.

1.6 PROJECT RECORD DOCUMENTS

A. Maintain at the job site a separate set of white prints (blue line or black line) of the contract drawings for the sole purpose of recording the "as-built" changes and diagrams of those portions of work in which actual construction is at variance with the contract drawings. Mark the drawings with a colored pencil. Prepare, as the work progresses and upon completion of work, reproducible drawings clearly indicating locations of various lines, valves, ductwork, traps, equipment, and other pertinent items, as installed. Include flow-line elevation of sewer lines. Record existing and new underground and under slab piping with dimensioned locations and elevations of such piping.

B. At the conclusion of project, obtain without cost to the Owner, erasable mylars of the original drawings and transfer as-built changes to these. Prior to transmittal of corrected drawings, obtain 3 sets of blue-line prints of each drawing, regardless of whether corrections were necessary and include in the transmittal (2 sets are for the Owner's use and one set is for the Architect/Engineer's records). Delivery of these as-built prints and reproducibles is a condition of final acceptance. Provide record drawings on one set each (reproducible Dayrex mylar film positives) and AutoCad 2012 / Revit CAD files on disk (CD Rom).

C. As-Built drawings should indicate the following information as a minimum:
1. Indicate all addendum changes to documents.
2. Remove Engineer’s seal, name, address and logo from drawings.
3. Mark documents RECORD DRAWINGS.
4. Clearly indicate: DOCUMENT PRODUCED BY
5. Indicate all changes to construction during construction. Indicate actual routing of all piping, ductwork, etc. that were deviated from construction drawings.
6. Indicate exact location of all underground plumbing and flow line elevation.
7. Indicate exact location of all underground plumbing piping and elevation.
8. Indicate exact location of all underground electrical raceways and elevations.
9. Correct schedules to reflect (actual) equipment furnished and manufacturer.
10. During the execution of work, maintain a complete set of drawings and specifications upon which all locations of equipment, ductwork, piping, devices, and all deviations and changes from the construction documents in

the work shall be recorded.

11. Location and size of all ductwork and mechanical piping above ceiling including exact location of isolation of domestic and plumbing valves.
12. Exact location of all electrical equipment in and outside of the building.
13. Fire Protection System documents revised to indicate exact location of all sprinkler heads and zone valves.
14. Exact location of all roof mounted equipment, wall, roof and floor penetrations.
15. Cloud all changes.

1.7 SPACE REQUIREMENTS

A. Consider space limitations imposed by contiguous work in selection and location of equipment and material. Do not provide equipment or material that is not suitable in this respect.

1.8 RELATION WITH OTHER TRADES

A. Carefully study all matters and conditions concerning the project. Submit notification of conflict in ample time to prevent unwarranted changes in any work. Review other Divisions of these specifications to determine their requirements.

B. Because of the complicated relationship of this work to the total project, conscientiously study the relation and cooperate as necessary to accomplish the full intent of the documents.

C. Provide sleeves and inserts in forms as required for the work. Stub up and protect open ends of pipe before any concrete is placed. Furnish sizes of required equipment pads. Furnish and locate bolts and fittings required to be cast in them.

D. Locate and size openings required for installation of work specified in this Division in sufficient time to prevent delay in the work.

E. Refer to other Divisions of the specifications for the scope of required connections to equipment furnished under that Division. Determine from the Contractor for the various trades, the Owner, and by direction from the Architect/Engineer, the exact location of all items.

1.9 CONCEALED AND EXPOSED WORK

A. When the word "concealed" is used in connection with insulating, painting, piping, ducts and the like, the work is understood to mean hidden from sight as in chases, furred spaces or above ceilings. "Exposed" is understood to mean open to view.

1.10 GUARANTEE

A. Guarantee work for 1 year from the date of substantial completion of the project.

During that period make good any faults or imperfections that may arise due to defects or omissions in material, equipment or workmanship. At the Owner's option, replacement of failed parts or equipment shall be provided.

1.11 MATERIAL AND EQUIPMENT

A. Furnish new and unused materials and equipment meeting the requirements of the paragraph specifying acceptable manufacturers. Where two or more units of the same type or class of equipment are required, provide units of a single manufacturer.

1.12 NOISE AND VIBRATION

A. Select equipment to operate with minimum noise and vibration. If objectionable noise or vibration is produced or transmitted to or through the building structure by equipment, piping, ducts or other parts of work, rectify such conditions at no additional cost. If the item of equipment is judged to produce objectionable noise or vibration, demonstrate at no additional cost that equipment performs within designated limits on a vibration chart.

1.13 ACCEPTABLE MANUFACTURERS

A. Manufacturers names and catalog number specified under sections of Division 22 are used to establish standards of design, performance, quality and serviceability and not to limit competition. Equipment of similar design, equal to that specified, manufactured by a named manufacturer will be acceptable on approval. A request for prior approval of equipment not listed must be submitted ten (10) days before bid due date. Submit complete design and performance data to the Engineer.

1.14 OPERATING TESTS

A. After all plumbing systems have been completed and put into operation, subject each system to an operating test under design conditions to ensure proper sequencing and operation throughout the range of operation. Tests shall be made in the presence of the Architect/Engineer. Make adjustments as required to ensure proper functioning of all systems. Special tests on individual systems are specified under individual sections. Submit 3 copies of all certifications and test reports adequately in advance of completion of the work to allow for remedial action as required to correct deficiencies discovered in equipment and systems.

1.15 WARRANTIES

A. Submit 3 copies of all warranties and guarantees for systems, equipment, devices and materials. These shall be included in the Operating and Maintenance Manuals.

1.16 BUILDING CONSTRUCTION

A. It shall be the responsibility of each sub-contractor to consult the Architectural and Engineering drawings, details, and specifications and thoroughly familiarize himself with the project and all job related requirements. Each sub-contractor shall cooperate with the General Contractor to verify that all piping and other items are placed in the walls, furred spaces, chases, etc., so there will be no delays in the job.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 OPENINGS

A. Framed, cast or masonry openings for ductwork, equipment or piping are specified under other divisions. Drawings and layout work for exact size and location of all openings are included under this division.

3.2 HOUSEKEEPING PADS

A. Provide equipment housekeeping pads under all floor mounted and ground mounted plumbing equipment, and as shown on the drawings.

B. Concrete work as specified in Division 3.

C. Concrete pads:
1. 4" high, rounded edges, minimum 2500 psi unless otherwise indicated on the drawings
2. Chamfer strips at edges and corner of forms.
3. Smooth steel trowel finish.
4. Doweled to existing slab

D. Install concrete curbs around multiple pipe penetrations.

3.3 VANDAL RESISTANT DEVICES

A. Provide a handle for each loose keyed operated valve and hose bibb on the project.

B. Where vandal resistant screws or bolts are employed on the project, deliver to the Owner 2 suitable tools for use with each type of fastener used.

C. Proof of delivery of these items to the Owner shall be included in the Operating and Maintenance Manuals.

3.4 INSTRUCTION OF OWNER'S PERSONNEL

A. Prior to final inspection, conduct an on-site training program to instruct the Owner's operating personnel in the operation and maintenance of the plumbing systems.
   1. Provide the training during the Owner's regular working day.
   2. The Instructors shall each be experienced in their phase of operation and maintenance of building plumbing systems and with the project.

B. Time to be allocated for instructions.
   1. Minimum of _______ hours dedicated instructor time.
   2. _____ hours on each of ______ days.

C. Before proceeding with the on-site training program, submit the program syllabus; proposed time and dates; and other pertinent information for review and approval.
   1. One copy to the Owner.
   2. One copy to the Architect/Engineer.

D. The Owner will provide a list of personnel to receive instructions, and will coordinate their attendance at the agreed upon times.

E. Use the operation and maintenance manuals as the basis of instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.

F. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shut down of each item of equipment.

G. Demonstrate equipment functions (both individually and as part of the total integrated system).

H. Prepare and insert additional data in the operating and maintenance manuals when the need for additional data becomes apparent during instructions.

I. Submit a report within one week after completion of the training program that instructions have been satisfactorily completed. Give time and date of each demonstration and hours devoted to the demonstration, with a list of people present.

J. At the conclusion of the on-site training program, have the person designated by the Owner sign a certificate to certify that he/she has a proper understanding of the system, that the demonstrations and instructions have been satisfactorily completed, and the scope and content of the operating and maintenance manuals used for the training program are satisfactory.

K. Provide a copy of the report and the certificate in an appropriately tabbed section of each Operating and Maintenance Manual.

3.5 EQUIPMENT IDENTIFICATION

A. Provide a laminated engraved plastic nameplate on each piece of equipment and starter.
   1. Designation approved by Architect/Engineer.

2. Equipment includes, but is not limited to, water heaters, pumps, boilers and utility controllers.
3. Submit schedule of equipment to be included and designations.

B. Provide nameplates with 1/2" high letters and fastened with epoxy or screws.

3.6 OBSTRUCTIONS

A. The drawings indicate certain information pertaining to surface and subsurface obstructions which has been taken from available drawings. Such information is not guaranteed, however, as to accuracy of location or complete information.
1. Before any cutting or trenching operations are begun, verify with Owner's representative, utility companies, municipalities, and other interested parties that all available information has been provided.
2. Should obstruction be encountered, whether shown or not, alter routing of new work, reroute existing lines, remove obstruction where permitted, or otherwise perform whatever work is necessary to satisfy the purpose of the new work and leave existing services and structures in a satisfactory and serviceable condition.

B. Assume total responsibility for and repair any damage to existing utilities or construction, whether or not such existing facilities are shown.

3.7 PROTECTION

A. Protect work, equipment, fixtures, and materials. At work completion, work must be clean and in original manufacturer's condition.

END OF SECTION 220100

SECTION 220510 - PLUMBING CONTRACT QUALITY CONTROL

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Contract quality control including workmanship, manufacturer's instructions and demonstrations.

1.2 QUALITY CONTROL PROGRAM

A. Maintain quality control over supervision, subcontractors, suppliers, manufacturers, products, services, site conditions and workmanship to produce work in accordance with contract documents.

1.3 WORKMANSHIP

A. Comply with industry standards except when more restrictive tolerances or specified requirements indicate more rigid standards or more precise workmanship.

B. Perform work by persons qualified to produce workmanship of specified quality.

C. Secure products in place with positive anchorage devices designed and sized to withstand stresses, vibration, and racking. Under no conditions shall material or equipment be suspended from structural bridging.

D. Provide finishes to match approved samples. All exposed finishes shall be approved by the Architect. Submit color samples as required.

1.4 MANUFACTURER'S INSTRUCTIONS

A. Comply with instructions in full detail, including each step in sequence.

B. Should instruction conflict with Contract Documents, request clarification from Architect / Engineer before proceeding.

1.5 MANUFACTURER'S CERTIFICATES

A. When required in individual Specification Sections, submit manufacturer's certificate in duplicate, certifying that products meet or exceed specified requirements.

1.6 MANUFACTURER'S FIELD SERVICES

A. When required in individual Specification Sections, manufacturer shall provide qualified personnel to observe:
1. Field conditions.
2. Condition of installation.
3. Quality of workmanship.
4. Start-up of equipment.
5. Testing, adjusting, and balancing of equipment.

B. Representative shall make written report of observations and recommendations to Architect / Engineer.

PART 2 - PRODUCTS

2.1 REFERENCE APPLICABLE SPECIFICATION SECTIONS.

PART 3 - EXECUTION

3.1 PROTECTION OF EQUIPMENT

A. Do not deliver equipment to the project site until progress of construction has reached the stage where equipment is actually needed or until building is closed in enough to protect the equipment from weather. Equipment allowed to stand in the weather will be rejected, and the Contractor is obligated to furnish new equipment of a like kind at no additional cost to the Owner.

B. Adequately protect equipment from damage after delivery to the project. Cover with heavy tarpaulins, drop cloths or other protective coverings as required to protect from plaster, paint, mortar and/or dirt. Do not cover with plastic materials and trap condensate and cause corrosion.

END OF SECTION 220510

SECTION 220512 - PLUMBING SHOP DRAWINGS, COORDINATION DRAWINGS AND PRODUCT DATA

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Prepare submittals as required by Division 1.

B. The term submittal, as used herein, refers to all:
1. Shop Drawings
2. Coordination Drawings
3. Product data

C. Submittals shall be prepared and produced for:
1. Distribution as specified
2. Inclusion in the Operating and Maintenance Manual, as specified, in the related section

1.2 SHOP DRAWINGS

A. Present drawings in a clear and thorough manner. Identify details by reference to sheet and detail, schedule, or room numbers shown on Contract Drawings.

B. Show all dimensions of each item of equipment on a single composite Shop Drawing. Do not submit a series of drawings of components.

C. Identify field dimensions; show relationship to adjacent features, critical features, work, or products.

D. Submit shop drawings in plan, elevation and sections, showing equipment in mechanical equipment areas.

1.3 COORDINATION DRAWINGS

A. Present in a clear and thorough manner. Title each drawing with project name. Identify each element of drawings by reference to sheet number and detail, or room number of contract documents. Minimum drawing scale: ¼” = 1’-0”.

B. Prepare coordination drawings to coordinate installations for efficient use of available space, for proper sequence of installation, and to resolve conflicts. Coordinate with work specified in other sections and other divisions of the specifications.

C. For each mechanical room and for each outside equipment pad where equipment is located, submit plan and elevation drawings. Show:
   1. Actual mechanical equipment and components to be furnished
   2. Service clearance
   3. Relationship to other equipment and components
   4. Roof drains and leader piping
   5. Fire protection piping and equipment

D. Identify field dimensions. Show relation to adjacent or critical features of work or products.

E. Related requirements:
   1. Ductwork shop drawings
   2. Coordination drawing specified in Division 26

F. Submit shop drawings in plan, elevation and sections, showing equipment in mechanical equipment areas.

G. Gas piping sketch indicating proposed location of piping prior to proceeding with the installation.

1.4 PRODUCT DATA AND INSTALLATION INSTRUCTION

A. Submit only pages which are pertinent to the project. All options which are indicated on the product data shall become part of the contract and shall be required whether specified are not.

B. Mark each copy of standard printed data to identify pertinent products, referenced to specification section and article number.

C. Show reference standards, performance characteristics and capacities; wiring and piping diagrams and controls; component parts; finishes; dimensions and required clearances.

D. Modify manufacturer's standard schematic drawings and diagrams to supplement standard information and to provide information specifically applicable to the work. Delete information not applicable.

E. Mark up a copy of the specifications for the product. Indicate in the margin of each paragraph the following: “Comply, ”Do Not Comply”, or “Not Applicable”. Explain all “Do Not Comply” statements.

F. Provide a separate transmittal for each submittal item. Transmittals shall indicate product by specification section name and number. Separate all submittals into appropriate specification section number. Do not combine specification sections.

1.5 MANUFACTURERS INSTRUCTIONS

A. Submit Manufacturer's instructions for storage, preparation, assembly, installation, start-up, adjusting, calibrating, balancing and finishing.

1.6 CONTRACTOR RESPONSIBILITIES

A. Review submittals prior to transmittal.

B. Determine and verify:
   1. Field measurements
   2. Field construction criteria
   3. Manufacturer's catalog numbers
   4. Conformance with requirements of Contract Documents

C. Coordinate submittals with requirements of the work and of the Contract Documents.

D. Notify the Architect/Engineer in writing at time of submission of any deviations in the submittals from requirements of the Contract Documents.

E. Do not fabricate products, or begin work for which submittals are specified, until such submittals have been produced and bear contractor's stamp. Do not fabricate products or begin work scheduled to have submittals reviewed until return of reviewed submittals with Architect/Engineer's acceptance.

F. Contractor's responsibility for errors and omissions in submittals is not relieved whether Architect/Engineer reviews submittals or not.

G. Contractor's responsibility for deviations in submittals from requirements of Contract Documents is not relieved whether Architect/Engineer reviews submittals or not, unless Architect/engineer gives written acceptance of the specific deviations on reviewed documents.

H. Submittals shall show sufficient data to indicate complete compliance with Contract Documents:
   1. Proper sizes and capacities
   2. That the item will fit in the available space in a manner that will allow proper service
   3. Construction methods, materials and finishes

I. Schedule submissions at least 15 days before date reviewed submittals will be needed.

1.7 SUBMISSION REQUIREMENTS

A. Make submittals promptly in accordance with approved schedule, and in such sequence as to cause no delay in the Project or in the work of any other Contractor.

B. Number of submittals required:

1. Shop Drawings and Coordination Drawings: Submit one reproducible transparency and three opaque reproductions.
2. Product Data: Submit the number of copies which the contractor requires, plus those which will be retained by the Architect/Engineer.

C. Accompany submittals with transmittal letter, in duplicate, containing:
1. Date
2. Project title and number
3. Contractor's name and address
4. The number of each Shop Drawing, Project Datum and Sample submitted
5. Other pertinent data

D. Submittals shall include:
1. The date of submission
2. The project title and number
3. Contract Identification
4. The names of:
   a. Contractor
   b. Subcontractor
   c. Supplier
   d. Manufacturer
5. Identification of the product
6. Field dimensions, clearly identified as such
7. Relation to adjacent or critical features of the work or materials
8. Applicable standards, such as ASTM or federal specifications numbers
9. Identification of deviations from contract documents
10. Suitable blank space for General Contractor and Architect/Engineer stamps
11. Contractor's signed and dated Stamp of Approval

E. Coordinate submittals into logical groupings to facilitate interrelation of the several items:
1. Finishes which involve Architect/Engineer selection of colors, textures or patterns
2. Associated items which require correlation for efficient function or for installation

1.8 SUBMITTAL SPECIFICATION INFORMATION

A. Every submittal document shall bear the following information as used in the project manual:
1. The related specification section number
2. The exact specification section title

B. Submittals delivered to the Architect/Engineer without the specified information will not be processed. The Contractor shall bear the risk of all delays, as if no submittal had been delivered.

1.9 RESUBMISSION REQUIREMENTS

A. Make re-submittals under procedures specified for initial submittals.
   1. Indicate that the document or sample is a re-submittal
   2. Identify changes made since previous submittals

B. Indicate any changes which have been made, other than those requested by the Architect / Engineer.

1.10 CONTRACTOR'S STAMP OF APPROVAL

A. Contractor shall stamp and sign each document certifying to the review of products, field measurements and field construction criteria, and coordination of the information within the submittal with requirements of the work and of Contract Documents.

B. Contractor's stamp of approval on any submittal shall constitute a representation to Owner and Architect/Engineer that Contractor has either determined and verified all quantities, dimensions, field construction criteria, materials, catalog numbers, and similar data or assumes full responsibility for doing so, and that Contractor has reviewed or coordinated each submittal with the requirements of the work and the Contract Documents.

C. Do not deliver any submittals to the Architect/Engineer that do not bear the Contractor's stamp of approval and signature.

D. Submittals delivered to the Architect/Engineer without Contractor's stamp of approval and signature will not be processed. The Contractor shall bear the risk of all delays, as if no submittal had been delivered.

1.11 ARCHITECT/ENGINEER REVIEW OF IDENTIFIED SUBMITTALS

A. The Architect/Engineer will:
   1. Review identified submittals with reasonable promptness and in accordance with schedule
   2. Affix stamp and initials or signature, and indicate requirements for re-submittal or approval of submittal
   3. Return submittals to Contractor for distribution or for resubmission

B. Review and approval of submittals will not extend to design data reflected in submittals which is peculiarly within the special expertise of the Contractor or any party dealing directly with the Contractor.

C. Architect/Engineer's review and approval is only for conformance with the design concept of the project and for compliance with the information given in the contract.
   1. The review shall not extend to means, methods, sequences, techniques or procedures of construction or to safety precautions or programs incident thereto.

2. The review shall not extend to review of quantities, dimensions, weights or gauges, fabrication processes or coordination with the work of other trades.

D. The review and approval of a separate item as such will not indicate approval of the assembly in which the item functions.

1.12 SUBSTITUTIONS

A. Do not make requests for substitution employing the procedures of this Section.

B. The procedure for making a formal request for substitution is specified in Div. 1.

PART 2 - PRODUCTS - NOT USED.

PART 3 - EXECUTION - NOT USED

END OF SECTION 220512

SECTION 220513 - ELECTRICAL PROVISIONS OF PLUMBING WORK

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Electrical provisions to be provided as plumbing work are indicated in other Division 22 sections, on drawings, and as specified.

B. Types of work, normally recognized as electrical but provided as plumbing, specified or partially specified in this Section, include but are not necessarily limited to the following:
   1. Motors for plumbing equipment.
   2. Starters for motors of plumbing equipment, but only where specifically indicated to be furnished integrally with equipment.
   3. Wiring from motors to disconnect switches or junction boxes for motors of plumbing equipment, but only where specifically indicated to be furnished integrally with equipment.
   4. Wiring of field-mounted float control switches, flow control switches, and similar plumbing-electrical devices provided for plumbing systems, to equipment control panels.
   5. Pipe heat tracing.

C. Refer to Division 22 sections for specific individual plumbing equipment electrical requirements.

D. Refer to Division 26 sections for motor starters and controls not furnished integrally with plumbing equipment.

E. Refer to Division 26 sections for junction boxes and disconnect switches required for motors and other electrical units of plumbing equipment.

1.2 RELATED WORK

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

1.3 QUALITY ASSURANCE

A. Wherever possible, match elements of electrical provisions of plumbing work with similar elements of electrical work specified in Division 26 sections for electrical work not otherwise specified.

B. For electrical equipment and products, comply with applicable NEMA standards, and refer to NEMA standards for definitions of terminology. Comply with National Electrical Code (NFPA 70) for workmanship and installation requirements.

1.4 SUBMITTALS

A. Include in listing of motors, voltage, notation of whether motor starter is furnished or installed integrally with motor or equipment containing motors.

PART 2 - PRODUCTS

2.1 MOTORS

A. Provide motors for plumbing equipment manufactured by one of the following:
   1. Baldor Electric Company.
   2. Century Electric Div., Inc.
   3. General Electric Co.
   4. Louis Allis Div.; Litton Industrial Products, Inc.
   5. Lincoln Electric
   6. Marathon Electric Mfg. Corp.
   7. Reliance Electric Co.
   8. Westinghouse Electric Corp.

B. Motor Characteristics. Except where more stringent requirements are indicated, and except where required items of plumbing equipment cannot be obtained with fully complying motors, comply with the following requirements for motors of plumbing work:

C. Temperature Rating. Rated for 40°C environment with maximum 50°C temperature rise for continuous duty at full load (Class A Insulation).

D. Provide each motor capable of making starts as frequently as indicated by automatic control system, and not less than 5 starts per hour for manually controlled motors.

E. Phases and Current Characteristics. Provide squirrel-cage induction polyphase motors for 3/4hp and larger, and provide capacitor-start single-phase motors for 1/2hp and smaller, except 1/6hp and smaller may, at equipment manufacturer's option, be split-phase type. Coordinate current characteristics with power specified in Division 26 sections, and with individual equipment requirements specified in other Division 22 requirements. For 2-speed motors provide 2 separate windings on polyphase motors. Do not purchase motors until power characteristics available at locations of motors have been confirmed, and until rotation directions have been confirmed.

F. Service Factor. 1.15 for polyphase motors and 1.35 for single-phase motors.

G. Motor Construction. Provide general purpose, continuous duty motors, Design "B" except "C" where required for high starting torque.
1. Frames. NEMA #56.
2. Bearings are to be ball or roller bearings with inner and outer shaft seals, regreasable except permanently sealed where motor is inaccessible for regular maintenance. Where belt drives and other drives produce lateral or axial thrust in motor, provide bearings designed to resist thrust loading. Refer to individual section of Division 22 for fractional-hp light-duty motors where sleeve-type bearings are permitted.
3. Except as indicated, provide open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation, and provide guarded drip-proof motors where exposed to contact by employees or building occupants. Provide weather-protected Type I for outdoor use, Type II where not housed. Refer to individual sections of Division 22 for other enclosure requirements.
4. Provide built-in thermal overload protection and, where indicated, provide internal sensing device suitable for signaling and stopping motor at starter.
5. Noise Rating: Provide "Quiet" rating on motors.

H. All motors shall be premium efficiency.

2.2 EQUIPMENT FABRICATION

A. Fabricate plumbing equipment for secure mounting of motors and other electrical items included in work. Provide either permanent alignment of motors with equipment, or adjustable mountings as applicable for belt drives, gear drives, special couplings and similar indirect coupling of equipment. Provide safe, secure, durable, and removable guards for motor drives. Arrange for lubrication and similar running-maintenance without removal of guards.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install motors on motor mounting systems in accordance with motor manufacturer’s instructions, anchored to resist torque, drive thrusts, and other external forces inherent in plumbing work. Secure sheaves and other drive units to motor shafts with keys and Allen set screws on flat surface of shaft. Unless otherwise indicated, set motor shafts parallel with machine shafts.

B. Verify voltage with Electrical Plans.

END OF SECTION 220513

SECTION 220514 - PLUMBING ALTERATIONS PROJECT PROCEDURES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Inspect and service existing equipment and materials that are to remain or to be reused.

B. Disposal of equipment, materials, or housekeeping pads to be abandoned. Prior to disposal, the Contractor shall verify with the Owner what is to be salvaged by the Owner and what is to become the property of the Contractor.

C. Handling of equipment and materials to be removed.

1.2 QUALITY ASSURANCE

A. Coordination with the Owner prior to the disconnection or shutdown of existing equipment, or to the modification of existing operational systems.

1.3 CONTRACT DRAWINGS

A. There is the possibility that existing conditions and devices are affected by the work indicated on the drawings and called for in the specifications (project manual) that do not appear on the drawings. It is the Contractor’s responsibility to visit the site and determine all of the existing conditions and to consider these existing conditions when making and presenting a proposal, to have a complete proposal.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Material used to upgrade and repair existing equipment shall conform to that specified.

B. Material used to upgrade and repair existing equipment shall not void existing warranties or listings of the equipment to be upgraded or repaired.

C. Material used to upgrade and repair existing equipment shall be new and shall be of the same manufacturer of the existing equipment, shall be acquired through the existing original equipment manufacturer’s approved distribution channels, shall have manufacturer’s warranties for the new material being used, and shall be listed for the use intended.

PART 3 - EXECUTION

3.1 INSPECTION

A. Existing materials and equipment indicated on the drawings or in the specifications to be reused shall be inspected for damaged or missing parts. Contractor shall notify the Architect/Engineer, in writing, accordingly.

B. If using materials specified or shown on the drawing voids or diminishes the warranty or operation of remaining equipment or systems, the Contractor shall notify the Architect/Engineer, in writing.

C. Verify field measurements, above and underground piping connections and flows.

D. Demolition Drawings are based on casual field observation, and when available, existing record documents. Report discrepancies to Architect before disturbing existing installation, and immediately after such discrepancies are discovered.

E. Field verify existing conditions and actual utility uses prior to final connections. Existing drawings may not have been available for all required information. Use pipe inspection camera system to field verify existing sanitary / grease waste connections. Verify flow direction and depth prior to connection to existing plumbing systems.

3.2 APPLICATION

A. Existing materials and equipment indicated on the drawings or in the specifications to be reused shall be cleaned and reconditioned, including cleaning of piping systems prior to installation and reuse.

B. Material and equipment removed that is not to be salvaged for Owner's use or for reuse on the project shall become the property of the Contractor and be removed from the site.

C. Material or equipment salvaged for Owner's use shall be carefully handled and stored where directed by the Owner or the Architect / Engineer. Relocate material and / or equipment as directed by Owner.

D. Materials and equipment not indicated to be removed or abandoned shall be reconnected to the new system.

E. Materials, equipment and housekeeping pads not to be reused or reconnected shall be removed for Owner’s review and salvaged by Contractor.

F. Prior to start of construction, Contractor shall walk areas to be renovated with Owner to identify and document items to be salvaged for Owner's use.

G. Clean and repair existing materials and equipment that remain or are to be reused.

H. Contractor shall utilize spaces efficiently to maximize accessibility for other installations, for maintenance, and for repairs.

3.3 SEQUENCE AND SCHEDULE

A. Coordinate utility service outages with Utility Company, Architect and Owner.

B. Provide additional or temporary valves, piping and connections to maintain existing systems in service during construction.

C. Existing Plumbing Service: Refer to drawings for work in remodeled areas. Where facilities in these areas are to remain in service, any related work to keep the facilities in operation is specified in this Division. Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Obtain permission from Owner at least 48 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area. Maintain acceptable temperature and humidity control within existing building during renovation activities.

D. Remove and replace existing Plumbing systems and appurtenances as occasioned by new or remodeled construction. Re-establish service that may be interrupted by remodeled construction.

E. Refer to other drawings series for work in remodeled areas. Where facilities in these areas are required to remain in service, any related work required to keep these facilities in operation is specified in this Division.

F. Remove and replace existing piping coincident with the construction.

G. Remove or relocate existing piping or housekeeping pads as occasioned by new or remodeled construction. Cap unused domestic piping beyond the new finish line.

H. Relocate all domestic piping as required to accommodate new work requiring precedence.

I. Remove concrete housekeeping pad where materials or equipment have been removed.

J. Remove all known utilities that do not provide service to the buildings that remain.

K. Remove existing plumbing vent penetrations through roof not to be reused.

3.4 DEMOLITION AND EXTENSION OF EXISTING PLUMBING WORK

A. The Contractor shall modify, remove, and/or relocate all materials and items so indicated on the drawings or required by the installation of new facilities. All removals and/or dismantling shall be conducted in a manner as to produce maximum salvage. Salvage materials shall remain the property of the Owner, and shall be delivered to such destination as directed by the Owner’s representative unless they are not wanted, then it will be the responsibility of this Contractor to remove such items and properly dispose of them. Materials and/or items scheduled for relocation and which are damaged during dismantling or reassembly operations shall be repaired and restored to good operative condition. The Contractor may, at his discretion, and upon approval of the Owner’s representative substitute new materials and/or items of like design and quality in lieu of materials and/or items to be relocated.

B. All items to be relocated shall be carefully removed in reverse to original assembly or placement and protected until relocated. The Contractor shall clean, repair, and provide all new materials, fittings, and appurtenances required to complete the relocations and to restore them to good operative order. All relocations shall be performed by workmen skilled in the work and in accordance with standard practice of the trades involved.

C. When items scheduled for relocation and/or reuse are found to be in damaged condition before work has been started on dismantling, the Contractor shall call the attention of the Owner’s representative to such items and receive further instructions before removal. Items damaged in repositioning operations are the contractor’s responsibility and shall be repaired or replaced by the contractor as approved by the owner’s representative, at no additional cost to the Owner.

D. Plumbing, piping and appurtenances to be removed, salvaged, or relocated shall be removed to points indicated on the drawings, specified, or acceptable to the Owner’s representative. Piping not scheduled for reuse shall be removed to the points at which reuse is to be continued or service is to remain. Such services shall be sealed, capped, or otherwise tied-off or disconnected in a safe manner acceptable to the Construction Inspector. All disconnections or connections into the existing facilities shall be done in such a manner as to result in minimum interruption of services to adjacent occupied areas. Services to existing areas or facilities that must remain in operation during the construction period shall not be interrupted without prior specific approval of the Owner’s representative hereinbefore specified.

E. Repair adjacent construction and finishes damaged during demolition and extension work.

F. Maintain access to mechanical installations that remain active. Modify installation or provide access panel as appropriate.

G. Extend existing installations using materials and methods compatible with existing plumbing installations, or as specified.

H. Existing plumbing piping and devices found to need additional hangers installed should be added at no additional cost to the Owner.

3.5 PROTECTION OF THE WORK

A. Provide adequate temporary support and auxiliary structure as necessary to ensure structural value or integrity of affected portion of work.

B. Provide devices and methods to protect other portions of work from damage.

C. Execute fitting and adjustment of products to provide a finished installation to comply with specified products, functions, tolerances and finishes.

3.6 IDENTIFICATION OF EQUIPMENT IN RENOVATED AREAS

A. Identification of Equipment: Provide new identification of all existing equipment to be reused and located within the renovated areas. Do not include the description “existing”. Provide new nameplates for all existing plumbing equipment in renovated areas as specified in Section 22 05 00 Plumbing General Provisions.

END OF SECTION 220514

SECTION 220515 - PLUMBING EARTHWORK

PART 1 - GENERAL

A. Excavate and backfill for pipe trenches for underground piping, and excavate for structures installed as part of plumbing work.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION

3.1 EXCAVATION

A. Excavate trenches for underground piping to the required depth to ensure 2 foot minimum coverage over piping.

B. Cut the bottom of the trench or excavation to uniform grade.

C. Should rock be encountered, excavate 6 inches below grade, fill with bedding material and tamp well.

D. Lay out alignment of pipe trenches to avoid obstructions. Assure that proposed route of pipe will not interfere with building foundation before any cutting is begun. Should interference be found, contact the Architect/Engineer before proceeding.

3.2 BACKFILL

A. Backfill shall not be placed until the work has been inspected, tested and approved. Complete backfill to the surface of natural ground or to the lines and grades shown on drawings. Except where special materials are requested, use suitable friable soils from other excavation as backfill material. Do not use peat, silt, muck, debris or other organic materials. Deposit backfill in uniform layers and compact each layer as specified in Division 2.

B. Compacting Backfill. Place material in uniform layers of prescribed maximum thickness and wet or dry the material to optimum moisture content. Compact with power-driven tampers to the prescribed density. Place regular backfill in 8 inch maximum layers, loose measure. Compact to not less than 95% of maximum soil density as determined by ASTM D-698 Standard Proctor.

C. Restoration. Compact backfill, where trenching or excavation is required in improved areas such as pavements, walks, and similar areas, to a condition equal to the adjacent undisturbed earth, and restore surface of the area to the condition existing prior to trenching or excavating operation.

D. Provide 6 inch stabilized sand bed with 4 inch stabilized sand cover around each pipe.

3.3 DISPOSAL OF EXCESS MATERIAL

A. Remove excess excavation material or material unsuitable for backfill. Excess material can be spread on grade, or shall be removed from site as directed by the Owner/Architect.

END OF SECTION 220515

SECTION 220517 - PLUMBING ACCESS DOORS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install access doors in wall or ceiling locations as required or shown for access to valves, controls, regulating devices, water arresters and other equipment requiring maintenance, adjustment or operation.

PART 2 - PRODUCTS

2.1 NON-FIRE RATED ACCESS DOORS

A. 16-Gauge frames

B. 14-gauge steel panels

C. Continuous fully concealed hinges

D. Flush screwdriver cam lock & cylinder lock for Owner selection

E. Prime coat finish

F. Brushed satin stainless steel finish for restroom, kitchen or cafeteria installation

G. Material suitable for wall and/or ceiling mounting

2.2 FIRE RATED ACCESS DOORS

A. UL listed, 1-1/2 hour Label “B”, access doors

B. 16-Gauge stainless steel

C. 20-Gauge insulated sandwich-type door panel.

D. Two inch thick with fire rated insulation

E. Continuous fully concealed hinge

F. Automatic closing and latching mechanism

G. Knurled knob and recessed key operation for Owner selection

H. Interior latch release slide for opening from inside

I. Prime coat finish

J. Material suitable for wall and/or ceiling mounting

2.3 ACCEPTABLE MANUFACTURERS

A. Milcor

B. MIFAB

C. Acudor

D. Elmdor

PART 3 – EXECUTION

3.1 INSTALLATION

A. Access doors specified in Division 22 will be installed by other crafts. Not all required access doors are shown. Coordinate with the Contractor to locate access doors for ease of operation and maintenance of concealed equipment.

B. Installation shall be in accordance with the manufacturer’s printed instructions.

C. Minimum size required:
   1. 24” x 24” for plumbing multiple isolation valves and electrical related items in ceilings
   2. 8”x8” for plumbing for single isolation valve or shock arrestor

END OF SECTION 220517

SECTION 220533 - PIPE HEAT TRACING

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install a complete industrial, constant wattage, UL listed system of electric pipe heat tracing and controls on all make-up water piping outdoors above grade to prevent freezing. The heat tracing system shall conform to ANSI/IEEE Standard 515-1989.

B. Protect the pipe, valves, fittings, meters and appurtenances. Apply sufficient cable and overheat thermostat to protect the entire system.

1.2 SUBMITTALS

A. Submit shop drawings and product data as specified in Section 22 05 12.

B. Submit detailed calculations for length of heat tracing cable per foot of pipe, based on actual length of piping installed.

C. Submit manufacturer's certified capacity charts with selections plotted thereon.

D. Submit manufacturer's installation instructions.

E. Submit full load ampere requirement and voltage for branch circuit.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Raychem Corporation

B. Thermon Manufacturing Company

2.2 COMPONENTS

A. Self-regulating heater.

1. The self-regulating heater shall consist of two 16 AWG tinned-copper bus wires embedded in parallel in a self-regulating polymer core that varies its power output to respond to temperature all along its length, allowing the heater to be crossed itself without overheating and to be cut in the field.

The heater shall be covered by a radiation cross-linked modified polyolefin dielectric jacket.

2. In order to provide energy conservation, and to prevent overheating, the heater shall have a self-regulating factor of at least 90%.
3. The heater shall operate on a line voltage of 120 VAC without the use of transformers.
4. The heater shall be sized according to the following. The required heater output rating is in watts per foot at 50°F (heater selection based on 1-1/2 inch fiberglass insulation on metal piping).
5. The heater shall be XL-Trace as manufactured by Raychem Corporation or XL-Econotrace as manufactured by Thermon Manufacturing Company.
6. Power connection, end seal, splice and tee kits components shall be applied in the field.
7. The system shall be controlled by an ambient sensing thermostat set at 40°F either directly or through an appropriate contactor.
8. Provide an end-of-circuit voltage indicating light

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install and start up the pipe heat tracing system in accordance with the manufacturer's Installation, Start-up and Service Instructions.

B. Install the pipe heat tracing cable under the pipe insulation.

C. Apply “Electrically Traced” signs to the outside of the thermal insulation.

D. Ground fault protection of the equipment shall be provided per the 1996 National Electrical Code, Article 427-22.

E. Provide a cast aluminum weatherproof NEMA-4 rated junction box for installation of the cable, with pilot light to indicate operation of the cable.

F. Use only electrical components as recommended by the manufacturer.

3.2 ELECTRICAL WORK

A. Furnish and install the wire, conduit and raceway systems required for the automatic operation of the pipe heat tracing system. Conform to the National Electrical Code.

B. The specified wiring work includes:
1. Wiring of control instruments between thermostat and junction boxes
2. Installation of thermostat and junction boxes
3. Wiring from the heat tracing cable to the junction boxes

C. Related branch circuit power wiring from the junction box to ground fault type circuit is specified to be provided in Division 26.

D. Provide devices and appurtenances as specified in Division 26.

E. Identify each circuit at each terminal with a separate tag.

F. Color code wires in accordance with IPCEA Standards.

G. Make all joints and connections with approved mechanical connectors.

3.3 TESTING OF THE PIPE HEAT TRACING SYSTEM

A. Test the pipe heat tracing system:
   1. Simulate freezing outside air conditions
   2. Measure the amperage draw of the heat tracing system
   3. Compare to the manufacturer's capacity rating of the actual system
   4. After installation and before and after installing the thermal insulation, subject heat to testing using a 1000 VDC megger. Minimum insulation resistance should be between 20 to 1000 megohms regardless of the length.

B. Submit records of test for approval prior to substantial completion; insert in the Owner's Manual.

END OF SECTION 220533

SECTION 220719 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install piping insulation, jackets, accessories and covering of specified materials. The insulation shall be used for high and low temperature piping applications including domestic hot and cold water, roof and overflow drain sump bodies and rain leaders, horizontal sanitary drain piping which receives condensate, make-up water and pool heating water.

B. Furnish and install plenum wrap insulation over PVC vent piping.

1.2 QUALITY ASSURANCE

A. The intent of insulation specifications is to obtain superior quality workmanship resulting in an installation that is absolutely satisfactory in both function and appearance. Provide insulation in accordance with the specifications for each type of service and apply as recommended by the manufacturer and as specified.

B. An approved contractor for this work under this Division shall be:
   1. A specialist in this field and have the personnel, experience, training, skill, and the organization to provide a practical working system.
   2. Able to furnish evidence of having contracted for and installed not less than 3 systems of comparable size and type that have served their owners satisfactorily for not less than 3 years.

C. All piping insulation used on the project inside the building must have a flame spread rating not exceeding 25 and a smoke developed rating not exceeding 50, as determined by test procedures ASTM E 84, NFPA 255 and UL 723. These ratings must be as tested on the composite of insulation, jacket or facing, and adhesive. Components such as adhesives, mastics and cements must meet the same individual ratings as the minimum requirements and bear the UL label.

D. Condensation on any insulated piping system is not acceptable.

E. Replace insulation damaged by either moisture or other means. Insulation that has been wet, whether dried or not, is considered damaged. Make repairs where condensation is caused by improper installation of insulation. Also repair any damage caused by the condensation.

F. Where existing insulated piping, or other surfaces are tapped, remove existing insulation back to undamaged sections for hot surfaces or to nearest insulation stop for cold surfaces, and replace with new insulation of the same type and thickness as existing insulation. Apply as specified for insulation of the same service.

1.3 APPROVALS

A. Submit product data on each insulation type, adhesive, and finish to be used in the work. Make the submittal as specified in Division 1 General Requirements and obtain approval before beginning installation. Include product description, list of materials and thickness for each service and location and the manufacturer's installation instructions for each product.

B. Make a field application of each type of insulation to display the material, quality and application method. Obtain approval of the sample application before proceeding with installation of the work.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Glass fiber pipe insulation:
   1. Johns-Manville Micro-Lok AP-T
   2. Owens-Corning ASJ/SSL
   3. Knauf ASJ/SSL

B. Cellular Glass Insulation (Foamglass):
   1. Pittsburg Corning
   2. Cell-U-Foam

C. Aluminum Jacketing:
   1. Childers
   2. Pabco
   3. RPR

D. Fiberglass reinforcing cloth mesh:
   1. Perma Glass Mesh
   2. Alpha Glass Mesh
   3. Childers Chil-Glas
   4. Vimasco

E. Mastics and Adhesives
   1. Childers
   2. Foster
   3. Vimasco
   4. Armstrong 520 Adhesive

F. Elastomeric Insulation
   1. Armacell

G. Weather Resistant Coating

1. WB Armaflex Finish

H. Glass fiber blanket insulation
   1. Manville R-series Microlite FSKL
   2. Owens-Corning eD75 or ED100 RKF
   3. Knauf 0.75 PCF FSK

I. Fire Barrier Plenum Wrap Insulation
   1. Totally encapsulated with foil facing
   2. Single layer fire protection
   3. Plenum Protection System UL910
   4. Acceptable Manufacturers:
      a. FyreWrap 0.5 Plenum Insulation
      b. 3M Fire Barrier Plenum Wrap 5A

2.2 FIBERGLASS PIPE INSULATION

A. Heavy density, dual temperature fiberglass insulation with factory applied, all service, reinforced vapor barrier jacket having integral laminated vapor barrier. Provide with a factory applied pressure sensitive tape closure system and matching butt strips. Supply in thickness as shown.
   1. Thermal conductivity 0.23 @ 75°F mean (ASTM 335).

2.3 ELASTOMERIC INSULATION

A. Insulation material shall be flexible, closed-cell elastomeric insulation in tubular or sheet form. Material shall have a flame spread rating of 25 or less and a smoke developed rating of 50 or less when tested in accordance with ASTM E84, latest revision. Sheet material with a thickness greater than ¾" shall have a flame spread rating of 25 or less and a smoke developed rating of 100 or less when tested in accordance with ASTM E84, latest revision. In addition, the product, when tested, shall not melt or drip flaming particles, and the flame shall not be progressive. In addition, all materials shall pass simulated end-use fire test. Minimum ¾" thick.
   1. Thermal conductivity 0.27 at 75°F mean (ASTM C177 or C518)

2.4 CELLULAR GLASS INSULATION

A. ASTM C552:
   1. "k" value of 0.35 @ 75°F ("ksi" value of 0.047 @ 24°C);
   2. 8.0 lb/cu.ft. (128 kg/cu.m.) density

2.5 INSULATION/SHIELD AT HANGERS

A. Field fabricated: Use 360° sections of rigid foamglass insulation that will support the bearing area at hangers and supports. Further support insulation at hangers and supports with a shield of galvanized metal covering at least half of the pipe circumference, and conforming to the schedule. Insulation shall extend at least 1" beyond metal shield on each end. When pipe is guided at top and bottom, metal shields shall cover the whole pipe circumference. Adhere metal shield to insulation so that metal will not slide with respect to insulation with ½" aluminum bands (2) per shield.

1. Sections of foam glass insulation may be used of the same outside diameter of the adjoining pipe insulation.
2. Minimum thickness of foam glass insulation shall not be less than 1" thick.

B. Pipe saddles: Formed galvanized sheets at each support point for insulated pipe, shaped to fit pipe, and covering bottom half of pipe. Length at saddle shall be not less than twice the insulation outside diameter or more than 22". Provide 18 gauge through 4" pipe and 16-gauge 5" pipe and above.

2.6 SEALANT, ADHESIVE AND FINISH

A. Lap Adhesive. Provide Childers CP-82 adhesive.

B. Vapor Barrier Finish:
1. Indoors: Provide as insulation coating Childers CP-35, white.
2. Outdoors: Provide as insulation coating Childers Encacel X.
3. Underground: Provide Childers CP-22/24 for fittings and areas. Pittwrap cannot be used.

C. Sealant. Provide Childers CP-76 vapor barrier sealant.

D. Lagging Adhesive. Provide Childers CP-50.

E. Other products of equal quality will be acceptable only upon approval.

2.7 ALUMINUM JACKETING

A. Finish insulated piping outdoors with a smooth prefabricated Z-lock aluminum jacket 0.016" thick with factory applied 1 mil polyethylene/40 lb and Fab strap. Kraft moisture barrier. Childers Lock-On or approved equal.

B. Valves, Fittings and Flanges. For finishing valves, fittings, flanges and similar installations, provide formed aluminum covers, 0.024" thick.

C. Straps and Seals. Provide ½" x 0.020 stainless steel strapping and seals for jackets and covers according to manufacturer's recommendations.

2.8 GLASS FIBER BLANKET INSULATION

A. Minimum density of 1.0 PCF, 2" thick, installed R value to be 6.0 or better at 75°F mean, facing of 0.35 mil foil reinforced with glass yarn mesh and laminated to 40 lbs fire resistant kraft.

2.9 FIRE BARRIER PLENUM WRAP

A. High temperature insulation blanket specifically designed to provide a single layer, flexible enclosure around combustible items located within fire rated return air plenums.

PART 3 - EXECUTION

3.1 INTERIOR PIPING

A. Cover all piping with glass fiber, heavy density, dual temperature pipe insulation with a vapor barrier jacket. Apply insulation to clean, dry pipes. Longitudinal seams shall be joined firmly together and sealed with self-sealing lap joints. Butt insulation joints firmly together and seal with a 3” wide ASJ butt strip seal. Longitudinal seams and butt strip laps shall be coated and sealed with CP-35 vapor barrier coating for chilled water piping applications.

B. Install hanger with protective shield, on the outside of all insulation.

C. Where domestic water pipes (1/2” & ¾” pipe sizes) are installed on trapeze type hangers, provide galvanized sheet metal protection shields at these locations. Place insulation jacket directly on hanger. Incompressible, load bearing insulation segments are not required.

D. Pipe Saddles: Formed galvanized sheets at each support point for insulated pipe, shaped to fit pipe, and covering bottom half of pipe. Length at saddle shall be not less than twice the insulation outside diameter. Provide 18-gauge through 4” pipe and 16-gauge for 5” pipe and above.

E. Seal ends of pipe for drinking chilled water insulation with vapor barrier mastic at valves, flanges, fittings and every 21' on straight runs of piping. Mastic should extend on top of ASJ jacket, across the glass, down onto the pipe making a complete seal.

F. Apply a smooth flood coat of white lagging Foster 8142W over all exposed insulation.

G. Piping to be insulated as specified above:
  1. All hot and cold water.
  2. Make-up water
  3. Horizontal sanitary drain piping that receives condensate
  4. Exposed to view storm drainage system including roof and overflow drain bodies, vertical piping from drain body and all horizontal rain leaders to first elbow turning down

3.2 PIPING OUTDOORS ABOVE GRADE

A. Insulate all water piping exterior of building above grade with rigid foam insulation and aluminum jacketing.

B. Adhere the vapor barrier jacket longitudinal seam with vapor barrier adhesive.

C. Cover all valves, fittings and flanges with factory made molded or field fabricated segments of pipe insulation of a thickness and material equal to the adjoining insulation. Adhere segments together with no voids, using CP-82 adhesive. Secure fitting insulation covers and segments in place with ½” wide glass filament tape.

D. Apply a tack coat of fitting mastic over the insulation and tape.

E. Neatly embed with 10 x 10 fiberglass cloth into the tack coat.

F. Apply mastic over the fiberglass cloth to a thickness where the fabric is not visible after completion.

G. Seal ends of pipe insulation with vapor barrier mastic at valves, flanges, fittings and every 21' on straight runs of piping. Mastic should extend on top of ASJ jacket, across the foam, down onto the pipe, making a complete seal.

H. Finish with aluminum jacketing as specified.

3.3 FLANGE, VALVE AND FITTING INSULATION

A. Cover valves and flanges with fabricated segments, fittings with two-piece factory molded fittings, and both of matching pipe insulation type and thickness equal to that of the adjoining pipe. Fittings and fabricated segments shall be securely held in place.
   1. Apply a tack coat of insulating mastic to the insulated fitting to produce a smooth surface.
   2. After mastic is dry, apply a second coat of vapor barrier mastic. Neatly embed with 10 x 10 fiberglass cloth into the tack coat.
   3. Overlap mastic and fiberglass cloth by 2” on adjoining sections of pipe insulation.
   4. Apply a second coat of mastic over the fiberglass cloth to present a smooth surface.
   5. Apply mastic to a wet film thickness of 3/64”.
   6. Fabric shall not be visible after completion.
   7. Vapor seal flanges, valves and fittings with Childers CP-35.

B. PVC fitting covers are not acceptable.

3.4 ALUMINUM JACKETING (Insulated Piping Outdoors Above Grade)

A. Apply smooth aluminum jacket on piping, valves, fittings and flange covers according to manufacturer's recommendations, using stainless steel strapping and seals, to provide weather tight covering and to shed water.

B. Aluminum jacketing is not considered as contributing to the vapor barrier or the insulation jacket. The vapor barrier must be sufficient in itself for this function. Lap each adjoining jacket section a minimum of 3” to make a weather tight seal.

C. Install straps on 9” centers and at each circumferential lap joint.

D. Cover and seal all exposed surfaces.

E. The use of screws and rivets is not approved.

F. Provide isolation (30# felt) between the aluminum jacket and the sheetmetal protection shield at each pipe support point.

3.5 CONCEALED STORM DRAIN PIPING

A. Provide flexible glass fiber insulation with factory-applied, reinforced UL labeled Foil-Skrim-Kraft (FSK) facing. Install insulation of clean, dry piping.

B. Insulation shall be wrapped tightly on the piping with all circumferential joints and longitudinal joints overlapped a minimum of 2” with facing to the outside to obtain specified R-value using a maximum of 25% compression.

C. Provide vapor retarder at penetrations, joints, seams and damage to the facing with staples and FSK foil tape. The facing shall be taped with a minimum 3” wide strip of reinforced foil tape. Pressure-sensitive tape shall be a minimum 3” (76mm) wide and shall be applied with moving pressure using an appropriate sealing tool. Staples shall be outward cinch and placed 6” (152mm) on center.

D. Mechanical / Electrical rooms and above ceilings are considered concealed spaces.

3.6 MISCELLANEOUS

A. Install materials after piping has been tested and approved.

B. Apply insulation on clean, dry surfaces only.

C. Apply weather protective finish on elastomeric insulation installed in non-conditioned spaces. Provide a minimum of three coats.

D. Install plenum wrap material with bands as specified at PVC vent piping as required.

3.7 INSULATION THICKNESS

INSULATED UNIT	THICKNESS (Inches)

Exposed Roof Drain Bodies and Horizontal Roof Drain Leaders	1
Exposed Roof Overflow Drain Bodies and Horizontal Drain Leaders	1
Domestic Cold Water/Make-Up Water Piping/Drinking Chilled Water	1
Horizontal Sanitary Drain Piping Which Receives Condensate	1
Domestic Hot Water Piping, 1-1/2” Pipe and Smaller	1
Domestic Hot Water Piping, 2” Pipe and Larger	1-1/2
PVC Vent Piping	1/2

END OF SECTION 220719

SECTION 221116 - DOMESTIC WATER PIPING AND APPURTENANCES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install domestic hot and cold water piping.

1.2 RELATED WORK

A. Division 22 Plumbing
   1. Valves, Strainers and Vents
   2. Pipe and Pipe Fittings - General
   3. Plumbing Piping Insulation
   4. Plumbing Fixtures and Fixture Carriers

PART 2 - PRODUCTS

2.1 PIPING AND FITTINGS

A. Below Slab on Grade Piping for Water Entries:
   1. 2-inch and smaller, provide ASTM B88 Type L annealed tempered (soft) seamless copper water tube. No joints below slab entries.
   2. 2-1/2-inch and 3-inch, provide ASTM B88 Type L annealed tempered (soft) seamless copper water tube, 20 ft. straight lengths. One joint allowed below slab entry using wrought copper, solder-joint pressure fittings: ASME B16.22 with an approved brazing filler metal or pipe can be shop bent for no joint installation by using a “bending” temper tubing.
   3. 4-inch and larger, provide ductile iron pipe with mechanical joints, ANSI A21.6.
   4. 3 inch and larger, provide one-piece stainless steel IBR (in building riser), Watts or Ames.

B. Below Grade Piping Outside Building (beyond 5’-0” of building): Provide PVC water main pipe 4 inch through 12 inch in diameter in conformance with AWWA C900. When using 3” or smaller provide Schedule 40 PVC ASTM D1785 with ASTM D-2466 socket type fittings. Provide fittings in conformance with ASTM 2466. Furnish pipe with a minimum pressure rating of 150 lbs. per square inch. Provide PVC pipe as manufactured by Johns-Manville, CertainTeed, Clow or approved equal.

C. Below Slab on Grade Piping. Furnish ASTM B 88 and ANSI/NSF Standard 61 annealed tempered (soft), Type L copper water tube. Run continuous with no joints under the floor slab. Provide copper pipe corrosion protection as specified in this Section.

D. Above Slab Piping. Provide seamless ASTM B 88 and ANSI/NSF Standard 61 drawn tempered (hard) Type L copper water tube with wrought copper or bronze fittings with solder-joints, ANSI B16.22. Solder material shall be 95-5 (lead free) (Tin-Antimony-Grade 95TA) ASTM B 32.

E. Unions. Provide 150 lb. standard unions with ground joint and bronze seat. Flange joints larger than 2 inches. Provide dielectric isolating unions at junctions or connection between metallic piping of dissimilar metal. Provide pipe threads with standard taper pipe threads ANSI B2.1.

F. Alternate Method of Joining Copper Pipe and Tubing: Press Fittings: Copper press fitting shall conform to the material and sizing requirements of ASME B16.51. O-rings for copper press fittings shall be EPDM. VIEGA. The system intended for use shall be approved by submittal. Systems from various manufacturers may vary in technology. The field personnel shall carry training credentials from the approved manufacturer for the project. Mixing of fittings from different manufacturers is strictly prohibited.

2” Pipe and Smaller:

1. Vic-Press 304™: ASTM A-312 stainless steel housings with ASTM A-276 and A-312 outlets and austenitic stainless steel plain or grooved ends, type 304, complete with synthetic rubber Grade “H” (HNBR) seals rated for applicable services to +210 Deg F (+98 Deg C); or Grade “O” Fluoroelastomer for applicable services to +300 Deg F (+149 Deg C). System shall be rated to 500 psi (3447 kPa) unless noted otherwise.
   a. Flange Adapters: ANSI Class 150 flange adapter, Van Stone type with stainless steel back-up flange and Vic-Press™ ends. Rated for services to 275 psi (1876 kPa). Victaulic Style P565.
   b. Unions: Threaded union, 304/304L stainless steel, with Vic-Press™ ends. Victaulic Style P584.
   c. Vic-Press with HNBR or EPDM seals shall be ANSI/NSF 61 Annex G Certified for Potable Water.
   d. Vic-Press system shall be FM approved for fire protection services.

   Or

2. Vic-Press 316™: ASTM A-312 stainless steel housings with ASTM A-276 and A-312 outlets and stainless steel plain or grooved ends, type 316, complete with synthetic rugger Grade “H” (HNBR) seals rated for applicable services to +210 Deg F (+98 Deg C); Grade “E” EPDM for applicable services to +250 Deg F (+120 Deg C); or Grade “O” Fluoroelastomer for applicable services to +300 Deg F (+149 Deg C). System shall be rated to 500 psi (3447 kPa) unless noted otherwise.
   a. Flange Adapters: ANSI Class 150 flange adapter, Van Stone type with stainless steel back-up flange and Vic-Press ™ ends. Rated for services to 275 psi (1876 kPa). Victaulic Style P566.
   b. Unions: Threaded union, 316/316L stainless steel, with Vic-Press™ ends Victaulic Style P585.
   c. Vic-Press with HNBR or EPDM seals shall be ANSI/NSF 61 Annex G

Certified for Potable Water.

d. Vic-Press System shall be FM approved for fire protection services.

2-1/2” to 4” Pipe Size:

3. Couplings shall be Installation-Ready, for direct stab installation without field disassembly, with Nitrile grade T gasket rated +180 deg F for compressed air with oil vapors. Victaulic Style 107H (rigid) or Style 177 (flexible). Where required coupling housing galvanized coating may be used.
4. Roll groove stainless steel pipe with Victaulic grooving tools equipped with RX roll sets, specifically designed for stainless steel pipe.
5. A factory trained field representative (direct employee) shall provide on-site training for contractor’s field personnel in the proper use of grooving tools, application of groove, and installation of grooved piping products. The coupling manufacturer’s representative shall periodically visit the job site and review installation. Contractor shall remove and replace any joints deemed improperly installed.
6. All grooved joint coupling, fittings, valves and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.

2.2 WATER HAMMER ARRESTORS

A. Provide piston type hydraulic engineered/manufactured water hammer arrestors in cold and hot water supply lines in chases or walls to each fixture branch or battery of fixtures serving quick closing valves of electrical, pneumatic, spring loaded type, or quick hand closure valves on fixture trim. Provide water hammer arrestors at the end of the branch line between the last two fixtures served. Provide Precision Plumbing Products, Inc., or equal. Size units according to water hammer arrestor’s Standard PDI WH-201; refer to schedule on drawings.

B. Install all water hammer arrestors so as to attain 100% effectiveness according to Plumbing and Drainage Institute PDI-WH201 Table 5, 6 and 6-A for water hammer arrestors.

C. All water hammer arrestors shall be installed in a vertical position.

D. All water hammer arrestors shall be accessible and shall have access panels where required. Arrestors located above ceilings in fixture drops will not be acceptable. Refer to sizing and placement data as indicated in PDI Standard PDI-WH-201.

PART 3 - EXECUTION

3.1 DRAINAGE

A. Install water piping systems with uniform horizontal grade of 1/8 inch per 10 foot, minimum, to low points to provide complete system drainage. Where constant pitch cannot be maintained for long runs, establish intermediate low points and rise to new level. Grade branches to drain to mains or risers. Unless otherwise indicated, terminate low points of risers with drain valve piped to nearest hub or floor drain.

3.2 STERILIZATION

A. Sterilize the water system with solution containing not less than 50PPM available chlorine. Allow chlorinating solution to remain in system for period of 8 hours (minimum). Have valves and faucets opened and closed several times during the period. After sterilization, flush the solution from the system with clean water until residual chlorine content is less than 0.2 parts per million.

3.3 UNDERGROUND WATER PIPING SYSTEM PROCEDURES

A. Lay sewer and water lines in separate trenches, separated by 10 foot of undisturbed or compacted soil.

3.4 TESTING

A. Test under a cold water hydrostatic pressure of 1-1/2 times operating pressure (150 psig minimum) and carefully check for leaks. Repair leaks and retest system until proven watertight.

B. Test the domestic water piping system at 150psig hydrostatic pressure, maintained for 6 hours.

C. Use only potable water for the test.

D. Perform the test before fixtures, faucets, trim or final connections are made to equipment.

E. If the system is tested in sections, the entire domestic water piping system shall be submitted to a final test, employing the specified procedure.

F. Do not insulate or conceal piping systems until tests are satisfactorily complete.

G. If any leaks or other defects are observed, suspend the test and correct the condition at once. Repeat testing until leaks are eliminated and the full test period is achieved.

H. The satisfactory completion of testing does not relieve the Contractor of responsibility for ultimate proper and satisfactory operation of piping systems and their accessories.

3.5 COPPER PIPE CORROSION PROTECTION

A. Corrosion protect copper tube piping systems:
   1. In the building slab.
   2. Beneath the building slab.
   3. Buried.
   4. Route plasti-sleeve 0.006 thick material entire length of below slab on grade copper tubing.

B. Cover copper tubing piping system with:
   1. "Tapecoat" TC Primer.
   2. "Tapecoat" CT cold applied coating tape.

C. Install coating system as specified by the manufacturer.

D. Extend the corrosion protection 2 inches above concrete slab on grade.

3.6 TEST OF PIPE CORROSION PROTECTION SYSTEM

A. Test the pipe corrosion protection coating with an approved high voltage tester adjusted to provide sufficient voltage to produce a spark through a pinhole in the coating (at least 15 kv AC).

B. Make repairs to small holes in accordance with the manufacturer's instructions.

C. Retest the repairs using procedures listed above.

D. Furnish certificate of compliance with field testing in Owner's manual.

END OF SECTION 221116

SECTION 221123 - DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. General characteristics for pumps specified in Division 22 - Plumbing.

1.2 RELATED WORK

Requirements for pumps are specified in other sections of Division 22 - Plumbing, including the following:

A. Division 22 Plumbing - Electrical Provisions of Plumbing Work.

1.3 PUMP SELECTION

A. Select pumps conservatively for scheduled conditions. Furnish pumps that have reasonably high efficiencies, with peak efficiency at or near rated conditions. Select pumps that will operate stably at 15' suction lift despite substantial reduction in head or substantial increase in delivery.

B. If the pumps proposed are not considered suitable, submit manufacturer's data on other pumps, for review.

C. Scheduled design flow, design head, pump efficiency, and motor horsepower are the minimum acceptable.

D. The pump curve shall rise continuously from maximum flow to cut-off.

E. Shut-off head approximately 10 percent greater than design head, unless otherwise indicated in pump schedules.

F. Pump brake horsepower shall not exceed the motor horsepower rating over the entire operating range from shut-off to run-out.

G. Select the pump for operation at or near peak efficiency.

H. Cavitation-free at all points on the curve.

I. Impeller diameter shall not exceed 90 percent of the maximum published diameter.

1.4 PUMP SIZE AND TYPE

A. Provide motor-driven pumps of the type and speed scheduled. Select pumps that are not overloaded throughout the entire range of pump operation. Provide pump connection sizes as indicated.

B. Submit copies of manufacturer's performance curves, as shop drawings on each pump. Clearly mark the curves for each pump to indicate the diameter of the impeller and the selection point.

1.5 CERTIFIED DATA

A. Submit factory certified pump curves showing pump performance characteristics with pump and system operating points plotted. Curves shall include as a minimum, flow (gallons per minute), head (feet of water), all available impeller diameters (inches), efficiency (percent), net positive suction head required (feet of water), brake horsepower, pump size and pump model. Show pump curves with system curve plotted.

PART 2 - PRODUCTS

2.1 HORIZONTAL PUMPS

A. Pump Construction:
1. Cast iron, designed for 175 psi working pressure
2. Bronze case wear rings
3. Grease lubricated ball bearings selected for an average life of 200,000 hours; pressure grease fittings
4. Flexible coupled
5. Hot Dipped galvanized drip-rim structural steel base extending past the pump flanges allowing all condensation to be accumulated. Galvanized integral drain pan.
6. Falk all-metal center dropout spacer coupling
7. Totally enclosed metal or high-impact polyethylene plastic (Orange Peel) coupling guard per ANSI B15.1, Section 8 and OSHA 1910.219
8. Suction and discharge flange gauge ports
9. Fully enclosed bronze impeller keyed to the shaft
10. 304 Stainless steel shaft minimum

B. End suction pump volute with integrally cast pedestal support foot for back pullout to allow pump to be serviced without disturbing the system piping. Pumps utilizing pedestal mounted bearing frames in lieu of volute will not be accepted.

C. Bearings:
1. Conform to Anti-Friction Bearing Manufacturers Association (AFBMA) Standards
2. Ball or roller bearing pillow block type
3. Self-aligning

4. AFBMA L50 rating of 200,000 hours

D. Horizontal or vertical split case pumps: Double row grease lubricated ball bearing each side.

E. Provide each pump with an internally flushed mechanical seal. If external flush line is required, provide sediment filter for each line.
   1. Use seal materials suitable for the pumped liquid
   2. Renewable bronze or stainless shaft sleeve

F. Provide each pump with a stuffing box with packing:
   1. Hardened 440C stainless steel renewable shaft sleeve
   2. Bronze gland and stainless steel gland bolts
   3. Oil graphite packing

G. Paint entire unit with two coats of machinery enamel after completion of installation.

H. Pump Motor:
   1. Premium efficiency
   2. Totally enclosed fan cooled
   3. Cast iron frame and end plate
   4. Forge steel lifting eye
   5. Over sized conduit box with ground lug
   6. So sized with relation to the pump impeller that the brake horsepower requirements will not overload the motor at any point on the pump curve
   7. Designed for Variable Frequency Drive Application
   8. Minimum Efficiency

3 hp	1800 rpm	89.5%
5 hp	1800 rpm	90.2%
7.5 hp	1800 rpm	91.7%
10 hp	1800 rpm	91.7%
15 hp	1800 rpm	92.4%
20 hp	1800 rpm	93%
25 hp	1800 rpm	93.6%
30 hp	1800 rpm	94.1%
40 hp	1800 rpm	94.5%
50 hp	1800 rpm	94.5%
60 hp	1800 rpm	95%
75 hp+	1800 rpm	95.4%

I. Data plates:
   1. Provide the pump with a nameplate constructed of 300 series stainless steel securely fastened to pump casing with stainless steel pins.
   2. Locate the nameplate for easy visibility.
   3. Clearly stamp the rating conditions and other data below, as a minimum, on the nameplate.
      a. Manufacturer, address, telephone number
      b. Pump model number

c. Pump serial number
d. Size (including impeller diameter scheduled in inches)
e. Type
f. Equipment designation as listed on the pump schedule.
g. Flow scheduled (gallons per minute)
h. Dynamic head scheduled (feet of water)
i. Efficiency (percent)
j. Shut-off head (feet of water)
k. Speed (rpm)
l. Brake horsepower
m. Maximum brake horsepower with rated impeller
n. Rotation
o. Maximum allowable pressure (psig)

J. The schedule on the drawing sets forth the type of pump and GPM required.
1. The head capacities and horsepower are for bidding purposes only.
2. Make pump selection based on actual system calculations.

K. Acceptable manufacturers:
1. Pacific
2. Bell & Gossett
3. Amtrol/Thrush
4. Armstrong
5. Aurora
6. Weinman

2.2 DOMESTIC HOT WATER CIRCULATOR

A. Pump construction:
1. Cast iron, designed for 125 psi working pressure
2. Bronze fitted
3. Grease lubricated ball bearings selected for an average life of 150,000 hours
4. Flexible coupled
5. Horizontal or vertical in-line
6. Flanged connections

B. Provide each pump with a mechanical seal. Use seal materials suitable for the pumped liquid.

C. Paint entire unit with two coats of machinery enamel after completion of installation.

D. Pump motor:
1. NEMA Standard
2. Open drip proof
3. So sized with relation to the pump impeller that the brake horsepower requirements will not overload the motor at any point on the pump curve.
4. Provide insertion thermostat (Aquastat) or (timer) to control operation of

the domestic hot water return pumps.

E. The schedule on the drawing sets forth the type of pump and GPM required.
   1. The head capacities and horsepower are for bidding purposes only.
   2. Make pump selection based on actual system calculations.

F. Acceptable manufacturers:
   1. Bell & Gossett
   2. Amtrol/Thrush
   3. Armstrong
   4. Aurora
   5. Grundfos

2.3 DOMESTIC HOT WATER CIRCULATING PUMPS (SMALL) FRACTIONAL HORSEPOWER

A. Pump Construction:
   1. Wet-rotor, in-line, single stage
   2. Bronze housings with ½” and ¾” sweat connections
   3. Stainless steel housing with union threaded connections
   4. Integrated check valve inside union fitting on a sweat pump housing
   5. Built-in 5-foot, 115 volt AC line cord with NEMA 3 Prong male plug or line cord
   6. Built-in timer
   7. Aquastat thermostatic control

2.4 VERTICAL PEDESTAL TYPE PUMPS (Sump Pump & Sewage Pumps)

A. Pump construction:
   1. Cast iron designed for 150-psi working pressure
   2. Bronze fitted
   3. Cast iron pedestal base and suction elbow fitting

B. Bearings:
   1. Conform to Anti-Friction Bearing Manufacturers Association (AFBMA) Standards
   2. Ball or roller bearing pillow block type
   3. Self-aligning
   4. AFBMA L10 rating of 25,000 hours

C. Arrange pump for back pull out.

D. Provide each pump with a mechanical seal.
   1. Use seal materials suitable for the pumped liquid.
   2. Renewable bronze shaft sleeve.

E. Paint entire unit with two coats of machinery enamel after completion of installation.

F. Pump motor:
   1. NEMA Standard
   2. Open drip-proof
   3. TEFC where located outdoors
   4. So sized with relation to the pump impeller that the brake horsepower requirements will not overload the motor at any point on the pump curve.

G. Data plates:
   1. Provide the pump with a nameplate constructed of 300 series stainless steel securely fastened to pump casing with stainless steel pins.
   2. Locate the nameplate for easy visibility.
   3. Clearly stamp the rating conditions and other data below, as a minimum, on the nameplate.
      a. Manufacturer, address, telephone number
      b. Pump model number
      c. Pump serial number
      d. Size (including impeller diameter scheduled in inches)
      e. Type
      f. Equipment designation as listed on the pump schedule.
      g. Flow scheduled (gallons per minute)
      h. Dynamic head scheduled (feet of water)
      i. Efficiency (percent)
      j. Shut-off head (feet of water)
      k. Speed (rpm)
      l. Brake horsepower
      m. Maximum brake horsepower with rated impeller
      n. Rotation
      o. Maximum allowable pressure (psig)

H. The type of pump and gpm required are scheduled on the drawings.
   1. The head capacities and horsepower are for bidding purposes only.
   2. Make pump selection based on actual system calculations.

I. Acceptable Manufacturers:
   1. Pacific
   2. Bell & Gossett
   3. Amtrol/Thrush
   4. Armstrong
   5. Aurora

2.5 SUBMERSIBLE SUMP PUMPS AND SEWAGE EJECTORS

A. Pump Construction:
   1. Hermetically sealed motor
   2. Positive action air operated diaphragm switch
      a. High water alarm contact
   3. Housing and base cast iron construction

B. Provide an alarm terminal cabinet.
1. In the event of a high water alarm, energize a pulsing 2" diameter red signal light with graphic "sump pump high water alarm”.

C. Test the sump pump package by operation of the completed system through four cycles of operation.
1. Fill the sump to operational levels
2. Visually check level controls
3. Pump operation
4. Verify absence of piping leaks, sump leaks, excessive noise, and excessive vibration
5. Verify alarms
6. Verify pump capacity

D. Sump pump package capacity shall be as scheduled.

E. Acceptable Manufacturers:
1. Hydromatic
2. Little Giant Pump Co.
3. Weil
4. Goulds
5. Grundfos
6. Crane (Barnes) Air Pumps
7. Ebara

2.6 FLOW INDICATOR

A. Flow Indicator
1. Bronze Construction
2. Rotating wheel
3. Line Size
4. Double Window
5. Ernst Flow Industries Model EFI E-57-3

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install the pumps in accordance with Manufacturer's "Installation, Start-up and Service Instructions".
1. Provide access space around pumps for service.
2. Lubricate pumps prior to start-up.
3. Install hot water circulator horizontally, properly supported to wall, in an accessible location for testing and maintenance at a height not to exceed 60” above finished floor. Install line size Ernst bronze rotating wheel, flow indicator with double window, downstream of circulator.

B. Provide a line size isolation valve and strainer on the pump suction and a line size silent check valve and balancing valve on the pump discharge. Provide an automatic air vent off the pump casing. For base mounted pumps, provide a drain line the full size of the base connection and extend it to and terminate it over the nearest floor drain.

C. Support piping adjacent to the pump such that no weight is carried on the pump casing. Decrease from pipe size with eccentric reducer on suction side and concentric increaser on discharge side.

D. Ensure pumps:
   1. Operate at specified system fluid temperatures without vapor binding and cavitation.
   2. Are non-overloading in parallel and individual operation.
   3. Operate within 25 percent of midpoint of published maximum efficiency curve.

E. Refer to pump detail on the Contract Drawings for piping accessories to be provided.

3.2 ALIGNMENT FOR BASE MOUNTED PUMPS

A. Set the pump on a concrete inertia base or concrete housekeeping pad as specified. Anchor, level and grout.

B. Align the pump and driver in accordance with Hydraulic Institute Standards for centrifugal, rotary and reciprocating pumps.

C. Realign the pump and driver after initial leveling of pump base before placing the grout and again after the grout has set and the foundation bolts are tightened. Recheck the alignment after the piping has been connected.

3.3 MANUFACTURER START-UP SERVICE ALIGNMENT

A. After installation, the pumps and motors are to be aligned by the manufacturer or their representative utilizing a dial indicator. After completion, a formal report must be submitted by the Manufacturer to the Engineer prior to final acceptance. This report must include pump serial number, location, beginning and final alignment at a minimum.
   1. Technicians, as required, shall be trained and experienced in the work they perform (Contractor start-up / alignment is unacceptable).

B. Before starting pumps, but after connecting piping:
   1. Align shafts and coupling with a precision dial indicator alignment instrument to the minimum tolerances .004 (TIR) per inch of coupling radius or as recommended by the manufacturer, whichever is the greater.
   2. Tabulate the actual pump alignment reading with manufacturer's minimum tolerances.

3. Submit readings for approval.
4. Include the approved readings in the Owner's Maintenance Manual.

3.4 FINAL PUMP FLOW CALIBRATION

A. Based on the results of the final phases of the test and balance sequences, if the flow of the unthrottled pump is more than 10% above the scheduled values:
1. Request detailed instructions from the pump manufacturer for the correct impeller diameter.
2. Trim the impeller to the diameter recommended by the manufacturer, employing precision machinery.

B. Enter the information on the final configuration of the pump in the Owner's Manual.
1. Modify the pump nameplate to reflect the correct head and flow data and the impeller diameter.

3.5 SPARE PARTS

A. Provide the following spare parts and material to the Owner for his use after the warranty period.
1. A mechanical seal for each pump
2. A set of bearings for each pump

END OF SECTION 221123

SECTION 221316 - SOIL, WASTE AND SANITARY DRAIN PIPING, VENT PIPING AND APPURTENANCES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install piping in buildings and underground laterals to 5 foot outside of building.

B. Cellular Core PVC pipe is not permitted.

1.2 RELATED WORK

A. Site Work:
  1. Sanitary Sewers
  2. Excavation, Trenching and Backfilling for Utilities

B. Division 22 Plumbing:
  1. Pipe and Pipe Fittings
  2. Plumbing Fixtures and Fixture Carriers
  3. Drains, Cleanouts and Hydrants
  4. Earthwork
  5. Plumbing Piping Insulation

1.3 REFERENCES

A. CISPI - Cast Iron Soil Pipe Institute

B. ASTM - American Society for Testing and Materials

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. All No-Hub clamps must have 4 bands minimum. Sizes 5” through 10” shall have six bands minimum.
  1. No-Hub Clamps – Sanitary Waste:
     a. Husky SD 4000
  2. No-Hub Clamps - Vents
     a. Husky SD – 2000
     b. Mission Rubber Co., LLC Heavy Weight Couplings
  3. Clamp-All Hi-TorQ 80 or approved equal

B. Provide Fernco "Pro-flex" shielded couplings Series 3000 with one piece neoprene gasket for all cast iron pipe transitions to Schedule 40 DWV pipe penetrations through slabs. Sizes 1-1/2" through 8" Series 3000.

C. Cast Iron Soil Pipe and Fittings:
1. AB&I
2. Charlotte Pipe and Foundry Co.
3. Tyler Pipe / Soil Division

2.2 DRAIN PIPE AND FITTINGS

A. Above Slab Piping:
1. Schedule 40 PVC plastic pipe and DWV fittings with solvent welded joints.
2. Pipe and fittings shall conform to ASTM D 1784-82.
3. Provide with fire barrier plenum wrap in return air plenums.

B. Below Slab on Grade Pipe for Grease Waste as indicated on Drawings for Hot Grease Waste Discharge:
1. Service weight/cast iron hub and spigot pipe and fittings
2. Compression type, with neoprene gaskets shall conform to ASTM C-564.
3. Pipe shall conform to requirements of ASTM A74.
4. All Cast Iron Soil Pipe and Fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute

C. Below Slab on Grade Piping:
1. Schedule 40 PVC plastic pipe and DWV fittings.
2. Solvent welded DWV joints shall conform to IAPMO Installation Standard IS-9.
3. Pipe and fittings shall conform to ASTM D 1784, ASTM D 1785, ASTM D 2665, ASTM D 3311 and NPS Standard 14 & 61.

2.3 VENT PIPE AND FITTINGS

A. Above Slab Pipe.
1. Service weight cast iron bell and spigot pipe and fittings
2. Compression type, with neoprene gaskets shall conform to ASTM C-564.
3. Pipe shall conform to requirements of ASTM A 74.
4. All Cast Iron Soil Pipe and Fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute

B. Above Slab Pipe:
1. No-hub cast iron soil pipe and fittings shall conform to CISPI 301 and ASTM A888.
2. Pipe shall conform to ASTM A74.
3. No-hub couplings shall conform to CISPI 310 and shall be listed by NSF International

4. Rubber gaskets for cast iron soil pipe and fittings shall conform to ASTM C564

C. Above Slab Piping. Provide Schedule 40 PVC plastic pipe and DWV fittings with solvent welded joints. Pipe and fittings shall conform to ASTM D 1784-82. Provide with fire barrier plenum wrap in return air plenums.

D. Below Slab on Grade Piping:
 1. Provide Schedule 40 PVC with DWV fittings with solvent welded joints. Pipe and fittings shall conform to ASTM D1784-82.

E. Above Slab Pipe.
 1. Drainage-waste-vent copper pipe and fittings for waste stub-outs for all fixture locations.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All above and below slab soil, waste, sanitary drain and vent piping installation methods shall be in accordance with Cast Iron Soil Pipe Institute Standards.

B. Above ground installation in the horizontal position shall be supported at every hub (hub & spigot or hubless type). Hangers are to be placed within 18” of hub or coupling. For large diameter fittings, 5 inches and larger shall be braced to prevent horizontal movement. Every branch opening or change of direction, braces, blocks, rodding or other suitable method shall be used to prevent movement. Riser clamps to be used for each floor, not to exceed 15’-0”.

C. All above and below slab PVC sanitary waste and vent piping installation methods shall be in accordance with IAPMO Installation Standard 18-9 for Schedule 40 PVC-DWV, per manufacturer’s recommendations and applicable standards.

D. Tracer wires shall be installed on all underground PVC sanitary sewer lines installed outside the building slab.

E. All PVC underground shall be installed in accordance with ASTM D2321.

3.2 GRADE

A. Give horizontal pipe grade of ¼-inch per foot where possible, but not less than 1/8 inch per foot unless otherwise shown.

3.3 DRAIN PIPE AND FITTINGS

A. Offsets and Fittings.
   1. Use reduction fittings to connect two pipes of different diameter.
   2. Change directions by appropriate use of 45-degree wyes, long-sweep quarter-bends, and sixth-, eights-, and sixteenth-bends. Sanitary tees can be used on vertical stacks. Use long sweeps at the base of risers.
   3. Provide a separate trap at each fixture, unless a trap is built into the fixture. Provide a deep seal trap at each floor drain and hub drain. Place traps so that the discharge from any fixture will pass through only one trap before reaching a building drain.

B. Hub Drains. Install hub drains where indicated, with the top of the hub 1/2 above the finished floor, unless otherwise indicated on the drawings.

C. Cleanouts. Install cleanouts the same size as the soil waste lines in which the cleanouts are placed; however, no cleanout should be larger than 4 inches in diameter.
   1. Where cleanouts occur in pipe chases, bring the cleanouts through the walls and install covers. Where cleanouts occur in floor slabs, set flush. Reference drawing schedule.
   2. Provide cleanouts where soil lines change direction, every 50 foot on long runs, or as shown on the drawings, at the end of each horizontal waste line, and at the base of each riser (and at each increase in pipe size).
   3. Cleanouts shall occur at the end of each battery of water closets, urinals, lavatories, sinks, and single water closets. Cleanouts shall be installed so as to access the main sanitary or soil line. Extend and offset above flood rim of water closet.
   4. Double sanitary tees and double quarter bends do not allow for easy access to main lines, therefore these types of fittings are not allowed.

D. Floor Drains. Locate floor drains 1/2-inch below finish floor elevation unless otherwise shown.

3.4 VENT PIPING

A. Make vent connections to vent stacks with inverted wye fittings. Extend full-size vents through the roof to at least 6 inches above the roof.

B. Flash the roof penetration with 6 lb. lead flashing approximately 24 inches square. Flange the flashing to the lead sleeve. Extend the flashing up and around the vent pipe. Turn the flashing down inside the pipe at least 2 inches to make a watertight joint. Flashing shall comply with the roofing manufacturer's requirements. Reference the Architectural Drawings for exact requirements.

C. Locate vent piping through roof a minimum horizontal distance of not less than 20 feet from any air intake opening or supply fan.

3.5 TESTING

A. Below Slab on Grade and All Floors in Multi-Story Buildings:
1. Test pipe below slab on grade before backfilling and connecting to city sewers.
2. Maintain not less than 10 foot of hydrostatic head for1 hour without a leak.
3. Before acceptance of the work the contractor must ensure the piping is in working order before and after the slab is poured. To ensure this the contractor must test completed systems in the presence of the Architect, Engineer and authorities having jurisdiction after installation is complete.
4. Maintain the test on the system till after the slab is poured. Provide an accessible connection that may be reviewed by Architect, Engineer and authorities having jurisdiction prior to and after the slab is poured.
5. Test drainage piping systems in accordance with governing codes and the requirements specified. Provide equipment and materials and make test connections required to execute tests.
6. Test drainage and waste piping hydraulically by filling system to its highest point or, whichever is greater, at a static head of 10 feet. Leaks at any joint shall be sufficient cause for rejection.
7. Air tests may be substituted for hydraulic tests by forcing air into the closed system at a uniform pressure sufficient to balance a column of 10 inch hg in height.
8. Under any of the previously described tests, the water height shall remain constant, after stabilization, for not less than 15 minutes without any further addition of water.

B. System Test. After the various sections of soil, waste and vent piping are installed, but before fixtures are connected, test the system by:
1. Plugging outlets.
2. Filling vertical sections of multiple story buildings of not less than three floors at a time with water. Provide wyes as required to facilitate plugging.
3. Test for 6 hours without any drop in the water level.

3.6 RODDING SEWERS

A. All sanitary soil and waste lines, both in the building and out, shall be rodded out and flushed out after completion of construction and prior to finish floor being installed. All work must be completed prior to substantial completion. All floor drains and cleanout locations must be included in this work.

B. All sanitary soil and waste lines below building 3” and larger shall be internally videotaped at time of substantial completion. All videotaping shall include on-screen date and time, and include audio narration. All videotaping shall be provided by experienced individual in videotaping piping systems. An Owner’s Representative shall be present during video-taping. Three copies of the videotape shall be delivered to the Owner for future records.

C. This work shall be done in the presence of the Owner’s Representative, as part of the Contract, to ensure all lines are clear, and any obstruction that may be discovered shall be removed immediately. Rodding shall be accomplished by utilizing the proper rotary head to clear sewer. Pipe sizes 8 inches and larger shall be hydro-flushed.

3.7 SMOKE TESTING

A. Interior Plumbing Piping:
1. Contractor shall perform smoke testing on all interior sanitary sewer piping and sanitary vent piping above and below floor prior to cover-up..
2. Artificially created smoke used must be a persistent white tracer smoke and produced by thermogenic chemical reaction. All smoke candles or smoke pencils to be used must be non-toxic and EPA approved. Provided by Superior Signal Smoke Candles.
3. All plumbing fixtures must be installed including floor drains with wetted trap seals.
4. Smoke testing shall be performed after completion of any videotaping, rodding or flushing of the sanitary system. Test must be performed prior to ceiling installation in new construction projects. Smoke is usually injected into the building through the two-way cleanout in the main sewer line leaving the building or a plumbing roof vent or fixture. Smoke will travel through the sanitary sewer and vent system and through the air spaces in the sewer lines and emanate from any leaks in the system. The smoke must reach the last roof vent in the system to indicate the entire system has been completely filled with smoke. The smoke must travel the full length of the piping system. Contractor must provide manpower as necessary to visually trace the flow of smoke through the wall cavities, annular floor/ceiling spaces, inject the smoke, observe the roof vents and to identify the integrity problems.
5. Contractor shall provide a detailed list of findings and a drawing indicating the location, fixture type, type and size of pipe, and or description of type of problems found.
6. Typical findings from indoor smoke testing may include:
   a. Dry traps in floor drains
   b. Improperly capped sewer lines or vents
   c. Broken sewer lines or vents
   d. Cross connected sewer vents and drains
   e. The drawing of air emanating from sewer vents into intakes of air exchange systems
   f. Poorly glued pipe joints
   g. Loose no-hub couplings
7. An Owner’s Representative shall be present during smoke testing.

3.8 SMOKE TESTING – LIQUID SMOKE SYSTEM

A. Interior Plumbing Piping:
1. Contractor shall perform smoke testing for finding leaks in all interior of building sanitary sewer piping and sanitary vent piping above and below building slab prior to cover up.

2. Contractor must use a laboratory tested safe liquid smoke with a patented liquid smoke generating system. The liquid smoke must be contained in a pressure tank with inline filter and quick disconnect.
3. Smoke generating system must generate up to 3 hours or more of continuous and constant smoke. Generating system must have a metering valve to precisely control smoke flow and density. Smoke generating system must have a 4" x 6" industrial flexible mining duct for connection to vent stack or cleanout.
4. Smoke generating system must be power full enough to push smoke through the smallest leaks.
5. The liquid smoke must not leave any stains or odors.
6. The liquid smoke shall not contain Zinc Chloride, a listed toxic compound in OSHA 1915,1000 – Air contaminants.
7. Smoke generating system must have a means to atomize the liquid smoke and have an enclosed fan system capable of up to 700 cfm with adjustable inlet damper control to adjust cfm as necessary for the size of system.
8. Provide Hurco "Power smoker " with Hurco "LiquiSmoke" system or approved equal.
9. All plumbing fixtures must be installed including floor drains with wetted trap seals.
10. Smoke testing shall be performed after completion of any videotaping, rodding or flushing of the sanitary system. Test must be performed prior to ceiling installation in new construction projects. Smoke is usually injected into the building through the two-way cleanout in the main sewer line leaving the building or a plumbing roof vent or fixture. Smoke will travel through the sanitary sewer and vent system and through the air spaces in the sewer lines and emanate from any leaks in the system. The smoke must reach the last roof vent in the system to indicate the entire system has been completely filled with smoke. The smoke must travel the full length of the piping system. Contractor must provide manpower as necessary to visually trace the flow of smoke through the wall cavities, annular floor/ceiling spaces, inject the smoke, observe the roof vents and to identify the integrity problems.
11. Contractor shall provide a detailed list of findings and a drawing indicating the location, fixture type, type and size of pipe, and or description of type of problems found.
12. Typical findings from indoor smoke testing may include:
    a. Dry traps in floor drains
    b. Improperly capped sewer lines or vents
    c. Broken sewer lines or vents
    d. Cross connected sewer vents and drains
    e. The drawing of air emanating from sewer vents into intakes of air exchange systems
    f. Poorly glued pipe joints
    g. Loose no-hub couplings
13. An Owner's Representative shall be present during smoke testing.

END OF SECTION 221316

SECTION 221413 - ROOF DRAINAGE PIPING AND APPURTENANCES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install roof drains, drain pipes and accessories.

1.2 RELATED WORK

A. Division 22 Plumbing
   1. Pipe and Pipe Fittings - General; for general piping requirements.
   2. Drains and Cleanouts.
   3. Plumbing Piping Insulation.
   4. Earthwork

1.1 REFERENCES

A. CISPI – Cast Iron Soil Pipe Institute

B. ASTM – American Society for Testing and Materials

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Cast Iron Soil Pipe and Fittings
   1. AB&I
   2. Charlotte Pipe and Foundry Co.
   3. Tyler Pipe / Soil Division

2.2 STORM PIPE AND FITTINGS

A. Above Ground Pipe. Provide service weight cast iron Hub and Spigot soil pipe and fittings with compression type neoprene gaskets that conform to ASTM C-564. Pipe and fittings shall meet the requirements of ASTM A 74. All cast iron soil pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute.

B. Above Ground Piping. Provide Schedule 40 PVC plastic pipe and DWV fittings with solvent welded joints. Pipe and fittings shall conform to ASTM D 1784-82.

C. Below Slab on Grade: Provide hot-dip coated service weight cast iron Hub and

Spigot soil pipe and fittings with compression type neoprene gaskets. Pipe and fittings shall meet the requirements of ASTM A 74, and gaskets shall conform to ASTM C-564. All cast iron soil pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute.

D. Below Slab on Grade: Provide Schedule 40 PVC plastic pipe and DWV fittings with solvent welded joints. Pipe and fittings shall conform to ASTM D 1784-82.

E. Provide Fernco “Pro-Flex” shielded couplings, Series 3000 with one-piece neoprene gasket for cast iron pipe transitions to Schedule 40 DWV pipe penetrations through slabs. Sizes 2” through 8” use Series 3000.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All above and below slab storm piping installation methods shall be in accordance with the Cast Iron Soil Pipe Institute Standards.

B. Above ground installation in the horizontal position shall be supported at every hub (hub & spigot or hubless type). Hangers to be placed within 18” of hub or coupling. For large diameter fittings, 5 inches and larger shall be braced to prevent horizontal movement. Every branch opening or change of direction, braces, blocks, rodding or other suitable method shall be used to prevent movement. Riser clamps to be used for each floor, not to exceed 15’-0”.

C. All above and below slab PVC storm piping installation methods shall be in accordance with IAPMO Installation Standard 18-9 for Schedule 40 PVC-DWV, per manufacturer’s recommendations and applicable standards,and in accordance with ASTM D2321.

3.2 GRADE

A. Give horizontal lines minimum grade of 1/8 inch per foot.

3.3 TESTING

A. Below Floors.
1. Test pipe below floors before backfilling and connecting to sewers.
2. Maintain not less than 10 foot of hydrostatic head for 1 hour without a leak.

B. System Test. After all the various sections of soil, waste and vent piping are installed, but before fixtures are connected, test the system:
1. Plugging outlets.
2. Fill vertical sections with water. Provide wyes as required to facilitate plugging.

3. Test for 6 hours without any drop in the water level.

3.4 RODDING SEWERS

A. All storm sewer lines, both in the building and out, shall be rodded out and flushed out after completion of construction and prior to finish floor being installed. All work must be completed prior to substantial completion. All floor drains and cleanout locations must be included in this work.

B. All storm lines below building 3" and larger shall be internally video-taped at time of substantial completion. An Owner's Representative shall be present during video-taping. Three copies of the video-tape shall be delivered to the Owner for future records.

C. This work shall be done in the presence of the Owner's Representative, as part of the Contract, to ensure all lines are clear, and any obstruction that may be discovered shall be removed immediately. Rodding shall be accomplished by utilizing a rotary cutter, which shall be full size of pipe being cleaned for pipe sizes up to 6 inches. Pipe sizes 8 inches and larger shall be hydro-flushed.

END OF SECTION 221413

SECTION 222000 - PLUMBING PIPE AND PIPE FITTINGS - GENERAL

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install pipe and pipe fittings for piping systems specified in Division 22 - Plumbing.

1.2 RELATED WORK

A. Division 22 Plumbing
   1. Earthwork
   2. Valves, Strainers and Vents
   3. Insulation
   4. Other Piping Sections

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. The particular type of pipe and fittings for each system is specified in the individual sections.

2.2 UNIONS

A. Use 150 lb. standard (300 lb. WOG) malleable iron, ground joint unions with bronze seat. Provide flanged joints on piping 2-1/2" and larger.
   1. Where pipe materials of different types join, use a dielectric union. Union shall be threaded, solder or as required for its intended use.

2.3 BRANCH CONNECTIONS

A. Pipe 2" and Smaller. For threaded piping, use straight size reducing tee. When branch is smaller than header, a nipple and reducing coupling or swagged nipple may be used.

B. 2-1/2" through 36": For welding piping, when branch size is the same as header size, use welding tee. Use Weld-o-let when branch is smaller than header. For threaded branch connections, use 3000 lb. full coupling or Thread-o-let welded to header.

2.4 GASKETS

A. High Temperature Piping. Provide 1/16" thick ring gaskets of aramid reinforced SBR such as Garlock #3200 or 3400 or equal by Advanced Products and Systems.

B. Other Piping. Provide ring rubber gaskets, Garlock #7992 or equal by Advanced Products and Systems. Use 1/8" thick cloth reinforced neoprene gaskets. For smaller than 6", use 1/16" thick gasket.

2.5 FLOORS AND CEILING PLATES

A. Provide chrome-plated floor and ceiling plates around pipes exposed to view when passing through walls, floors, partitions, or ceilings in finished areas; size plates to fit pipe or insulation and lock in place.

PART 3 - EXECUTION

3.1 PIPE FABRICATION AND INSTALLATION

A. Make piping layout and installation in the most advantageous manner possible with respect to headroom, valve access, opening and equipment clearance, and clearance for other work. Give particular attention to piping in the vicinity of equipment. Preserve the required minimum access clearances to various equipment parts, as recommended by the equipment manufactured, for maintenance.

B. Cut all pipes to measurement determined at the site. After cutting pipe, remove burrs by reaming. Bevel plain ends of ferrous pipe.

C. Install piping neatly, free from unnecessary traps and pockets. Work into place without springing or forcing. Use fittings to make changes in direction. Field bending and mitering is prohibited. Make connections to equipment using flanged joints, unions or couplings. Make reducing connections with reducing fittings only.

D. Install piping without tapping out of the bottom of pipe.

E. Press Connections: Copper and steel press fittings ½” through 4” shall be applied in accordance with the manufacturer’s installation instructions. The tubing/pipe shall be fully inserted into the fitting and the tubing/pipe marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing/pipe to assure the tubing/pipe is fully engaged (inserted) in the fitting. The joints shall be pressed using the tool approved by the manufacturer. If soldering (thread adapters, etc.) near press fittings, take precautions to not damage the O-ring fittings. Maintain three pipe diameters or use a cooling agent. Viega-“Pro-Press”.

3.2 OFFSETS AND FITTINGS

A. Due to the small scale of drawings, the indication of offsets and fittings is not possible. Investigate the structural and finish conditions affecting the work and take steps required to meet these conditions.

B. Install pipe close to walls, ceilings and columns so pipe will occupy minimum space. Provide proper spacing for insulation coverings, removal of pipe, special clearances, and offsets and fittings.

3.3 SECURING AND SUPPORTING

A. Support piping to maintain line and grade, with provision for expansion and contraction. Use approved clevis-type or trapeze-type hangers connected to structural members of the building. Single pipe runs to be supported by approved clevis type hangers. Multiple pipe runs to be supported by approved trapeze type hangers. Do not support piping from other piping or structural joist bridging.

B. Provide supports both sides of elbows for pipe 6" and larger.

C. Support vertical risers with steel strap pipe clamps of approved design and size, supported at each floor. Support piping assemblies in chases so they are rigid and self-supported before the chase is closed. Provide structural support for piping penetrating chase walls to fixtures. On cold water pipe, supports shall be outside the insulation.

D. Where insulation occurs, design hangers to protect insulation from damage. Pipe saddles and insulation shields, where required, are specified in the appropriate insulation section and are sized in accordance with the schedule on the drawings.

E. Install trapeze hangers, properly sized, to support the intended load without distortion.

F. Use electro-galvanized or zinc plated threaded rods, nuts, washers and hangers.

G. At outdoor locations, all supports, brackets and structural members shall be hot-dipped galvanized.

H. Support spacing: As recommended by the project structural engineer and support manufacturer, but not more than listed below. Not to exceed spacing requirements of smallest pipe.

Pipe Size	Copper & Steel Max. Support Spacing, Feet	Cast Iron Max. Support Spacing, Ft.	Minimum Rod Diameter, Inches
1" & smaller	6		1/4
1-1/4" & 1-1/2"	8	5	1/4
2"	10	5	1/4
3"	10	5	3/8
4"	10	5	3/8

3.4 PIPE SUPPORTS

A. Provide P1001 or P 5000 Unistrut metal framing members and appurtenances for pipe support. Hot-dip galvanize members and appurtenances when located outside. Sagging of pipes or supports is not acceptable.

B. Adjustable clevis hangers shall be used for single pipe supports; Anvil Fig. 260. When oversized clevis is used, a nipple shall be placed over the clevis bolt as a spacer to assure that the lower U-strap will not move in on the bolt. Provide adjustable clevis with a nut / washer above and below the hanger on the support rod. Ring type clevis hangers are not acceptable.

C. Provide Anvil Figure 45 galvanized or primed and painted channel assembly for trapeze hangers.

3.5 PIPE SUPPORTS ON ROOF

A. Support gas pipe on roof with Portable Pipe Hanger Model PP-10 with roller and fully adjustable height throughout pipe run. Base material shall be high density / high impact polypropylene with UV inhibitors and anti-oxidants. Provide with hot dip galvanized rod finish and framing. Nuts and washers shall be hot dip galvanized.

3.6 ANCHORS

A. Provide anchors as required. Use pipe anchors consisting of heavy steel collars with lugs and bolts for clamping to pipe and attaching anchor braces. Install anchor braces in the most effective manner to secure desired results. Do not install supports, anchors or similar devices where they will damage construction during installation or because of the weight or the expansion of the pipe. When possible, install sleeves in structural concrete prior to pouring of concrete.

3.7 FLOOR PENETRATIONS

A. At locations where pipe passes through floors, provide watertight concrete curb around penetration.

3.8 PIPE SLEEVES

A. Sleeves through masonry and concrete construction:
   1. Fabricate sleeves of Schedule 40 galvanized steel pipe.
   2. Size sleeve large enough to allow for movement due to expansion and to provide continuous insulation.

B. Sleeves through gypsum wall construction.
   1. Fabricate sleeves of 16 gauge galvanized sheet metal.

C. Sleeves through elevated slab construction.
   1. Fabricate sleeves of Schedule 40 galvanized steel pipe with welded center flange in floor.

D. Extend each sleeve through the floor or wall. Cut the sleeve flush with each wall surface. Sleeves through floors shall extend 2” above floor lines for waterproofing purposes. Slab on grade floors shall not be sleeved except where penetrating waterproofing membrane or insect control is required.

E. Caulk sleeves water and air tight. Seal annular space between pipes and sleeves with mastic compound to make the space water and air tight.

F. For sleeves below grades in outside walls, provide Thunderline Link-Seal or Advance Product and System Interlynx, with 316 stainless steel nuts and bolts, with cast iron pressure plate.

G. Provide chrome plated escutcheon plates on pipes passing through walls, floors or ceilings exposed to view. At exterior walls, stainless steel sheet metal is to be used.

H. For sleeves through fire and smoke rated walls, seal with a UL through-penetration firestop, rated to maintain the integrity of the time rated construction. Install in accordance with the manufacturer's installation instructions. Comply with UL and NFPA standards for the installation of firestops. Refer to Architectural drawings for all fire and smoke rated partitions, walls, floors, etc.

3.9 ISOLATION VALVES

A. Provide piping systems with line size shutoff valves located at the risers, at main branch connections to mains for equipment, to isolate central plant, and at other locations.

3.10 DRAIN VALVES

A. Install drain valves at low points of water piping systems so that these systems can be entirely drained. Install a line size drain valve for pipes smaller than 2" unless indicated otherwise. For pipes 2-1/2" and larger, provide 2" drain valves unless indicated otherwise. Drain valves shall be plugged when not in use and at completion.

3.11 CLEANING OF PIPING SYSTEMS

A. General cleaning of piping systems. Purge pipe of construction debris and contamination before placing the systems in service. Provide and install temporary connections as required to clean, purge and circulate.

B. Install temporary strainers at the inlet of pumps and other equipment as necessary where permanent strainers are not indicated. Keep strainers in service until the equipment has been tested, then remove either entire strainer or straining element only. Fit strainers with a line size blow down ball valve and pipe to nearest drain. Blow down strainers, remove and clean as frequently as necessary.

C. Phase One: Initial flushing of system. Remove loose dirt, mill scale, weld beads, rust and other deleterious substances without damage to system components. Open valves, drains, vents and strainers at all system levels during flushing procedures. Flush until “potable water clear” and particles larger than 5 microns are removed.

D. Connect dead-end supply and return headers, even if not shown on the drawings, and provide terminal drains in bottom of pipe end caps or blind flanges.

E. Dispose of water in approved manner.

F. Phase Two: Cleaning of Piping Systems. Remove, without chemical or mechanical damage to any system component, adherent dirt (organic soil), oil, grease, (hydrocarbons), soldering flux, mill varnish, piping compounds, rust (iron oxide) and other deleterious substances not removed by initial flushing. Flush system and replace with clean water.

G. Phase Three: Final flushing and rinsing: Flush and rinse until “potable water clear” and particles larger than 5 microns are removed. Operate valves to dislodge any debris in valve body. Dispose of water in approved manner.

H. Submit status reports upon completion of each phase of work on each system.

3.12 TESTING

A. Test piping after installation with water hydrostatic pressure of 1-1/2 times operating pressure (150 psig minimum) and carefully check for leaks. Repair leaks and retest system until proven watertight.

B. Do not insulate or conceal piping systems until tests are satisfactorily complete.

C. If any leaks or other defects are observed, suspend the test and correct the condition at once. Repeat testing until leaks are eliminated and the full test period is achieved.

D. The satisfactory completion of testing does not relieve the Contractor of responsibility for ultimate proper and satisfactory operation of piping systems and their accessories.

3.13 PIPE MARKERS

A. Identify interior exposed piping and piping in accessible chases or plenums with Opti-Code Brady Pressure Sensitive Adhesive Pipe Markers, consisting of pipe marker and direction of flow arrow tape. Clean pipe prior to installation. Background colors of markers, arrows and tape for each type of system shall be the same. Meet ANSI/OSHA standards and clearly identify each system. Provide minimum 2-1/4-inch letters through 4-inch pipe and 4-inch letters for 5-inch pipe and larger.

B. Identify exterior and mechanical room piping with Snap Around pipe markers through 4-inch pipe and Strap Around markers 5-inch pipe and larger. Pipe markers consisting of pipe marker and direction of flow arrow tape; background colors of markers, arrows and type for each type of system shall be the same. Meet ANSI / OSHA standards and clearly identify each system. Provide minimum 2-1/4-inch letters through 4-inch pipe and 4-inch letters for 5-inch pipe and larger.

C. Install identification in the following locations:
   1. Both sides of penetrations through walls, floors and ceilings.
   2. Close to valves or flanges.
   3. Intervals on straight pipe runs not to exceed 50 feet
   4. Apply marker where view is obstructed.

D. Pipe markers shall meet or exceed the specifications of the ASME A13.1 “Scheme for Identification of Piping Systems”.

END OF SECTION 222000

SECTION 223313 - INSTANTANEOUS ELECTRIC WATER HEATER

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Electric water heaters for domestic water systems.

1.2 RELATED WORK

A. Division 22 Plumbing
   1. Domestic Water Piping.
   2. Plumbing Piping Insulation.
   3. Division 26 Electrical.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Chronomite

B. EEMAX

2.2 PRODUCTS

A. Provide tankless, flow switch activated heater.

B. Hot water temperature range of 103°F to 120°F.

C. 0.5 GPM flow rate.

D. Low pressure model if required. Contractor shall verify pressure at site.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install where shown on Drawings and in accordance with manufacturer's requirements.

3.2 WARRANTY

A. Provide standard manufacturer's 1 year commercial warranty for mechanical and electrical and 5 year warranty for leaks. Warranty shall start the date of the substantial completion certificate.

END OF SECTION 223313

SECTION 223432 - GAS-FIRED DOMESTIC WATER HEATER (Cyclone)

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Gas-fired domestic hot water heating systems, including hot water heaters, storage tanks, control valves, and pressure and temperature relief valves, as required.

1.2 RELATED ITEMS

A. Division 22 Plumbing:
   1. Domestic Water Piping
   2. Gas Piping
   3. Flue Piping
   4. Plumbing Piping Insulation

1.3 CERTIFICATION

A. Provide water heater listed by UL Laboratories, according to ANSZ21.10 Standards governing storage-type water heaters. Must meet ASHRAE/IESNA 90.1-1999 and be design-certified by Underwriter's Laboratories for 180°F water. Must meet SCAQMD Rule 1146.2 for low-nox emissions.

PART 2 - PRODUCTS

2.1 CAPACITY

A. Water heaters shall have the storage capacity and gallons per hour recovery at 100°F rise as scheduled.

2.2 TANK

A. Construct the tank with a 125 psi ASME rating in accordance with the ASME Code, Section IV. Tank shall have a seamless glass-lined steel tank construction.

B. Powered Anodes.

2.3 BURNER

A. A spiral-shaped heat exchanger placed entirely inside the tank which shall be glass-lined on the flue gas side to protect against acidic flue gas condensate.

B. Heater shall have a down-fired power burner designed for precise mixing of air and gas for optimum efficiency, requiring no special calibration on start-up.

2.4 INSULATION

A. Insulate the water heater with factory applied foam insulation and trim with a heavy-gauge, enameled steel jacket.

2.5 CONTROLS

A. Furnish 120V controls for heaters of 100,000 BTUH and above. Controls shall be an integrated solid-state temperature and ignition control device with integral diagnostics, LED fault display capability, and a digital display of temperature system.

2.6 FLUE

A. This water heater(s) shall be suitable for sealed combustion direct-venting with 4” diameter PVC air intake pipe and 4” diameter PVC exhaust pipe for a total of 70 feet of intake and 70 feet of exhaust. Provide a properly sized thermal expansion tank as scheduled on drawings. Refer to manufacturer’s installation instructions for material types used in air intake and exhaust pipe use.

2.7 ACCEPTABLE MANUFACTURERS

A. A.O. Smith

B. State

C. Lochinvar

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install a line size valve in the cold water supply close to each heater and a line size plug cock in the gas supply close to each heater.

B. Provide approved dielectric couplings at all cold water and hot water connections to storage tank, and at pressure and temperature relief valve connection.

C. Install according to manufacturer's specifications and pipe as shown.

D. Install water heater in galvanized drain pan piped to floor drain. Provide ¾” outlet connection.

E. Provide and install acid neutralization box for each heater on condensate from exhaust vent.

3.2 STARTUP

A. Startup shall be performed by factory trained and authorized personnel. The factory representative shall also provide a technical and practical operation and maintenance training seminar including a hands-on operation and maintenance demonstration, and classroom presentation with handouts and visual aids, for no less than three physical plant personnel.

3.3 WARRANTY

A. Provide standard manufacturer’s 1 year commercial warranty for mechanical and electrical and 5 year warranty for leaks. Warranty shall start the date of the substantial completion certificate.

END OF SECTION 223432

SECTION 224000 - PLUMBING FIXTURES AND FIXTURE CARRIERS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install water closets, urinals, lavatories, electric drinking fountains, fixture carriers and plumbing appurtenances.

1.2 RELATED WORK

A. Division 22 Plumbing
   1. Drains, Hydrants and Cleanouts.
   2. Domestic Water Piping.
   3. Soil, Waste and Sanitary Drain Piping and Vent Piping.

1.3 JOB REQUIREMENTS

A. Furnish plumbing fixtures and trim as shown and specified. Provide faucets, fittings, supply stops and similar devices of a single manufacturer. Furnish faucets and supply stops with renewable seats. Porcelain to steel and enameled cast iron fixtures shall be acid resistant. Wall hung fixtures shall be installed with a fixture carrier.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Plumbing Fixtures (Vitreous China):
   1. American Standard.
   2. Kohler.
   3. Toto
   4. Zurn

B. Plumbing Faucets:
   1. American Standard.
   2. Chicago.
   3. T&S Brass.
   4. Zurn.
   5. Symmons
   6. Speakman
   7. Moen Commercial

C. Supports and Carriers:
1. Wade
2. Zurn
3. J.R. Smith.
4. Josam.
5. Watts

D. Flush Valves:
1. Sloan
2. Zurn
3. Moen Commercial

E. Supplies, Stops and Chrome Plated Tubular Brass:
1. McGuire
2. Kohler
3. Chicago
4. Zurn

F. Water Closet Seats:
1. Beneke
2. Church
3. Olsonite
4. Bemis
5. Centoco

G. Electric Drinking Fountains:
1. Halsey Taylor
2. Elkay
3. Oasis
4. Haws

H. Floor Drains:
1. Wade
2. J.R. Smith
3. Josam
4. Zurn
5. Watts
6. Sioux Chief

I. Cleanouts:
1. Wade
2. J.R. Smith
3. Josam
4. Zurn
5. Watts

J. Shower Systems:
1. Bradley
2. Acorn
3. Willoughby

K. Shower Valves
1. Chicago
2. Acorn
3. Symmons
4. Bradley
5. Moen Commercial

L. Shower Stall
1. Aquabath
2. Aquatic
3. Aquarius
4. Best Bath Systems (Access)

M. Stainless Steel Sinks:
1. Elkay
2. Just
3. Griffin
4. Moen Commercial
5. Amtekco Industries

N. Mop Sinks:
1. Crane Fiat
2. Stern Williams
3. Acorn
4. CECO

O. Service Sinks:
1. American Standard
2. Kohler
3. Eljer
4. CECO

P. Roof Drains:
1. Wade
2. J.R. Smith
3. Josam
4. Zurn
5. Watts

Q. Thermostatic Mixing Valves
1. Lawler
2. Symmons
3. Leonard
4. Powers
5. Holby
6. Bradley

R. Emergency Safety Equipment
1. Speakman

2. Bradley
3. Encon
4. Guardian
5. Haws

S. Shock Arrestors:
1. Precision Products
2. Sioux Chief

T. Backflow Preventors
1. Watts
2. Febco
3. Wilkins
4. Beeco

U. Hose Bibbs
1. Wade
2. Chicago
3. Josam
4. Woodford
5. Zurn
6. J.R. Smith

V. Wall Hydrants
1. Wade
2. Woodford
3. Zurn
4. J.R. Smith
5. Josam

W. Solids Interceptors
1. Wade
2. J.R. Smith
3. Zurn
4. Josam
5. Schier

2.2 REQUIREMENTS

A. Refer to the drawings for equipment to be supplied.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in accordance with the manufacturer's instructions.

B. Make rough-in and final connection of service to each fixture provided under this Section and other Sections or Architectural or Plumbing Drawings.

C. Provide necessary stops, valves, traps, unions, vents, cold water, hot water, sanitary, etc. for a complete installation.

D. Provide isolation valves in domestic water lines to isolate all equipment, restrooms, hose bibbs, and where shown on drawings.

E. Remove piping and services roughed-in incorrectly and install correctly, without cost.

F. Exposed piping, fittings and appurtenances shall be chrome-plated brass.

G. Coordinate with the Contractor for locations and service required for each plumbing fixture.

H. All floor drains and floor sinks shall have trap primer connections. Provide trap primer valves and 1/2-inch water line to each floor drain connection. Trap primer supply line shall have ball valve and Y strainer on inlet side of trap primer valve to facilitate cleaning.

I. All floor drains and floor sinks shall have Pro-Set “Trap Guard” for trap seal protection.

J. All floor drains and floor sink locations are to be coordinated with all equipment. Locate drains in mechanical equipment spaces to conform to drain locations of equipment furnished. Coordinate drain location with food service equipment and Architectural Drawings.

K. All floor drains, floor sinks and cleanout covers are to be provided with stainless steel vandal resistant screws.

L. Trap primer valves installed in concealed spaces shall have approved access doors for accessibility.

END OF SECTION 224000

SECTION 226311 - GAS PIPING AND APPURTENANCES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install steel gas pipe inside buildings, including the supply line from the meter, service lines to gas equipment and appliances, termination of the service line with a plug valve, drip leg, and final connection to equipment and appliances with unions.

B. Coordinate service line from utility main and extend to meter. Coordinate installation of the service line and meter with Gas Company.

C. Extend steel gas piping from meter to inside the building to all fixtures, appliances and equipment requiring gas.

1.2 RELATED WORK

A. Division 22 Plumbing
   1. Plumbing Pipe and Fittings
   2. Valves and Vents

1.3 UTILITY CONNECTIONS

A. Make arrangements for and pay all fees and connection charges for obtaining service to the building.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS - ABOVE GRADE

A. Pipe 2 inch and Smaller:
   1. Schedule 40 ASTM A 53 black steel pipe
   2. Factory fabricated socket weld fittings.
   3. Where approved for a specific project and where accepted by local code, cold press mechanical joint fittings shall conform to material requirements of ASTM A420 or ASME B16.3 and performance criteria of ANSI/CSA LC4. Sealing elements shall be HNBR and the fittings shall bear the CSA stamp to confirm acceptability for fuel gas systems. MegaPress system manufactured by VIEGA including “Smart Connect” to assure unpressed fittings will not hold pressure. Installers shall carry training credentials from the manufacturer to confirm they have been instructed in the correct installation procedures.

B. Pipe Larger than 2 inch:
   1. Schedule 40 ASTM A 53 black steel pipe.
   2. Factory fabricated butt weld fittings for welded steel pipes shall conform to ASTM A-234 WPB (seamless weld fittings).

C. Unions:
1. Standard 150 lb. (300 lb. water, oil or gas) malleable iron.
2. Ground joint unions, with bronze seat.
3. Flange joints for pipe larger than 2 inch in diameter.

D. Flanges:
1. Steel flanges. ANSI B16.5 and ASTM A-105.

2.2 PIPE AND FITTINGS - BELOW GRADE OUTSIDE BUILDING

A. Polyethylene pipe shall be ASTM D3350 Grade PE24 cell classification and ASTM D1248 Class B material classification.

B. Pipe shall be medium density polyethylene PE 2406 and PE 2708 manufactured by Poly Pipe Industries, Inc. or Performance Pipe.

C. Polyethylene yellow molded butt fittings for use with medium density polyethylene pipe shall meet testing requirements of ASTM D2513 and resin material listing of ASTM D3350 with PPI designation of PE 2406 as manufactured by Central Plastics Co.

2.3 PIPE AND FITTINGS - IN SLEEVE TO ISLAND LAB TABLES (use only where allowed or required by City)

A. Corrugated stainless steel tubing meeting ASTM A240, type 304, with polyethylene jacketing, flame retardant ASTM E84 index flame 25, smoke 20, with cast bronze fittings. Gastite or approved equivalent.

2.4 PIPE AND FITTINGS - IN UTILITY TRENCH TO ISLAND LAB TABLES

A. Pipe as specified in paragraph 2.1 above, run in utility trench similar to ABT, Inc., Polyduct Utility Trench, 39.2 inch long sections x 12 inches wide x 7 inches deep rectangular polymer concrete, non-sloping, flat bottom, solid cover steel floor plate bolted to unitized frame.

2.5 VALVES

A. See Section 22 05 23.

2.6 GAS PRESSURE REGULATOR

A. Size the gas pressure regulator in accordance with the manufacturer's recommendations for flow quantities and reduced pressure as required for all equipment. Coordinate final equipment gas pressure requirements prior to ordering regulators. Provide American Meter Company regulators or approved equal, suitable for outdoor installation. Regulators outside exposed to weather shall be installed with vent in vertical down position.

B. All line pressure regulators shall be listed ANSI (American National Standard) E2.180A-2000 and CSA (Canadian Standards Association Standard) CGA6.22A-

M00.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation Standards: Install gas piping in accordance with recommendations of the National Fire Protection Association.

B. Drip Legs: Install a capped drip leg 6 inches long at the base of each vertical rise.

C. Coating and Wrapping. Coat and wrap underground piping in accordance with the service utility company standards.

D. Sleeves.
   1. Encase gas piping running in or through solid partitions with thin wall metal conduit. Sleeve piping and fittings shall be two pipe sizes, but not less than 1 inch larger than encased gas piping.
   2. Encase gas piping running below slab in Schedule 40 PVC, minimum size two pipe sizes larger than gas pipe. Vent PVC sleeve to atmosphere with a 1-1/2 inch vent with 1-1/2 inch return bend above building roof. Seal ends of sleeve with UL fire rated caulk.

E. Do not install gas piping exposed to view inside public area, or occupied spaces, without prior written approval.

F. Weld all gas piping above grade.

G. Provide test ports and isolation valves to enable proper testing of system in the future.

H. Provide isolation valve and unions across regulators for proper removal.

I. Provide transition risers where below grade polyethylene pipe changes to steel pipe above grade.

J. Gas Pressure Regulators / Vents:
   1. Piping shall be sized in accordance with the regulator manufacturer’s instructions. Where there is more than one regulator at a location, each regulator shall have a separate vent to the roof / outdoors.
   2. Install vent piping from regulators to location to prevent gas smells from entering building.
   3. Install double elbows and insect screen at end of piping to prevent moisture and insects from entering.
   4. When installed inside building route vents horizontally and terminate through building sidewall. Vents terminating through roof must have prior approval from Architect before installation. Through roof penetrations shall be minimized.
   5. Regulators installed outside or on roof top: Install regulator vent turned downward with insect screen over vent opening. The vent shall be designed to prevent the entry of water, insects, or other foreign materials that could cause blockage.

3.2 TESTING GAS PIPING

A. Preliminary gas test as required by Code, but minimum test pressure of 50 PSI held for not less than eight hours without noticeable drop.

B. Test joints with a soap solution while lines are under pressure.

C. Repair leaks.

D. Final gas test shall be with a 24 inch column of mercury or a diaphragm gauge with a minimum dial size of 3-1/2 inches with a set hand and a pressure range not to exceed twenty (20) psig with 2/10-pound increments. The minimum test pressure shall not be less than ten (10) psi and the maximum test pressure shall not exceed twelve (12) psig. This test will be observed for no less than (30) thirty minutes with no drop in pressure.

E. Provide copy of gas pressure test reports in Operations & Maintenance Manual.

F. Provide Railroad Commission of Texas Pipeline Safety Form PS-86B.
   1. To find form online, go to: Texas School Gas Test Form

G. School renovations projects shall have all gas piping tested. Report and document gas leaks found to the Architect and Engineer. Repair leaks at no additional cost to the Owner.

3.3 IDENTIFICATION CONDUCTOR

A. Spiral A #12 AWG insulated copper conductor the full length of the thermoplastic piping system. Fasten to the pipe at 3 foot intervals with plastic tie wraps.

B. Terminate at each end in a 12 inch x 12 inch x 4 inch FRP junction box.
   1. Bolted gasketed cover with stainless steel screws.
   2. Screw type terminal strip.
   3. Legend on cover "gas pipe identification conductor."

C. Set in concrete pad.

3.4 UNDERGROUND STEEL PIPE

A. Reference Specification Section 22 20 02, Underground Steel Pipe Corrosion Protection.

3.5 PAINT EXPOSED OUTSIDE GAS PIPE

A. Interior and Exterior Gas piping shall be protected from rust.

B. Paint pipe with a flat alkyd coating, clean pipe prior to painting by preparing surface by hand tool cleaning per SSPC-SP2-82, applying one coat of Glidden Y-590 Rustmaster Metal Primer White and top coat of Yellow Alkyd Flat Enamel.

END OF SECTION 226311

SECTION 230100 - HVAC OPERATING AND MAINTENANCE MANUALS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Compilation product data and related information appropriate for Owner's operation and maintenance of products furnished under Contract. Prepare operating and maintenance data as specified.

B. Instruct Owner's personnel in operation and maintenance of equipment and systems.

C. Submit three copies of complete manual in final form.

1.2 SUBMITTALS

A. Thirty (30) days after the Contractor has received the final scheduled identified submittals bearing the Architect/Engineer's stamp of acceptance (including resubmittals), submit for review one copy of the first draft of the Operating and Maintenance Manual. This copy shall contain as a minimum:

1. Table of Contents for each element.
2. Contractor information.
3. All submittals, coordination drawings and product data, reviewed by the Architect/Engineer; bearing the Architect/Engineer's stamp of acceptance. (When submittals are returned from Engineer "Correct as Noted", corrected inserts shall be included.)
4. All parts and maintenance manuals for items of equipment.
5. Warranties (without starting dates)
6. Certifications that have been completed. Submit forms and outlines of certifications that have not been completed.
7. Operating and maintenance procedures.
8. Form of Owner's Training Program Syllabus (including times and dates).
9. Control operations/equipment wiring diagrams.
10. Schedule of filters for each item of equipment.
11. Schedule of belts for each item of equipment.
12. Other required operating and maintenance information that are complete.

B. Copy will be returned to the Contractor within 15 days with comments for corrections.

C. Submit three (3) completed manuals in final form to the Architect/Engineer one day after substantial completion, and prior to Owner's instructions. Include all specified data, test and balance reports, drawings, dated warranties, certificates, reports, along with other materials and information.

D. The Architect/Engineer will review the manuals for completeness within fifteen

(15) days.

E. The Contractor shall be notified of any missing or omitted materials. The Manuals shall be reworked by the Contractor, as required, in the office of the Architect / Engineer. The manuals will not be retransmitted.

F. Two (2) complete Manuals will be delivered to the Owner.

PART 2 - PRODUCTS

2.1 BINDERS

A. Commercial quality black three-ring binders with clear overlay plastic covers.

B. Minimum ring size: 1".
Maximum ring size: 3".

C. When multiple binders are used, correlate the data into related groupings.

D. Label contents on spine and face of binder with full size insert. Label under plastic cover.

PART 3 - EXECUTION

3.1 OPERATION AND MAINTENANCE MANUAL

A. Form for Manuals:
1. Prepare data in form of an instructional manual for use by Owner's personnel.
2. Format:
   a. Size: 8-1/2" x 11".
   b. Text: Manufacturer's printed data or neatly typewritten.
3. Drawings:
   a. Provide reinforced punched binder tab and bind in text.
   b. Fold larger drawings to size of text pages.
4. Provide flyleaf indexed tabs for each separate product or each piece of operating equipment.
5. Cover: Identify each volume with typed or printed title "Operating and Maintenance Instructions". List:
   a. Title of Project
   b. Identity of separate structures as applicable.
   c. Identity of general subject matter covered in the manual.
6. Binder as specified.

B. Content of Manual:
1. Neatly typewritten Table of Contents for each volume arranged in systematic order as outlined in the specifications.

a. Contractor, name of responsible principal, address and telephone number.
b. A list of each product required to be included, indexed to content of the volume.
c. List with each product, name, address and telephone number of:
1) Subcontractor or installer.
2) Maintenance contractor as appropriate.
3) Identify area of responsibility of each.
4) Local source of supply for parts and replacement.
d. Identify each product by product name and other identifying symbols as set forth in Contract Documents.

2. Product Data:
a. Include those sheets pertinent to the specific product.
b. Annotate each sheet to:
1) Identify specific product or part installed.
2) Identify data applicable to installation.
3) Delete references to inapplicable information. (All options not supplied with equipment shall be marked out indicated in some manner.

3. Drawings:
a. Supplement product data with drawings as necessary to illustrate:
1) Relations of component parts of equipment and systems.
2) Control and flow diagrams.
b. Coordinate drawings with information in Project Record Documents to assure correct illustration of completed installation.
c. Do not use Project Record Documents as maintenance drawings.

4. Written text, as required to supplement product data for the particular installation:
a. Organize in consistent format under separate headings for different procedures.
b. Provide logical sequence of instructions for each procedure.

5. Copy of each warranty, bond and service contract issued.
a. Provide information sheet for Owner's personnel, giving:
1) Proper procedures in event of failure.
2) Instances that might affect validity of warranties or bonds.

6. Shop drawings, coordination drawings and product data as specified.

C. Sections for Equipment and Systems.
1. Content for each unit of equipment and system as appropriate:
a. Description of unit and component parts.
1) Function, normal operating characteristics, and limiting conditions.
2) Performance curves, engineering data and tests.
3) Complete nomenclature and commercial number of replaceable parts.
b. Operating procedures:
1) Start up, break-in, routine and normal operating instructions.
2) Regulation, control, stopping, shut down and emergency instructions.
3) Summer and winter operating instructions.

4) Special operating instructions.
c. Maintenance procedures:
1) Routine operations
2) Guide to trouble-shooting.
3) Disassembly, repair and reassembly.
4) Alignment, adjusting and checking.
5) Routine service based on operating hours.
d. Servicing and lubrication schedule. List of lubricants required.
e. Manufacturer's printed operating and maintenance instructions.
f. Description of sequence of operation by control manufacturer.
g. Original manufacturer's parts list, illustrations, assembly drawings and diagrams required for maintenance.
1) Predicted life of part subject to wear.
2) Items recommended to be stocked as spare parts.
h. As installed control diagrams by controls manufacturer.
i. Complete equipment internal wiring diagrams.
j. Schedule of filters for each air handling system.
k. Schedule of belts for each item of equipment.
l. Each Contractor's coordination drawings.
m. As installed color coded piping diagrams.
n. Charts of valve tag number, with location and function of each valve.
o. List of original manufacturer's spare parts and recommended quantities to be maintained in storage.
p. Other data as required under pertinent sections of the specifications.

2. Prepare and include additional data when the need for such data becomes apparent during instruction of Owner's personnel.
3. Additional requirements for operating and maintenance data as outlined in respective sections of specifications.
4. Provide complete information for products specified in Division 23.
5. Provide certificates of compliance as specified in each related section.
6. Provide start up reports as specified in each related section.
7. Provide signed receipts for spare parts and material.
8. Provide training report and certificates.
9. Provide extended compressor warranty certificates.

END OF SECTION 230100

SECTION 230500 - MECHANICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Except as modified in this Section, General Conditions, Supplementary Conditions, applicable provisions of the General Requirements, and other provisions and requirements of the contract documents apply to work of Division 23 Mechanical.

B. Applicable provisions of this section apply to all sections of Division 23, Mechanical.

1.2 CODE REQUIREMENTS AND FEES

A. Perform work in accordance with applicable statutes, ordinances, codes and regulations of governmental authorities having jurisdiction.

B. Mechanical work shall comply with applicable inspection services:
1. Underwriters Laboratories
2. National Fire Protection Association
3. State Health Department
4. Local Municipal Building Inspection Department
5. Americans with Disabilities Act Standards

C. Resolve any code violations discovered in contract documents with the Engineer prior to award of the contract. After Contract award, any correction or additions necessary for compliance with applicable codes shall be made at no additional cost to the Owner.

D. This Contractor shall be responsible for being aware of and complying with asbestos NESHAP regulations, as well as all other applicable codes, laws and regulations.

E. Obtain all permits required.

1.3 CONTRACTOR'S QUALIFICATIONS

A. An approved contractor for the work under this division shall be:
1. A specialist in this field and have the personnel, experience, training, skill, and organization to provide a practical working system
2. Able to furnish evidence of having contracted for and installed not less than 3 systems of comparable size and type that has served their Owners satisfactorily for not less than 3 years

1.4 REFERENCE SPECIFICATIONS AND STANDARDS

A. Materials which are specified by reference to Federal Specifications; ASTM, ASME, ANSI, or AWWA Specifications; Federal Standards; or other standard specifications must comply with latest editions, revisions, amendments or supplements in effect on date bids are received. Requirements in reference specifications and standards are minimum for all equipment, material, and work. In instances where specified capacities, size, or other features of equipment, devices, or materials exceed these minimums, meet specified capacities.

1.5 CONTRACT DRAWINGS

A. Contract drawings are diagrammatic only and do not give fully dimensioned locations of various elements of work. Determine exact locations from field measurements.

1.6 PROJECT RECORD DOCUMENTS

A. Maintain at the job site a separate set of white prints (black line) of the contract drawings for the sole purpose of recording the "as-built" changes and diagrams of those portions of work in which actual construction is at variance with the contract drawings. Mark the drawings with a colored pencil. Prepare, as the work progresses and upon completion of work, reproducible drawings clearly indicating locations and sizes of various lines, valves, ductwork, traps, equipment, and other pertinent items, as installed. Record existing and new underground and under slab piping with dimensioned locations and elevations of such piping.

B. At the conclusion of the project, obtain without cost to the Owner, copies of the original drawings and transfer as-built changes to these. Provide a hard copy of this As-Built Set for the owner’s records. The As-Built Set must include all drawings, regardless of whether corrections were necessary. Digital copies of the As-Built Set shall be provided to the architect and engineer. Digital drawings shall be in PDF format. The delivery of the As-Built Set is a condition of final acceptance.

C. Drawings in the As-Built Set should indicate the following information as a minimum:
1. Indicate all addendum changes to documents.
2. Remove Engineer’s seal, name, address and logo from drawings.
3. Mark documents RECORD DRAWINGS.
4. Clearly indicate: DOCUMENT PRODUCED BY
5. Indicate all changes to construction during construction. Indicate actual routing of all piping, ductwork, etc. that were deviated from construction drawings.
6. Indicate exact location of all underground mechanical piping and

elevation.

7. Indicate exact location of all underground electrical raceways and elevations.
8. Correct schedules to reflect (actual) equipment furnished and manufacturer.
9. Location and size of all ductwork and mechanical piping above ceiling including exact location of isolation of domestic and mechanical valves.
10. Exact location of all electrical equipment in and outside of the building.
11. Exact location of all roof mounted equipment, wall, roof and floor penetrations.
12. Cloud all changes.

1.7 SPACE REQUIREMENTS

A. Consider space limitations imposed by contiguous work in selection and location of equipment and material. Do not provide equipment or material that is not suitable in this respect.

1.8 RELATION WITH OTHER TRADES

A. Carefully study all matters and conditions concerning the project. Submit notification of conflict in ample time to prevent unwarranted changes in any work. Review other Divisions of these specifications to determine their requirements.

B. Because of the complicated relationship of this work to the total project, conscientiously study the relation and cooperate as necessary to accomplish the full intent of the documents.

C. Provide sleeves and inserts in forms as required for the work. Stub up and protect open ends of pipe before any concrete is placed. Furnish sizes of required equipment pads. Furnish and locate bolts and fittings required to be cast in them.

D. Locate and size openings required for installation of work specified in this Division in sufficient time to prevent delay in the work.

E. Refer to other Divisions of the specifications for the scope of required connections to equipment furnished under that Division. Determine from the Contractor for the various trades, the Owner, and by direction from the Architect/Engineer, the exact location of all items.

1.9 CONCEALED AND EXPOSED WORK

A. When the word "concealed" is used in connection with insulating, painting, piping, ducts and the like, the work is understood to mean hidden from sight as in chases, furred spaces or above ceilings. "Exposed" is understood to mean open to view.

1.10 GUARANTEE

A. Guarantee work for 1 year from the date of substantial completion of the project. During that period make good any faults or imperfections that may arise due to defects or omissions in material, equipment or workmanship. At the Owner's option, replacement of failed parts or equipment shall be provided.

1.11 MATERIAL AND EQUIPMENT

A. Furnish new and unused materials and equipment meeting the requirements of the paragraph specifying acceptable manufacturers. Where two or more units of the same type or class of equipment are required, provide units of a single manufacturer.

1.12 NOISE AND VIBRATION

A. Select equipment to operate with minimum noise and vibration. If objectionable noise or vibration is produced or transmitted to or through the building structure by equipment, piping, ducts or other parts of work, rectify such conditions at no additional cost. If the item of equipment is judged to produce objectionable noise or vibration, demonstrate at no additional cost that equipment performs within designated limits on a vibration chart.

1.13 ACCEPTABLE MANUFACTURERS

A. Manufacturers names and catalog number specified under sections of Division 23 are used to establish standards of design, performance, quality and serviceability and not to limit competition. Equipment of similar design, equal to that specified, manufactured by a named manufacturer will be acceptable on approval. A request for prior approval of equipment not listed must be submitted ten (10) days before bid due date. Submit complete design and performance data to the Engineer.

1.14 OPERATING TESTS

A. After all mechanical systems have been completed and put into operation, subject each system to an operating test under design conditions to ensure proper sequencing and operation throughout the range of operation. Tests shall be made in the presence of the Architect/Engineer. Make adjustments as required to ensure proper functioning of all systems. Special tests on individual systems are specified under individual sections. Submit 3 copies of all certifications and test reports adequately in advance of completion of the work to allow for remedial action as required to correct deficiencies discovered in equipment and systems.

1.15 WARRANTIES

A. Submit 3 copies of all warranties and guarantees for systems, equipment, devices and materials. These shall be included in the Operating and Maintenance Manuals.

1.16 BUILDING CONSTRUCTION

A. It shall be the responsibility of each sub-contractor to consult the Architectural and Engineering drawings, details, and specifications and thoroughly familiarize himself with the project and all job related requirements. Each sub-contractor shall cooperate with the General Contractor to verify that all piping and other items are placed in the walls, furred spaces, chases, etc., so there will be no delays in the job.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 OPENINGS

A. Framed, cast or masonry openings for ductwork, equipment or piping are specified under other divisions. Drawings and layout work for exact size and location of all openings are included under this division.

3.2 AIR FILTERS AND PIPE STRAINERS

A. Immediately prior to substantial completion of the project, inspect, clean and service air filters and strainers. Replace air filters.

3.3 LUBRICATION, REFRIGERANT AND OIL

A. Provide a complete charge of correct lubricant for each item of equipment requiring lubrication.

B. Provide a complete and working charge of proper refrigerant, free of contaminants, into each refrigerant system. After each system has been in operation long enough to ensure completely balanced conditions, check the charge and modify for proper operation as required.

C. Provide a complete charge of special oil for refrigeration use, suitable for operation with refrigerant, in each system.

3.4 HOUSEKEEPING PADS

A. Provide equipment housekeeping pads under all floor mounted and ground mounted HVAC equipment, and as shown on the drawings.

B. Concrete work as specified in Division 3.

C. Concrete pads:
   1. 4" high, rounded edges, minimum 2500 psi unless otherwise indicated on the drawings
   2. Chamfer strips at edges and corner of forms.
   3. Smooth steel trowel finish.
   4. Doweled to existing building slab.

D. Install concrete curbs around duct penetrations or multiple pipe penetrations.

3.5 INSTRUCTION OF OWNER'S PERSONNEL

A. Prior to final inspection, conduct an on-site training program to instruct the Owner's operating personnel in the operation and maintenance of the mechanical systems.
   1. Provide the training during the Owner's regular working day.
   2. The Instructors shall each be experienced in their phase of operation and maintenance of building mechanical systems and with the project.

B. Time to be allocated for instructions.
   1. Minimum of 24 hours dedicated instructor time.
   2. 8 hours on each of 3 days.

C. Before proceeding with the on-site training program, submit the program syllabus; proposed time and dates; and other pertinent information for review and approval.
   1. One copy to the Owner.
   2. One copy to the Architect/Engineer.

D. The Owner will provide a list of personnel to receive instructions and will coordinate their attendance at the agreed upon times.

E. Use the operation and maintenance manuals as the basis of instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.

F. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shut down of each item of equipment.

G. Demonstrate equipment functions (both individually and as part of the total integrated system).

H. Prepare and insert additional data in the operating and maintenance manuals when the need for additional data becomes apparent during instructions.

I. Submit a report within one week after completion of the training program that instructions have been satisfactorily completed. Give time and date of each demonstration and hours devoted to the demonstration, with a list of people present.

J. At the conclusion of the on-site training program, have the person designated by the Owner sign a certificate to certify that he/she has a proper understanding of the system, that the demonstrations and instructions have been satisfactorily completed, and the scope and content of the operating and maintenance manuals used for the training program are satisfactory.

K. Provide a copy of the report and the certificate in an appropriately tabbed section of each Operating and Maintenance Manual.

3.6 EQUIPMENT IDENTIFICATION

A. Provide a laminated engraved plastic nameplate on each piece of equipment and starter.
   1. Designation approved by Architect/Engineer.
   2. Equipment includes, but is not limited to, air handling units, fan coil units, variable volume boxes, fans, pumps, boilers and chillers.
   3. Submit schedule of equipment to be included and designations.

B. Provide nameplates with 1/2" high letters and fastened with epoxy or screws.

3.7 OBSTRUCTIONS

A. The drawings indicate certain information pertaining to surface and subsurface obstructions which has been taken from available drawings. Such information is not guaranteed, however, as to accuracy of location or complete information.
   1. Before any cutting or trenching operations are begun, verify with Owner's representative, utility companies, municipalities, and other interested parties that all available information has been provided.
   2. Should obstruction be encountered, whether shown or not, alter routing of new work, reroute existing lines, remove obstruction where permitted, or otherwise perform whatever work is necessary to satisfy the purpose of the new work and leave existing services and structures in a satisfactory and serviceable condition.

B. Assume total responsibility for and repair any damage to existing utilities or construction, whether or not such existing facilities are shown.

3.8 PROTECTION

A. Protect work, equipment, fixtures, and materials. At work completion, work must be clean and in original manufacturer's condition.

3.9 INDOOR AIR QUALITY

A. All equipment and ductwork shall be installed to allow sufficient space for testing, maintenance, and commissioning functions. Access doors or panels shall be installed in ventilation equipment, ductwork, and plenum enclosures for inspection and cleaning of outdoor air intakes, mixing plenums, up and downstream of coils, filters, drain pans and fans.

B. Practice source control and eliminate potential contaminants in material selection, installation, and maintenance.

C. Provide installation and disposal instructions for all materials and chemicals that are potential contaminants.

D. Obtain and conform to the requirements of the Material Safety Data Sheets (MSDSs) in the use of materials.

E. Utilize manufacturer’s recommendations and provide installation instructions for all chemicals, compounds, and potential contaminants including pre-installation degassing if required.

F. Ventilate completed building prior to final completion using no less than design outside air for at least 48 hours before occupancy.

G. Make provisions for controls to prevent the entry of air contaminants into the HVAC air distribution system.

H. Steps shall be taken to ensure that the HVAC system continues to function effectively and are not damaged or contaminated during construction activities.

END OF SECTION 230500

SECTION 230510 - HVAC CONTRACT QUALITY CONTROL

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Contract quality control including workmanship, manufacturer's instructions, mock-ups and demonstrations.

1.2 QUALITY CONTROL PROGRAM

A. Maintain quality control over supervision, subcontractors, suppliers, manufacturers, products, services, site conditions and workmanship to produce work in accordance with contract documents.

1.3 WORKMANSHIP

A. Comply with industry standards except when more restrictive tolerances or specified requirements indicate more rigid standards or more precise workmanship.

B. Perform work by persons qualified to produce workmanship of specified quality.

C. Secure products in place with positive anchorage devices designed and sized to withstand stresses, vibration, and racking. Under no conditions shall material or equipment be suspended from structural bridging.

D. Provide finishes to match approved samples. All exposed finishes shall be approved by the Architect. Submit color samples as required.

1.4 MANUFACTURER'S INSTRUCTIONS

A. Comply with instructions in full detail, including each step, in sequence.

B. Should instruction conflict with Contract Documents, request clarification from Architect / Engineer before proceeding.

1.5 MANUFACTURER'S CERTIFICATES

A. When required in individual Specification Sections, submit manufacturer's certificate in duplicate, certifying that products meet or exceed specified requirements.

1.6 MANUFACTURER'S FIELD SERVICES

A. When required in individual Specification Sections, manufacturer shall provide qualified personnel to observe:
   1. Field conditions.
   2. Condition of installation.
   3. Quality of workmanship.
   4. Start-up of equipment.
   5. Testing, adjusting, and balancing of equipment.

B. Representative shall make written report of observations and recommendations to Architect / Engineer.

PART 2 - PRODUCTS

2.1 REFERENCE APPLICABLE SPECIFICATION SECTIONS.

PART 3 - EXECUTION

3.1 PROTECTION OF EQUIPMENT

A. Do not deliver equipment to the project site until progress of construction has reached the stage where equipment is actually needed or until building is closed in enough to protect the equipment from weather. Equipment allowed to stand in the weather will be rejected, and the Contractor is obligated to furnish new equipment of a like kind at no additional cost to the Owner.

B. Adequately protect equipment from damage after delivery to the project. Cover with heavy tarpaulins, drop cloths or other protective coverings as required to protect from plaster, paint, mortar and/or dirt. Do not cover with plastic materials that may trap condensate and cause corrosion.

END OF SECTION 230510

SECTION 230511 - MECHANICAL ALTERATIONS PROJECT PROCEDURES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Inspect and service existing equipment and materials that are to remain or to be reused.

B. Disposal of equipment, materials, or housekeeping pads to be abandoned. Prior to disposal, the Contractor shall verify with the Owner what is to be salvaged by the Owner and what is to become the property of the Contractor.

C. Handling of equipment and materials to be removed.

1.2 QUALITY ASSURANCE

A. Coordination with the Owner prior to the disconnection or shutdown of existing equipment, or the modification of existing operational systems.

1.3 CONTRACT DRAWINGS

A. There is the possibility that existing conditions and devices are affected by the work indicated on the drawings and called for in the specifications (project manual) which do not appear on the drawings. It is the Contractor’s responsibility to visit the site and determine all the existing conditions and to consider these existing conditions when making and presenting a proposal, to have a complete proposal.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Material used to upgrade and repair existing equipment shall conform to that specified.

B. Material used to upgrade and repair existing equipment shall not void existing warranties or listings of the equipment to be upgraded or repaired.

C. Material used to upgrade and repair existing equipment shall be new and shall be of the same manufacturer of the existing equipment, shall be acquired through the existing original equipment manufacturer’s approved distribution channels, shall have manufacturer’s warranties for the new material being used, and shall be listed for the use intended.

PART 3 - EXECUTION

3.1 INSPECTION

A. Existing materials and equipment indicated on the drawings or in the specifications to be reused shall be inspected for damaged or missing parts. Contractor shall notify the Architect/Engineer, in writing, accordingly.

B. If using materials specified or shown on the drawing voids or diminishes the warranty or operation of remaining equipment or systems, the Contractor shall notify the Architect/Engineer, in writing.

C. Verify field measurements, above and underground piping connections and flows.

D. Demolition Drawings are based on casual field observation and, when available, existing record documents. Report discrepancies to Architect before disturbing existing installation, and immediately after such discrepancies are discovered.

E. Field verify existing conditions and actual utility uses prior to final connections. Existing drawings may not have been available for all required information. Verify actual HVAC supply and return piping connections. Verify flow direction and depth prior to connection to existing plumbing systems.

3.2 APPLICATION

A. Existing materials and equipment indicated on the drawings or in the specifications to be reused shall be cleaned and reconditioned, including cleaning of piping systems and HVAC coils prior to installation and reuse.

B. Material and equipment removed that is not to be salvaged for Owner's use or for reuse on the project shall become the property of the Contractor and be removed from the site.

C. Material or equipment salvaged for Owner's use shall be carefully handled and stored where directed by the Owner or the Architect / Engineer. Relocate material and / or equipment as directed by Owner.

D. Materials and equipment not indicated to be removed or abandoned shall be reconnected to the new system.

E. Materials, equipment and housekeeping pads not to be reused or reconnected shall be removed for Owner’s review and salvaged by Contractor.

F. Prior to start of construction, Contractor shall walk areas to be renovated with Owner to identify and document items to be salvaged for Owner’s use.

G. Clean and repair existing materials and equipment that remain or are to be reused.

H. Contractor shall utilize spaces efficiently to maximize accessibility for other installations, for maintenance, and for repairs.

3.3 SEQUENCE AND SCHEDULE

A. Coordinate utility service outages with Utility Company, Architect and Owner.

B. Provide additional or temporary valves, piping, ductwork and connections to maintain existing systems in service during construction.

C. Existing HVAC and Plumbing Service: Refer to drawings for work in remodeled areas. Where facilities in these areas are to remain in service, any related work to keep the facilities in operation is specified in this Division. Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Obtain permission from Owner at least 48 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area. Maintain acceptable temperature and humidity control within existing building during renovation activities.

D. Remove and replace existing Mechanical systems and appurtenances as occasioned by new or remodeled construction. Re-establish service that may be interrupted by remodeled construction.

E. Refer to other drawings series for work in remodeled areas. Where facilities in these areas are required to remain in service, any related work required to keep these facilities in operation is specified in this Division.

F. Remove and replace existing piping, grilles, boxes and ductwork coincident with the construction.

G. Remove or relocate existing piping, grilles, ductwork or housekeeping pads as occasioned by new or remodeled construction. Cap unused HVAC or domestic piping and duct beyond the new finish line.

H. Relocate all HVAC and or domestic piping, grilles, boxes and ductwork as required to accommodate new work requiring precedence.

I. Remove concrete housekeeping pad where materials or equipment have been removed.

J. Remove all known utilities which do not provide service to the buildings that remain unless otherwise instructed in the construction documents.

K. Remove existing plumbing or mechanical vent penetrations through roof not to be reused.

3.4 DEMOLITION AND EXTENSION OF EXISTING MECHANICAL WORK

A. The Contractor shall modify, remove, and/or relocate all materials and items so indicated on the drawings or required by the installation of new facilities. All removals and/or dismantling shall be conducted in a manner as to produce maximum salvage. Materials and/or items scheduled for relocation and which are damaged during dismantling or reassembly operations shall be repaired and restored to good operative condition. The Contractor may, at his discretion, and upon approval of the Owner’s representative substitute new materials and/or items of like design and quality in lieu of materials and/or items to be relocated.

B. All items to be relocated shall be carefully removed in reverse to original assembly or placement and protected until relocated. The Contractor shall clean, repair, and provide all new materials, fittings, and appurtenances required to complete the relocations and to restore them to good operative order. All relocations shall be performed by workmen skilled in the work and in accordance with standard practice of the trades involved.

C. When items scheduled for relocation and/or reuse are found to be in damaged condition before work has been started on dismantling, the Contractor shall call the attention of the

Owner's representative to such items and receive further instructions before removal. Items damaged in repositioning operations are the contractor's responsibility and shall be repaired or replaced by the contractor as approved by the owner's representative, at no additional cost to the Owner.

D. HVAC, Plumbing, piping, ductwork and appurtenances to be removed, salvaged, or relocated shall be removed to points indicated on the drawings, specified, or acceptable to the Owner's representative. Piping and ductwork not scheduled for reuse shall be removed to the points at which reuse is to be continued or service is to remain. Such services shall be sealed, capped, or otherwise tied-off or disconnected in a safe manner acceptable to the Construction Inspector. All disconnections or connections into the existing facilities shall be done in such a manner as to result in minimum interruption of services to adjacent occupied areas. Services to existing areas or facilities that must remain in operation during the construction period shall not be interrupted without prior specific approval of the Owner's representative hereinbefore specified.

E. Repair adjacent construction and finishes damaged during demolition and extension work.

F. Maintain access to mechanical installations that remain active. Modify installation or provide access panel as appropriate.

G. Extend existing installations using materials and methods compatible with existing mechanical installations, or as specified.

H. Existing mechanical piping and devices found to need additional hangers installed should be added at no additional cost to the Owner.

3.5 PROTECTION OF THE WORK

A. Provide adequate temporary support and auxiliary structure as necessary to ensure structural value or integrity of affected portion of work.

B. Provide devices and methods to protect other portions of work from damage.

C. Execute fitting and adjustment of products to provide a finished installation to comply with specified products, functions, tolerances and finishes.

3.6 IDENTIFICATION OF EQUIPMENT IN RENOVATED AREAS

A. Identification of Equipment: Provide new identification of all existing equipment to be reused and located within the renovated areas. Do not include the description “existing”. Provide new nameplates for all existing mechanical equipment in renovated areas as specified in Section 23 05 00 Mechanical General Provisions.

3.7 REFRIGERANT DISPOSAL

A. Contractor shall dispose of refrigerant from all DX equipment including refrigerant piping per OSHA, EPA, Federal, State and Local Codes.

END OF SECTION 230511

SECTION 230512 - SHOP DRAWINGS, COORDINATION DRAWINGS & PRODUCT DATA

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Prepare submittals as required by these specifications as outlined below.

B. The term submittal, as used herein, refers to all:
   1. Shop Drawings
   2. Coordination Drawings
   3. Product data

C. Submittals shall be prepared and produced for:
   1. Distribution as specified
   2. Inclusion in the Operating and Maintenance Manual, as specified, in the related section

1.2 SHOP DRAWINGS

A. Present drawings in a clear and thorough manner. Identify details by reference to sheet and detail, schedule, or room numbers shown on Contract Drawings.

B. Show all dimensions of each item of equipment on a single composite Shop Drawing. Do not submit a series of drawings of components.

C. Identify field dimensions; show relationship to adjacent features, critical features, work, or products.

D. Submit shop drawings in plan, elevation and sections, showing equipment in mechanical equipment areas.

1.3 COORDINATION DRAWINGS

A. Present in a clear and thorough manner. Title each drawing with project name. Identify each element of drawings by reference to sheet number and detail, or room number of contract documents. Minimum drawing scale: ¼” = 1’-0”.

B. Prepare coordination drawings to coordinate installations for efficient use of available space, for proper sequence of installation, and to resolve conflicts. Coordinate with work specified in other sections and other divisions of the specifications.

C. For each mechanical room and for each outside equipment pad where equipment is located, submit plan and elevation drawings. Show:

1. Actual mechanical equipment and components to be furnished
2. Service clearance
3. Relationship to other equipment and components
4. Roof drains and leader piping
5. Fire protection piping and equipment

D. Identify field dimensions. Show relation to adjacent or critical features of work or products.

E. Related requirements:
   1. Ductwork shop drawings
   2. Coordination drawing specified in Division 26

F. Submit shop drawings in plan, elevation and sections, showing equipment in mechanical equipment areas.

G. Gas piping sketch indicating proposed location of piping prior to proceeding with the installation.

1.4 PRODUCT DATA AND INSTALLATION INSTRUCTION

A. Submit only pages which are pertinent to the project. All options which are indicated on the product data shall become part of the contract and shall be required whether specified are not.

B. Mark each copy of standard printed data to identify pertinent products, referenced to specification section and article number.

C. Show reference standards, performance characteristics and capacities; wiring and piping diagrams and controls; component parts; finishes; dimensions and required clearances.

D. Modify manufacturer's standard schematic drawings and diagrams to supplement standard information and to provide information specifically applicable to the work. Delete information not applicable.

E. Provide a separate transmittal for each submittal item. Transmittals shall indicate product by specification section name and number. Separate all submittals into appropriate specification section number. Do not combine specification sections.

1.5 MANUFACTURER’S INSTRUCTIONS

A. Submit Manufacturer's instructions for storage, preparation, assembly, installation, start-up, adjusting, calibrating, balancing and finishing.

1.6 CONTRACTOR RESPONSIBILITIES

A. Review submittals prior to transmittal.

B. Determine and verify:
1. Field measurements
2. Field construction criteria
3. Manufacturer's catalog numbers
4. Conformance with requirements of Contract Documents

C. Coordinate submittals with requirements of the work and of the Contract Documents.

D. Notify the Architect/Engineer in writing at time of submission of any deviations in the submittals from requirements of the Contract Documents.

E. Do not fabricate products, or begin work for which submittals are specified, until such submittals have been produced and bear contractor's stamp. Do not fabricate products or begin work scheduled to have submittals reviewed until return of reviewed submittals with Architect / Engineer's acceptance.

F. Contractor's responsibility for errors and omissions in submittals is not relieved whether Architect / Engineer reviews submittals or not.

G. Contractor's responsibility for deviations in submittals from requirements of Contract Documents is not relieved whether Architect/Engineer reviews submittals or not, unless Architect / Engineer gives written acceptance of the specific deviations on reviewed documents.

H. Submittals shall show sufficient data to indicate complete compliance with Contract Documents:
1. Proper sizes and capacities
2. That the item will fit in the available space in a manner that will allow proper service
3. Construction methods, materials and finishes

I. Schedule submissions at least 15 days before date reviewed submittals will be needed.

1.7 SUBMISSION REQUIREMENTS

A. Make submittals promptly in accordance with approved schedule, and in such sequence as to cause no delay in the Project or in the work of any other Contractor.

B. Number of submittals required:
1. Shop Drawings and Coordination Drawings: Submit one reproducible transparency and three opaque reproductions.
2. Product Data: Submit the number of copies which the contractor requires, plus those which will be retained by the Architect/Engineer.

C. Accompany submittals with transmittal letter, in duplicate, containing:
   1. Date
   2. Project title and number
   3. Contractor's name, address and contact number.
   4. The number of each Shop Drawing, Project Datum and Sample submitted
   5. Other pertinent data

D. Submittals shall include:
   1. The date of submission
   2. The project title and number
   3. Contract Identification
   4. The names of:
      a. Contractor
      b. Subcontractor
      c. Supplier
      d. Manufacturer
   5. Identification of the product
   6. Field dimensions, clearly identified as such
   7. Relation to adjacent or critical features of the work or materials
   8. Applicable standards, such as ASTM or federal specifications numbers
   9. Identification of deviations from contract documents
   10. Suitable blank space for General Contractor and Architect/Engineer stamps
   11. Contractor's signed and dated Stamp of Approval

E. Coordinate submittals into logical groupings to facilitate interrelation of the several items:
   1. Finishes which involve Architect/Engineer selection of colors, textures or patterns
   2. Associated items which require correlation for efficient function or for installation

1.8 SUBMITTAL SPECIFICATION INFORMATION

A. Every submittal document shall bear the following information as used in the project manual:
   1. The related specification section number
   2. The exact specification section title

B. Submittals delivered to the Architect/Engineer without the specified information will not be processed. The Contractor shall bear the risk of all delays, as if no submittal had been delivered.

1.9 RESUBMISSION REQUIREMENTS

A. Make re-submittals under procedures specified for initial submittals.
   1. Indicate that the document or sample is a re-submittal
   2. Identify changes made since previous submittals

B. Indicate any changes which have been made, other than those requested by the Architect / Engineer.

1.10 CONTRACTOR'S STAMP OF APPROVAL

A. Contractor shall stamp and sign each document certifying to the review of products, field measurements and field construction criteria, and coordination of the information within the submittal with requirements of the work and of Contract Documents.

B. Contractor's stamp of approval on any submittal shall constitute a representation to Owner and Architect/Engineer that Contractor has either determined and verified all quantities, dimensions, field construction criteria, materials, catalog numbers, and similar data or assumes full responsibility for doing so, and that Contractor has reviewed or coordinated each submittal with the requirements of the work and the Contract Documents.

C. Do not deliver any submittals to the Architect/Engineer that do not bear the Contractor's stamp of approval and signature.

D. Submittals delivered to the Architect/Engineer without Contractor's stamp of approval and signature will not be processed. The Contractor shall bear the risk of all delays, as if no submittal had been delivered.

1.11 ARCHITECT / ENGINEER REVIEW OF IDENTIFIED SUBMITTALS

A. The Architect / Engineer will:
   1. Review identified submittals with reasonable promptness and in accordance with schedule
   2. Affix stamp and initials or signature, and indicate requirements for re-submittal or approval of submittal
   3. Return submittals to Contractor for distribution or for resubmission

B. Review and approval of submittals will not extend to design data reflected in submittals which is peculiarly within the special expertise of the Contractor or any party dealing directly with the Contractor.

C. Architect / Engineer's review and approval is only for conformance with the design concept of the project and for compliance with the information given in the contract.
   1. The review shall not extend to means, methods, sequences, techniques or procedures of construction or to safety precautions or programs incident thereto.
   2. The review shall not extend to review of quantities, dimensions, weights or gauges, fabrication processes or coordination with the work of other trades.

D. The review and approval of a separate item as such will not indicate approval of the assembly in which the item functions.

1.12 SUBSTITUTIONS

A. Do not make requests for substitution employing the procedures of this Section.

B. The procedure for making a formal request for substitution is specified in Div. 1.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION - NOT USED

END OF SECTION 230512

SECTION 230513 - ELECTRICAL PROVISIONS OF HVAC WORK

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Electrical provisions to be provided as mechanical work are indicated in other Division 23 sections, on drawings, and as specified.

B. Types of work, normally recognized as electrical but provided as mechanical, specified or partially specified in this Section, include but are not necessarily limited to the following:
   1. Motors for mechanical equipment.
   2. Starters for motors of mechanical equipment, but only where specifically indicated to be furnished integrally with equipment.
   3. Wiring from motors to disconnect switches or junction boxes for motors of mechanical equipment, but only where specifically indicated to be furnished integrally with equipment.
   4. Wiring of field-mounted float control switches, flow control switches, and similar mechanical-electrical devices provided for mechanical systems, to equipment control panels.
   5. Wiring of smoke detectors for shutdown of air handling equipment when a fire alarm system is not included in the project.
   6. Wiring of oil pump, vibration and oil level limit switches for cooling towers.
   7. Refrigerant monitor/sensor/alarming and field installed visual/audible display alarms.
   8. Pipe heat tracing.
   9. Cooling tower vibrations switch/interlock/reset.
   10. Field interlock wiring from chiller: flow switches, pump aux. Contracts, pump start/stop.
   11. Power supply 120 VAC and control signal from chiller control panel to condenser water flow control valve installed in piping leaving chiller.
   12. Wiring of all related circulating water system chemical treatment devices.
       a. Low voltage electric contacting water meter.
       b. Solenoid valve/blow-down assembly.
   13. Radiant heater timer switches and/or thermostats.
   14. Low Voltage thermostat wiring.

C. Refer to Division 23 Controls Sections for related control system wiring.

D. Refer to Division 23 sections for specific individual mechanical equipment electrical requirements.

E. Refer to Division 26 sections for motor starters and controls not furnished integrally with mechanical equipment.

F. Refer to Division 26 sections for junction boxes and disconnect switches required for motors and other electrical units of mechanical equipment.

1.2 RELATED WORK

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

1.3 QUALITY ASSURANCE

A. Wherever possible, match elements of electrical provisions of mechanical work with similar elements of electrical work specified in Division 26 sections for electrical work not otherwise specified.

B. For electrical equipment and products, comply with applicable NEMA standards, and refer to NEMA standards for definitions of terminology. Comply with National Electrical Code (NFPA 70) for workmanship and installation requirements.

1.4 SUBMITTALS

A. Include in listing of motors, voltage, notation of whether motor starter is furnished or installed integrally with motor or equipment containing motors.

PART 2 - PRODUCTS

2.1 MOTORS

A. Provide motors for mechanical equipment manufactured by one of the following:
1. Baldor Electric Company.
2. Century Electric Div., Inc.
3. General Electric Co.
4. Louis Allis Div.; Litton Industrial Products, Inc.
5. Lincoln Electric
6. Marathon Electric Mfg. Corp.
7. Reliance Electric Co.
8. Westinghouse Electric Corp.
9. WEG

B. Motor Characteristics. Except where more stringent requirements are indicated, and except where required items of mechanical equipment cannot be obtained with fully complying motors, comply with the following requirements for motors of mechanical work:

C. Temperature Rating. Rated for 40 Degrees C environment with maximum 50 Degrees C temperature rise for continuous duty at full load (Class A Insulation).

D. Provide each motor capable of making starts as frequently as indicated by automatic control system, and not less than 5 starts per hour for manually controlled motors.

E. Phases and Current Characteristics. Provide squirrel-cage induction polyphase motors for 3/4hp and larger, and provide capacitor-start single-phase motors for 1/2hp and smaller, except 1/6hp and smaller may, at equipment manufacturer's option, be split-phase type. Coordinate current characteristics with power specified in Division 26 sections, and with individual equipment requirements specified in other Division 23 requirements. For 2-speed motors provide 2 separate windings on polyphase motors. Do not purchase motors until power characteristics available at locations of motors have been confirmed, and until rotation directions have been confirmed.

F. Service Factor. 1.15 for polyphase motors and 1.35 for single-phase motors.

G. Motor Construction. Provide general purpose, continuous duty motors, Design "B" except "C" where required for high starting torque.
   1. Frames. NEMA #56.
   2. Bearings are to be ball or roller bearings with inner and outer shaft seals, regreasable except permanently sealed where motor is inaccessible for regular maintenance. Where belt drives and other drives produce lateral or axial thrust in motor, provide bearings designed to resist thrust loading. Refer to individual section of Division 23 for fractional-hp light-duty motors where sleeve-type bearings are permitted.
   3. Except as indicated, provide open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation, and provide guarded drip-proof motors where exposed to contact by employees or building occupants. Provide weather-protected Type I for outdoor use, Type II where not housed. Refer to individual sections of Division 23 for other enclosure requirements.
   4. Provide built-in thermal overload protection and, where indicated, provide internal sensing device suitable for signaling and stopping motor at starter.
   5. Noise Rating: Provide "Quiet" rating on motors.

H. All motors shall be premium efficiency.

I. Provide an inverter duty motor on all equipment that utilizes a variable frequency drive.

2.2 EQUIPMENT FABRICATION

A. Fabricate mechanical equipment for secure mounting of motors and other electrical items included in work. Provide either permanent alignment of motors with equipment, or adjustable mountings as applicable for belt drives, gear drives, special couplings and similar indirect coupling of equipment. Provide safe, secure, durable, and removable guards for motor drives. Arrange for lubrication and similar running-maintenance without removal of guards.

2.3 GENERAL REQUIREMENTS – SHAFT GROUNDING RINGS

A. All motors operated on variable frequency drives shall be equipped with a maintenance-free, conductive microfiber shaft grounding ring to meet NEMA MG-1, 3.4.4.4.3 requirements, with a minimum of two rows of circumferential microfibers to discharge damaging shaft voltages away from the bearings to ground. SGR's Service Life: Designed to last for service life of motor. Provide AEGIS SGR Conductive MicroFiber Shaft Grounding Ring, or approved equal.

B. Application Note: Motors up to 100 HP shall be provided with one shaft ground ring installed on either the drive end or non-drive end. Motors over 100 HP shall be provided with an insulated bearing on the non-drive end and a shaft grounding ring on the drive end of the motor with the exception of line contact bearings in the drive end of the machine. In this instance the line contact bearing must be electrically insulated and the AEGIS Bearing Protection Ring installed on the opposite drive end of the motor. Grounding rings shall be provided and installed by the motor manufacturer's recommendations.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install motors on motor mounting systems in accordance with motor manufacturer's instructions, anchored to resist torque, drive thrusts, and other external forces inherent in mechanical work. Secure sheaves and other drive units to motor shafts with keys and Allen set screws on flat surface of shaft. Unless otherwise indicated, set motor shafts parallel with machine shafts.

B. Verify voltage with Electrical Plans.

END OF SECTION 230513

SECTION 230514 - HVAC CONDENSATE DRAIN PIPING SYSTEM

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide and install air conditioning condensate drains.

1.2 RELATED WORK

A. Division 23 - Mechanical
   1. Insulation
   2. Fan/Coil Units
   3. Air Handling Units
   4. HVAC Pumps
   5. Air Compressor Storage Tanks
   6. Equipment Drain Pans
   7. Heat Pump Units

PART 2 - PRODUCTS

2.1 PIPE MATERIAL

A. Type “L” copper with drainage pattern fittings in plenum areas. Type PVC with drainage pattern fittings in non-plenum areas.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install the system to facilitate easy removal.
   1. Use threaded plugged tee at each change of direction to permit cleaning.
   2. Install a cleanout every 50 feet of straight run piping
   3. Maintain a positive slope on all piping

B. Install a water seal trap leg based on the fan pressure.
   1. Size the length of the trap leg 1 inch larger than the actual system pressure.

C. Install traps and cleanout as shown in the drawing details.
   1. Confirm requirements with manufacturer's installation instructions

3.2 SIZE PIPE AS SHOWN ON DRAWINGS.

A. Do not install piping sized smaller than the unit drain connection size.

3.3 SECONDARY DRAINS

A. Provide secondary drains where required by code, shown on the drawings, or where equipment has secondary drain connections.

END OF SECTION 230514

SECTION 230515 - HVAC SYSTEM EARTHWORK

PART 1 - GENERAL

A. Excavate and backfill for pipe trenches for underground piping, and excavate for structures installed as part of mechanical work.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION

3.1 EXCAVATION

A. Excavate trenches for underground piping to the required depth to ensure 2 foot minimum coverage over piping.

B. Cut the bottom of the trench or excavation to uniform grade.

C. Should rock be encountered, excavate 6 inches below grade, fill with bedding material and tamp well.

D. Lay out alignment of pipe trenches to avoid obstructions. Assure that proposed route of pipe will not interfere with building foundation before any cutting is begun. Should interference be found, contact the Architect / Engineer before proceeding.

3.2 BACKFILL

A. Backfill shall not be placed until the work has been inspected, tested and approved. Complete backfill to the surface of natural ground or to the lines and grades shown on drawings. Except where special materials are requested, use suitable friable soils from other excavation as backfill material. Do not use peat, silt, muck, debris or other organic materials. Deposit backfill in uniform layers and compact each layer as specified.

B. Compacting Backfill. Place material in uniform layers of prescribed maximum thickness and wet or dry the material to optimum moisture content. Compact with power-driven tampers to the prescribed density. Place regular backfill in 8 inch maximum layers, loose measure. Compact to not less than 95% of maximum soil density as determined by ASTM D-698 Standard Proctor.

C. Restoration. Compact backfill, where trenching or excavation is required in improved areas such as pavements, walks, and similar areas, to a condition equal to the adjacent undisturbed earth, and restore surface of the area to the condition existing prior to trenching or excavating operation.

D. Provide 6 inch stabilized sand bed with 4 inch stabilized sand cover around each pipe.

3.3 DISPOSAL OF EXCESS MATERIAL

A. Remove excess excavation material or material unsuitable for backfill. Excess material can be spread on grade, or shall be removed from site as directed by the Owner / Architect.

END OF SECTION 230515

SECTION 230517 - HVAC ACCESS DOORS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install access doors in wall or ceiling locations as required or shown for access to valves, controls, fire dampers, air distribution devices and other equipment requiring maintenance, adjustment or operation.

PART 2 - PRODUCTS

2.1 NON-FIRE RATED ACCESS DOORS

A. 16-Gauge frames

B. 14-gauge steel panels

C. Continuous fully concealed hinges

D. Flush screwdriver cam lock & cylinder lock for Owner selection

E. Automatic closing and latching mechanism

F. Prime coat finish

G. Brushed satin stainless steel finish for restroom, kitchen or cafeteria installation

H. Material suitable for wall and/or ceiling mounting

2.2 FIRE RATED ACCESS DOORS

A. UL listed, 1-1/2 hour Label “B”, access doors

B. 16-Gauge stainless steel

C. 20-Gauge insulated sandwich-type door panel.

D. Two inch thick with fire rated insulation

E. Continuous fully concealed hinge

F. Automatic closing and latching mechanism

G. Knurled knob and recessed key operation for Owner selection

H. Interior latch release slide for opening from inside

I. Prime coat finish

J. Material suitable for wall and/or ceiling mounting

2.3 ACCEPTABLE MANUFACTURERS

A. Milcor

B. MIFAB

C. Acudor

D. Elmdor

PART 3 - EXECUTION

3.1 INSTALLATION

A. Access doors specified in Division 23 will be installed by other crafts. Not all required access doors are shown. Coordinate with the Contractor to locate access doors for ease of operation and maintenance of concealed equipment.

B. Installation shall be in accordance with the manufacturer’s printed instructions.

C. Minimum size required:
1. 36” x 24” for Mechanical HVAC equipment related items
2. 18” x 18” for electrical related items

END OF SECTION 230517

SECTION 230518 - VARIABLE FREQUENCY INVERTER

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install a variable frequency inverter for the following equipment items.
   1. Variable Volume Air Handling Units.
   2. Pumps.

1.2 COOPERATION WITH OTHER TRADES

A. Coordinate this work with work under Division 26 Electrical to ensure that intended functions are achieved and proper equipment is provided.

B. Coordinate the size of the variable frequency inverter with the equipment being served by the inverter. The rated current output amps are to be equal to or greater than motor rated full load amps.

1.3 SUBMITTALS

A. Submit manufacturer's information and shop drawings as specified.
   1. Complete technical details.
   2. Dimensions and manufacturer's installation manual.
   3. Schematic diagrams of the circuitry and field connections.
   4. Manufacturer's start-up manual.

1.4 STANDARDS

A. UL.

B. CSA.

C. ISO 9001

D. NEC.

E. FCC.

1.5 WARRANTY

A. The manufacturer shall provide a full parts and labor warranty for a period of five

(5) years from substantial completion.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. ABB

B. Danfoss Graham

C. Yaskawa

2.2 CABINET

A. The inverter and all accessories shall be provided within a wall mounted UL Listed NEMA 12 enclosure with deadsides and removeable gasketed doors with provisions for locking. Cabinet shall be constructed of metal for reduction of radio frequency interference (RFI) and electromagnetic frequency interference.

2.3 INTERFERENCE WITH OTHER SYSTEMS

A. The inverter shall be designed and constructed to comply with IEEE Standard 519-1993 with respect to line noise and RFI generation. All units shall generate less than 3% total harmonic distortion back to the incoming power line at the point of common connection with sensitive equipment. A harmonic analysis shall be submitted with the approval drawings to verify compliance with the latest version of IEEE-519 voltage and current distortion limits as shown in Table 1.2 and 10.3 at the point of common coupling (PCC). The PCC shall be defined as the consumer-utility interface or primary side of the main distribution transformer.

B. Dual DC Bus filtered chokes (factory installed and wired in the drive enclosure) equivalent to 5% input line reactors shall be provided to minimize harmonics reflected onto the input line.
   1. Shall not interfere with computer and other electronic systems in the building.
   2. If not inherently protected, provide a suitable isolation transformer.
   3. The system shall not produce spikes on the incoming line.

C. Any inverter that generates sufficient electrical line noise to interfere with the operation of sensitive building equipment shall be field modified or replaced by the inverter supplier at no additional cost to the Owner.

2.4 PROTECTIVE CIRCUITS

A. Provide the following protection:

1. Input line fuses or molded case circuit breaker rated at 100 AIC.
2. Input line noise suppression with MOV's (metal oxide varistors) and snubber circuits. MOV's shall be provided across incoming line terminals, AC input reactors, DC choke filters, and transistors to protect inverter from voltage surges and spikes.
3. Protection of solid state inverter devices by limiting output current to 110% of inverter rating, automatically prevent overcurrent trip due to momentary overload conditions.
4. Current limiting DC buss fuse between input and output sections of inventor.
5. Input overvoltage trip at 480 vac + 10% trip.
6. Input undervoltage at 480 vac – 10% trip
7. Instantaneous overcurrent protection of solid state inverter devices.
8. Individual overcurrent protection of solid state inverter devices.
9. Output overvoltage trip.
10. Loss of input phase, phase reversals, or blown fuse.
11. Thermal overload trip for overload protection of solid state devices.
12. Ground fault protection on start-up.
13. Output line to line short circuit protection.
14. Phase to phase short circuit or severe overload conditions of output.
15. Overload of motor.
16. Frequency stall.
17. DC buss high voltage.
18. Control function error.
19. Heatsink over temperature (Max. operating ambient: 122 degrees F)
20. Controller able to operate without a motor or any other equipment connected to the output (To facilitate startup and troubleshooting).
21. Capable of restarting into a rotating motor without component damage.
22. Shut down safely without component failure in the event of a sustained power loss, and will automatically return to normal operation, if start is "on" and power is restored.
23. Shut down safely without component failure in the event of a momentary power loss. Automatically return to normal operation if the start is "on", and normal power is restored. Capable of establishing speed control without shutdown or component failure.
24. Designed for input power contactor opening or closing while control is activated, without damage to the controller.
25. Automatically reset trip resulting from overcurrent, undervoltage, overvoltage, or over temperature, and automatically restart after removal, or correction of the faulty condition.
26. Provide status lights or digital display for indication of failure conditions, and form C relay provided for remote indication. Digital display or status lights to indicate power on, at speed, and drive enabled.
27. Operation and fault diagnostic function circuits shall be built into each inverter that provides information in determining the cause and source of a fault. Diagnostics to provide the following information:
    a. Operating mode at trip (Accel, Decel, Constant speed).
    b. Output current at trip.
    c. Output voltage at trip.
    d. Additional faults that occurred simultaneously of immediately

before displayed tripped.

Any drive requiring separate card to provide this information shall provide a diagnostic card for each drive.

28. DC link reactor.
29. Input power disconnect, lockable type.
30. Input power disconnect switch / circuit breaker, with lockable type handle.

2.5 OPERATOR DEVICES

A. The following operator devices shall be door or remote mounted:

1. Digital keypad and LCD provided to perform all parameter adjustments, operation monitoring, and operation programming.
2. Power on indication light.
3. Flush mounted meters or digital display to indicate output voltage, output frequency, and output current, in percent of maximum 0 to 100%.
4. Manual/Off/Auto 3 position selector switch (hand-off-auto) and manual speed setting control to provide the following control sequences:
    a. In automatic mode, controller shall follow an external control signal and respond to remote start-stop contact.
    b. In manual (hand) mode, controller shall follow speed signal set via door mounted keypad and start/stop switch. Switching from “hand” to “auto” and vice versa shall require a single keystroke to a dedicated changeover key. Inverters requiring multiple keystrokes and/or reprogramming of internal parameters to accomplish changeovers are not acceptable.
    c. An integral "safety interlock" protection shutdown circuit shall be provided for interface with firestats, smoke detectors, high static pressure limit switches, vibration switches, etc.
5. Programmable lockout code to prevent unauthorized programming.
6. Critical frequency avoidance capability (up to 3 resonant points).

2.6 FIELD ADJUSTMENTS

A. The following shall be adjustable in the field:

1. Maximum Speed: 0 to 125% adjustable.
2. Minimum Speed: 0 to 100% adjustable.
3. Acceleration/deceleration rates: 0 to 3600 sec.
4. Instantaneous overcurrent trip: 50% to 2000%.
5. Volts/hertz ratio: Field adjustable to 16 patterns or set for automatic selection of proper V/F load profile to operate motor without overdriving or overloading.
6. Current limit circuit: 60 to 100%.
7. Carrier frequency: 6 to 16 KHZ.
8. Control interface: selectable to follow a 0-5 VDC, 0-10 VDC, 4-20 MA, either direct or indirect acting.
9. Control signal Bias: 0 to 80 HZ.
10. Control signal gain: 0 to 80 HZ.
11. Calibration of remote speed signal: 0 to 80 HZ.

2.7 ELECTRICAL CONSTANT SPEED BYPASS

A. Provide all components and circuitry necessary to provide manual bypass of the inverter. The bypass package shall be mounted in a cabinet common with the inverter and shall be constructed in such a manner that the inverter can be removed for repair while still operating the motor in the "bypass" mode. Manual bypass shall contain the following:
   1. Two contactors mechanically interlocked via a three position through the door selector switch to provide the following control:
      a. "Inverter" Mode connects the motor to the output of the inverter.
      b. "Bypass" Mode connects the motor to the input sine wave power. Transfer must occur with input disconnect open. Motor is protected via thermal overload.
      c. "Off" Mode disconnects motor from all input power.
   2. A molded case circuit breaker or fused disconnect switch with door interlocked handle (lock out type) that interrupts input power to both the bypass circuitry and the drive.
   3. An input contactor, interlocked with both the thermal motor overload and external safeties which disconnects power to the motor regardless of the mode of operation (either "inverter" or "bypass" mode).
   4. A thermal overload to provide protection of motor in the bypass mode.
   5. A safety interlock circuit that disconnects power to the motor (regardless of the mode of operation – “inverter” or “bypass”) in response to a signal from the thermal overload and/or external safety circuits.
   6. Line voltage to 24 volt DC power source, fused per NEC, shall provide power to all bypass control circuits.

2.8 SERIAL COMMUNICATIONS

A. The VFD shall have the capability of communicating with a building management control system via an RS-485 serial port.

B. VFD shall be provided with protocol information specific to the selected BMCS manufacturer and shall be pre-configured at the factory to automatic communications, without the need for field programming.

C. Serial communications capabilities shall be included, but not limited to: run/stop control, speed set adjustment, proportional/integral or PID control adjustments, current limit and accel/decel time adjustments. The drive shall also have the capability of allowing the DDC system to monitor the following feedback signals: process variable, output speed/frequency, current, torque, power (KW), operating hours, kilowatt hours; relay outputs, and diagnostic warning and fault information.

D. The VFD shall allow the DDC system to control the drive’s digital and analog outputs and monitor all drive digital and analog inputs via the serial interface.

E. Provide BACnet interface card.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation as per manufacturer's recommendations and requirements.
   1. Inverter chassis is properly grounded.
   2. Line, Load, Control, and Fire/Safety wiring are installed in separate conduits.
   3. Both ends of conduit entering and leaving VFD into AHU cabinets and motors must be sealed air tight.

3.2 MANUFACTURER START-UP SERVICE

A. Factory trained personnel shall be provided for start-up assistance, minimum (1) day per unit.
   1. The manufacturer shall provide start-up commissioning of the VFD and its optional circuits by a factory certified service technician who is experienced in start-up and repair services. Sales personnel and other agents who are not factory certified shall not be acceptable as commissioning agents.
   2. Start-up services shall include checking for verification of proper operation and installation for the VFD, its options and its interface wiring to the building automation system.
   3. Adjustable devices, components, and assemblies to assure optimum performance.
   4. Make final adjustments to the installed drive to assure proper operation of the fan system. Obtain performance requirements from installer of driven loads.
   5. Assistance will be provided to the Owner (upon request) to determine the optimum capacitance for per factory correction and avoidance of potential resonance problems and will determine optimum line filter required.
   6. A written report, duly signed by the technician detailing set points of adjustable devices, amperages recorded, and any other pertinent data. This information is to be included in the operation and maintenance manual.

A. Input DC voltage to dry motor windings when fan is not in operation at the following locations:
   1. Cooling tower fan motor
   2. Motors downstream of coils
   3. Rooftop unit motors

3.3 DEMONSTRATION AND TRAINING

A. Provide system demonstration to personnel, Owner, and/or Owner's selected representatives.

B. Demonstrate operation of controllers in the automatic and manual modes.

C. Provide a minimum of two days of technical training for the owner's operating and technical staff. Schedule training with owner's authorized representatives, during normal business hours and not less than 30 days prior to planned session. Coordinate with training required per 23 05 00 Mechanical General Provisions.

D. Training may be consecutive or random, at Owner's option.

END OF SECTION 230518

SECTION 230519 - HVAC PRESSURE AND TEMPERATURE INSTRUMENTS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This section specifies gauges, thermometers, wells and/or pressure and temperature test stations to be installed as specified.

1.2 RELATED WORK

A. Division 23, Mechanical
1. 23 05 00 - Mechanical General Provisions
2. 23 20 00 - Pipe and Pipe Fittings, General
3. 23 05 23 - Valves, Strainers and Vents
4. 23 21 13 - Hot Water and Chilled Water Piping, Valves and Appurtenances
5. - Steam and Condensate Piping and Valves
6. 23 21 24 - Condenser Water Piping, Valves and Appurtenances

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS - GAUGES AND THERMOMETERS

A. Trerice

B. Taylor

C. Marsh

D. Weksler

E. Marshalltown

F. Weiss

G. Miljoco

2.2 PRESSURE GAUGES

A. Case and Ring: 4" type 304 stainless steel; liquid filled case with stainless steel bayonet ring.

B. Dial: White aluminum with black markings

C. Window: Clear acrylic

D. Tube: Phosphor bronze and forged brass socket.

E. Gauge accuracy: +/- 1% over operating range.

F. For pulsating service, provide impulse dampers.

G. Without flange for pipe mounting.

H. With flange for wall mounting.

I. Weiss Model: LF44S-1B or equal.

2.3 THERMOMETER WELLS

A. Brass or type 300 stainless steel. Machined bar stock, 1-piece construction.

B. Where installed in insulated piping or vessels, provide with extension neck to match insulation thickness.

C. Provide metal-to-metal contact with bulb chamber for maximum sensitivity.

D. Wells shall be sized to extend a minimum of 50% into pipe.

2.4 THERMOMETERS IN PIPING SYSTEMS OR VESSELS

A. Die cast aluminum case with baked epoxy finish.

B. Adjustable angle 9" scale length.

C. Clear acrylic window.

D. Brass stem, length to match well.

E. Red reading organic spirit filled-in magnifying glass column.

F. White background with black figures and markings.

G. Brass stems and union connections.

H Accuracy: +/- 1% of scale range.

I. Range:
1. Hot water lines: 30°F to 240°F.
2. Chilled water lines: 0°F to 100°F or 120°F

3. Condenser water: 0°F to 100°F.

2.5 PRESSURE AND TEMPERATURE TEST STATIONS

A. "Test Station" fitting to receive either a temperature or pressure probe. Fitting shall be solid brass with two valve cores of Nordel.
   1. Fitted with a color coded cap strap with gasket.
   2. Acceptable Manufacturer: Peterson Equipment Company.
   3. Provide with extension neck to match insulation thickness.

B. Provide to the Owner a fitted case with:
   1. Two 0-100 psi pressure gauges as specified and adapters with 1/8" OD probe.
   2. Four 5" stem pocket testing thermometers.
      a. Two with range 25°F to 125°F for chilled water and condenser water.
      b. Two with range 0°F to 220°F for hot water.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with drawing details and manufacturer's recommendations.

B. Provide a ball valve at each gauge.

C. Locate gauges and thermometers to be easily readable from the floor at a 5'-6" eye level. Use adjustable angle or rigid stem as required. Install gauges in upright position.

D. Install gauges in the following locations: across pumps, chiller cooler and condenser, storage tanks, heat exchangers.

E. Test wells for automatic temperature controls shall be furnished by Building Management Control Section and installed by Mechanical Contractor.

F. Install thermometer in the following locations: Across chiller cooler and condenser, storage tanks, across heat exchangers, across boiler, leaving side of water heater, leaving water side of tempered water valves, common chilled and hot water lines.
   1. Hot water lines: 30°F to 240°F.
   2. Chilled water lines: 0°F to 100°F or 120°F
   3. Condenser water 0°F to 100°F.

END OF SECTION 230519

SECTION 230520 - FLOW METERS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install flow meters. This Specification applies to Division 23. Flow meters for control functions are specified in the Controls Section, and are to be supplied under the work of that Section.

PART 2 - PRODUCTS

2.1 FLOW ELEMENTS

A. Provide and install annular elements, complete with bar stock valved connections for piping to flow transmitter. Furnish quick-disconnect valves and bar stock shutoff valves for connection to portable meter. Construct elements of 316 stainless steel. Provide annubars manufactured by Ellison or equal.

B. Furnish a metal identification tag and chain giving pipe size, design flow rate, meter reading at design flow rate, metered fluid and station number.

C. For station sizes 1/2" through 1-1/2", use Ellison 71 nipple section type. For station sizes 2" and larger, use Ellison 73 or 75 standard insert type.

D. Select flow sensors so that the design flow rate occurs between 10 and 40" of water pressure differential with permanent pressure loss of not more than 5" of water. An accuracy of plus or minus 2.5% of actual flow rate form 40 to 120% of design flow rate is required.

E. Acceptable Manufacturers:
1. Taco.
2. Paco.
3. Annubar.
4. Preso.
5. Barco.
6. BIF.
7. Venturi.

2.2 FLOW ELEMENTS (optional)

A. Furnish and install venturi flow stations, complete with bar stock valved connections for piping to flow transmitter. Provide quick-disconnect valves and bar stock safety shutoff valves for connection to the portable meter.

B. Provide a brass identification tag on the chain giving the pipe size, venturi series, station identification, and meter reading at the specified flow rate.

C. For 3/4" through 2" size, use one-piece brass screwed venturi station. Make sizes 2-1/2" through 8" of plated cast iron with a venturi insert held between specially machined, self-centering, 150 lb. steel plate with welding ends.

D. Select venturi size and series so that the design flow rate occurs between 10 and 40" of water pressure differential and with permanent pressure loss of not more than 25% of indicated flow rate differential pressure. An accuracy of plus or minus 3% of actual flow rate from 40 to 120% of design flow rate is required.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with Manufacturer's written instructions.

END OF SECTION 230520

SECTION 230523 - HVAC VALVES, STRAINERS AND VENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. HVAC Valves

B. Pipe strainer and suction diffusers.

PART 2 - PRODUCTS

2.1 VALVES

A. Pressure Ratings:
   1. Unless otherwise indicated, use valves suitable for 125 minimum psig working steam pressure (WSP) and 450°F.
   2. The pressure temperature rating of valves shall be not less than the design criteria applicable to components of the system.

B. Butterfly Valves
   1. Butterfly valves shall conform to MSS-SP67.
   2. Liners, inserts and discs shall be suitable for the intended service.
   3. Valves shall have a full lug type body designed for installation between ANSI standard flanges, and shall be rated at full working pressure with downstream flange removed.

C. Balancing Valves
   1. Provide balancing valves with:
      a. Corrosion resistant plug with resilient seal when required.
      b. O-ring stem seal.
      c. Permanently lubricated, corrosion resistant bearings.
   2. Connections
      a. Through 2" pipe size use threaded connections.
      b. For valves 2-1/2" pipe size and larger shall be provided with 150 psig flange connections.
   3. Provide each valve with:
      a. Memory stop.
      b. Plastic drip cap.
      c. 1/8" gauge tap.

D. Ball Valves
   1. Provide ball valves with:
      a. Blowout proof stem.
      b. Full size port, 316 stainless steel ball and stem.

c. Cast bronze body.
d. Threaded ends.
2. Seat, seals, thrust washers and packing shall be suitable for the intended service.
3. Service rating:
a. 150 psi saturated steam.
b. 600 psi WOG.
4. Where piping is insulated, ball valves shall be equipped with 2” extended handles of non-thermal conductive material. Provide a protective sleeve that allows operation of the valve without breaking the vapor seal or disturbing the insulation.
5. Provide with memory stop for balancing valves.

E. Valve Connections
1. Provide valves suitable to connect to adjoining piping as specified for pipe joints. Use pipe size valves. Sweated joints are not allowed.
2. Thread pipe sizes 2" and smaller.
3. Flange pipe sizes 2-1/2" and larger.
4. Use screw to solder adapters for copper tubing.
5. Use grooved body valves with mechanical grooved jointed piping.

F. Valve Operators
1. Where butterfly valves are provided:
a. Provide gear operators on valves 6" and larger.
b. Where valves are located 7' or more above the finished floor in equipment room areas provide chain-operated sheaves. Extend chains to about 5' above floor and hook to clips, arrange to clear walking space.
c. Lever lock handle with toothed plate for shut-off service and infinitely adjustable handle with lock and nut and memory stop for throttling service on valves 4" and smaller.
d. Provide worm gear operators on discharge side of pumps for balancing, for all sizes of valves.
e. All valves 2-1/2” and larger provided by Milwaukee Valve shall be provided with gear operators.

G. Acceptable Manufacturers
1. Dezurik
2. Crane
3. Nibco
4. Keystone
5. Milwaukee Valve

H. Check Valves
1. Bronze body, 2" and smaller, bronze disc (Teflon disc for steam service), regrinding swing check, screw-in cap, threaded connection.
2. Iron body, 2-1/2" and larger, bronze trim, non-slam: stainless steel pins and springs, and bronze plate or bronze mounted, regrind-renew check, bronze seat ring and disc. Provide either wafer or threaded lug.
3. Acceptable Manufacturers

a. Mission Duochek
b. Nibco
c. Keystone
d. Milwaukee Valve

I. Provide valves of same manufacturer throughout where possible.

J. Provide valves with manufacturer's name and manufacturing location, duty and pressure rating clearly marked on outside of body.

K. Where valves are installed in insulated piping, provide with extended neck so valve operator and stop plate clears the full thickness insulation.

L. Provide valve, seat and trim materials suitable for the intended service.

M. Provide memory stops for all valves used for throttling service. Valves for throttling service shall be butterfly, plug, caged or ball type.

N. Condenser Water Basin Float Valve:
1. Ductile Iron valve, body and cover
2. Stainless steel trim
3. Fully adjustable high and low level settings
4. Stainless steel float, float linkage and float rod
5. Flow clean strainer
6. CV Flow Control for opening and closing
7. ASTM A 536, B16.42, 150# Class
8. Stilling well
9. Acceptable Manufacturer: CLA-VAL

2.2 PIPE SYSTEMS STRAINERS

A. Body:
1. "Y" pattern or basket as shown on the drawings.
2. Line size.
3. Threaded strainer blow down port.
4. ASTM A #126 Class B Cast Iron Body.

B. Construction:
1. 2" size and smaller with screw connections rated 400 psi WOG.
2. Over 2" size with flanged connections, rated 125 psi WOG.

C. Fabricate screens of Monel or type 304 stainless steel:
1. With 20 mesh woven wire in piping systems through 2".
2. With 0.45 perforations in piping systems 2-1/2" and 3".
3. With 0.125 perforations in piping systems 4" and larger.

D. Start-up:
1. Provide an additional fine mesh disposable screen for use during start-up operations.

2. Remove after 30 days.
3. Attach to piping for owners review.

E. Acceptable Manufacturers
1. Crane
2. Keckley
3. Zurn
4. Mueller
5. McAlear
6. Muesco

2.3 SUCTION DIFFUSER

A. For each pump as shown on the drawing, provide an angle type suction diffuser. Body is to fit both the pump inlet and suction pipe size.

B. Components:
1. Inlet straightening vanes.
2. Removable end cap.
3. Gauge ports.
4. Threaded strainer blow down port.
5. Adjustable support foot.
6. Removable magnetic insert.

C. The screen shall be as specified for pipe system strainers.

D. Provide an additional fine mesh disposable strainer for use during start up operations.
1. Remove after 30 days operation and all flushing is complete.
2. Attach to piping for owners review.

E. Construction:
1. 2" size and smaller with screw connections rated 400 psi WOG.
2. Over 2" size with flanged connections, rated 125 psi WOG.

F. Fabricate screens of Monel or type 304 stainless steel:
1. With 20 mesh woven wire in piping systems through 2".
2. With 0.045 perforations in piping systems 2-1/2" and 3".
3. With 0.125 perforations in piping systems 4" and larger.

2.4 VALVE SCHEDULE

A. Hydronic Service
1. Chilled Water Service
   a. Ball Valves up to 2": Nibco T-585-70-66 w/Nib-Seal insulated Handle
   b. Butterfly Valve 2-1/2" and larger: Nibco LD - 2000
      Keystone Figure 222
2. Heating & Condenser Water Service

a. Ball Valves up to 2": Nibco T-585-70-66
b. Butterfly Valve 2-1/2" and larger: Nibco LD - 2000
Keystone Figure 222
3. Check Valve:
a. Nibco Check Valve: T - 413 - B
b. Nibco Check Valve 2-1/2" and larger: F - 918 - B
c. Nibco Check Valve 2-1/2" and larger: W - 920 -W (Wafer)
d. Keystone Check 2-1/2" and larger: FIQ 810

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Install valves for shut-off and isolating service at each piece of equipment, at vertical risers, and where shown on the drawings.

C. Use butterfly valves and ball valves in circulating water systems, for balancing duty. Provide infinite position gear operator with memory stop.

D. Provide drain valves at main shut-off valves and low points of piping and apparatus so the systems can be entirely drained.
1. 1" valve for pipes 6" and larger.
2. 3/4" valve for pipes smaller than 6".
3. Terminate with pipe plug.
4. Drain valves shall be ball valves.

E. Where valves are installed in insulated pipe, valve operator shall have an insert so the lever or handle will not damage the insulation. Install handles so the lever or handles will not damage the insulation.

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

G. Provide access where valves are not exposed.

H. Provide float valves / stilling wells in cooling tower or condenser water basins for water level control. Provide stilling wells around float valve to prevent turbulence ripples or wind interference.

3.3 PIPE SYSTEMS STRAINERS

A. Provide an additional fine mesh disposable strainer for use during start up operations.
1. Remove after 30 days operation and all flushing is complete.
2. Attach to piping for owners review.

B. Provide strainer in supply piping for all coil connections.

C. Provide strainer in condenser water piping entering chiller.

3.4 WATER SYSTEM AIR VENTS

A. Provide manual air vents at high points and at any other air pockets of closed circulating pipe systems. Extend 3/8" hard drawn copper tubing discharge drains to nearest floor or hub drain. Provide 1/4" Ball Valve as specified.

B. Where high point vents are not readily accessible provide additional valves at vent termination.

END OF SECTION 230523

SECTION 230548 - VIBRATION ISOLATION

PART 1 - GENERAL

1.1 SCOPE

A. Furnish, install, and adjust vibration isolation.

1.2 RELATED WORK

A. Division 23 Mechanical.
   1. Refer to the Section on Ductwork for flexible connections between fans and ducts.
   2. Refer to the Section on Equipment Supports for equipment foundation pads.

2.3 SUBMITTALS

A. Submit product data showing type, size, load, deflection and other information required. Include clearly outlined procedures for installing and adjusting isolators.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Amber Booth

B. Kinetics

C. Mason

D. Korfund

E. VSI.

F. Vibration Eliminator Co., Inc.

G. Metraflex

2.2 ISOLATOR TYPES

A. Neoprene mountings shall have a minimum static deflection of 0.35 inches (9mm). All metal surfaces shall be neoprene covered and have friction pads both top and bottom. Bolt holes shall be provided on the bottom and a tapped hole and cap screw on top. Steel rails shall be used above the mountings under equipment such as small vent sets to compensate for the overhang.

B. Spring isolators shall be free standing and laterally stable without any housing and complete with a molded neoprene cup or ¼ inch (6mm) neoprene acoustical friction pad between the base plate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Installed and operating heights shall be equal. The ratio of the spring diameter divided by the compressed spring height shall be no less than 0.8. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include spring diameters, deflection, compressed spring height and solid spring height.

C. Restrained spring mountings shall have an SLF mounting as described in Specification B, 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 ½ inch (12mm) shall be maintained around restraining bolts and between the housing and the spring 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 under outdoor equipment there must be an internal isolation pad in addition to the friction pad on the bottom.

D. Hangers shall consist of rigid steel frames containing minimum 1-1/4 inch (32mm) thick neoprene elements at the top and a steel spring with general characteristics as in specification B seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. In order to maintain stability the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30-degree arc from side to side before contacting the cup bushing and short circuiting the spring. Submittals shall include a hanger drawing showing the 30-degree capability.

E. Hangers shall be as described in D, but they shall be pre-compressed and locked at the rated deflection by means of a resilient seismic upstop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30-degree capability.

F. Vibration hangers shall be as described under Type D- Spring and Neoprene hangers above. Hangers shall be provided with weldless eye bolts top and bottom to facilitate attachment to flat duct straps.

G. Vibration isolation manufacturer shall furnish integral structural steel bases. Rectangular bases are preferred for all equipment. Centrifugal refrigeration machines and pump bases may be T or L shaped where space is a problem. Pump bases for split case pumps shall be large enough to support suction and discharge elbows. All perimeter members shall be steel beams with a minimum depth equal to 1/10 of the longest dimension of the base. Base depth need not exceed 14 inches (350mm) provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer. Height saving brackets shall be employed in all mounting locations to provide a base clearance of 1 inch (25mm).

H. Vibration isolation manufacturer shall provide steel members welded to height saving brackets to cradle equipment having legs or bases that do not require a complete supplementary base. Members shall have sufficient rigidity to prevent misalignment of equipment.

I. Vibration isolation manufacturer shall furnish rectangular steel concrete pouring forms for floating concrete bases. Bases for split case pumps shall be large enough to provide for suction and discharge elbows. Bases shall be a minimum of 1/12 of the longest dimension of the base but not less than 6 inches (150mm). The base depth need not exceed 12 inches (300mm) unless specifically recommended by the base manufacturer for mass or rigidity. Forms shall include minimum concrete reinforcing consisting of 1/2-inch (12mm) bars welded in place on 6 inch (150mm) centers running both ways in a layer 1-1/2 inch (40mm) above the bottom. Forms shall be furnished with steel templates to hold the anchor bolt sleeves and anchor bolts while concrete is being poured. Height saving brackets shall be employed in all mounting locations to maintain a 1-inch (25mm) clearance below the base. Wooden formed bases leaving a concrete rather then a steel finish are not acceptable.

J. Flexible spherical expansion joints shall employ Peroxide cured EPDM in the covers, tubes and frictioning of the reinforcement. Reinforcement must be DuPont Kevlar. Solid steel rings shall be used within the raised face rubber ends to prevent pullout. No substitutions for the DuPont Kevlar or the solid steel embedded flange rings are acceptable. Sizes 2 inch (50mm) and larger shall have two spheres reinforced with a metal ring between spheres to maintain shape and complete with split ductile iron or steel flanges with hooked or similar interlocks. Sizes 16 inch (400m) to 24 inch (600mm) may be single sphere. Sizes 3/4 inch (20mm) to 1-1/2 inch (40mm) may have threaded bolted flange assemblies, one sphere and cable retention. 14 inch (300mm) and smaller connectors shall be rated at 250 psi (17 BAR) up to 190°F (88°C) with a uniform drop in allowable pressure to 190 psi (13 BAR) at 250°F (121°C). 16 inch (400mm) and larger connectors are rated 180 psi (12 BAR) at 190°F (88°C) and 135 psi (9 BAR) at 250°F (121°C). Safety factors to burst and flange pullout shall be a minimum of 3/1. All joints must have permanent markings verifying a 5 minute factory test at twice the rated pressure. Concentric reducers to the above specifications may be substituted for equal ended expansion joints.

High pressure joints shall be substituted for the above where operating pressures are higher than standard. Expansion joints shall be installed in piping gaps equal to the length of the expansion joints under pressure. Control rods need only be used in unanchored piping locations where the manufacturer determines the installation exceeds the pressure requirement without control rods. Control rods are not desirable in seismic work. If control rods are used, they must have ½- inch (12mm) thick Neoprene washer bushings large enough in area to take the thrust at 1000 psi

(6.9 N/mm5) maximum on the washer area. Standard diameter bolt washers are not acceptable.

Submittals shall include two test reports by independent consultants showing minimum reductions of 20 DB in vibration accelerations and 10 DB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer. All expansion joints shall be installed on the equipment side of the shut off valves.

K. Flexible stainless steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3 inch (75mm) and larger shall be flanged. Smaller sizes shall have male nipples. Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible.

L. Split Wall Seals consist of two bolted pipe halves with minimum ¾- inch (20mm) thick neoprene sponge cemented to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Concrete may be packed around the seal to make it integral with the floor, wall or ceiling if the seal is not already in place around the pipe prior to the construction of the building member. Seals shall project a minimum of 1 inch (25mm) past either face of the wall. Where temperatures exceed 240°F (115°C), 10 lb. density fiberglass may be used in lieu of the sponge.

M. All-directional acoustical pipe anchor, consisting of two sizes of steel tubing separated by a minimum 1/2 inch (12mm) thick 60 durometer neoprene. Vertical restraint shall be provided by similar material arranged to prevent vertical travel in either direction. Allowable loads on the isolation material shall not exceed 500 psi (3.45 N/mm5) and the design shall be balanced for equal resistance in any direction.

N. Pipe guides shall consist of a telescopic arrangement of two sizes of steel tubing separated by a minimum 1/2 inch (12mm) thickness of 60 durometer neoprene. The height of the guides shall be preset 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. Guides shall be capable of ± 1-5/8 inch (42mm) motion, or to meet location requirements.

O. Air Springs shall be manufactured with upper and lower steel sections connected by a replaceable flexible nylon reinforced neoprene element. Air spring configuration shall be multiple bellows to achieve a maximum natural frequency of 3 Hz. Air Springs shall be designed for a burst pressure that is a minimum of three times the published maximum operating pressure. All air spring systems shall be connected to either the building control air or a supplementary air supply and equipped with three leveling valves to maintain leveling within plus or minus 1/8 inch (3mm). Submittals shall include natural frequency, load and damping tests performed by an independent lab or acoustician.

P. Restrained air spring mountings shall have an MT air spring as described in Specification O, within a rigid housing that includes vertical limit stops to prevent air 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 1/2 inch (12mm) shall be maintained around restraining bolts and between the housing and the air spring so as not to interfere with the air spring action. Limit stops shall be out of contact during normal operation.

Q. Curb mounted rooftop equipment shall be mounted on spring isolation curbs. The lower member shall consist of a sheet metal Z section containing adjustable and removable steel springs that support the upper floating section. The upper frame must provide continuous support for the equipment and must be captive so as to resiliently resist wind forces. All directional neoprene snubber bushings shall be a minimum of 1/4 inch (6mm) thick. Steel springs shall be laterally stable and rest on 1/4 inch (6mm) thick neoprene acoustical pads. Hardware must be plated and the springs provided with a rust resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing nailed over the lower curbs waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2 inches (50mm) of insulation.

R. Horizontal thrust restraints shall consist of a spring element in series with a neoprene molded cup as described in specification B with the same deflection as specified for the mountings or hangers supporting the unit. The spring element shall be designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of 1/4 inch (6mm) movement at start and stop. The assembly shall be furnished with a rod and angle brackets for attachment to both the equipment and the ductwork or the equipment and the structure. Horizontal restraints shall be attached at the centerline of thrust and symmetrical on either side of the unit.

2.3 ISOLATOR APPLICATION

EQUIPMENT	ISOLATOR TYPE	MINIMUM DEFLECTION
Air Handling Units Floor Mounted – up to 15 HP Floor Mounted – 20 HP and Over Suspended	 B B D	 1” 1.5” 1”
Chiller	A	0.35”
Cooling Towers	A	0.35”
Pump (Above Grade)	B & I	1.5”
Suspended Fan Coil Units	D	0.5”
Floor Mounted Fan Coil Units	A	0.35”
Condensing Units	A	0.35”

EQUIPMENT	ISOLATOR TYPE	MINIMUM DEFLECTION
In-Line Fans	D	0.5”
Roof Mounted HVAC Units	Q	2”
Roof Mounted HVAC Equipment	Q	2”

2.4 PIPING ISOLATOR APPLICATIONS

EQUIPMENT	ISOLATOR TYPE
Floor Mounted Pumps	J
Suspended Pumps	J
Chiller Pipe Connections	J
Chiller Refrigerant Relief	K

2.5 FLEXIBLE CONNECTIONS IN PIPING AT PUMPS

A. Provide flexible connections at suction and discharge of chilled water, and hot water pumps, piping connections on chillers and where indicated on drawings. Refer to schedule above.

2.6 PIPING

A. Provide a floating piping system in the central plant and in all mechanical rooms.
   1. To create a floating pipe system, install pipe hangers at regular intervals according to the pipe hanger schedule.
   2. Where floor supports are required, provide sufficient spring capacity to absorb expansion and contraction of piping and yet, to permit piping to function as a floating system.
   3. Size hangers for 200% rated load.
   4. Size isolators for a minimum of 1-inch static deflection.
   5. Provide Type D or E spring hangers and Type B support isolators. Coordinate selection of piping supports with equipment supports to accommodate expansion and contraction without creating excessive stresses at equipment connections.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Stock Requirements. The isolation manufacturer's representative shall maintain an adequate stock of springs and isolators of type used so that changes required during construction and installation can be made.

B. Factory Representation. After installation, furnish factory-trained representative of the isolation manufacturer to check various isolators and report measured versus anticipated deflection on all isolators. Have the representative certify that isolators have been installed in accordance with manufacturer's recommendations and approved submittals. Provide written report to Engineer indicating compliance prior to final acceptance.

END OF SECTION 230548

SECTION 230593 - TESTING, BALANCING AND ADJUSTING (TAB) OF ENVIRONMENTAL SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Balance, adjust and test the air distribution system including the exhaust system.

B. Balance, adjust and test the hydronic system.

C. Verify and record the duct test results performed by the mechanical contractor.

1.2 RELATED SECTIONS

A. COORDINATION OF TESTING AND BALANCING

1.3 PAYMENT PROCEDURES

A. The work of this Section of the Specifications shall bid the project directly to the General Contractor.

1.4 SUBMITTALS

A. History of the TAB organization.

B. Agency certification.

C. Personnel qualifications.

D. TAB data forms.

E. Instrumentation list.

F. Name of the project supervising engineer.

G. Name and address and contact person of five successfully completed projects of similar size and scope.

H. To perform required professional services, the balancing agency shall have a minimum of one test and balance engineer certified by the Associated Air Balance Council.

1.5 TAB FIRM QUALIFICATIONS

A. The organization performing the work shall be a Certified member in good standing of the (AABC) Associated Air Balance Council.

B. Able to furnish evidence of having contracted for and completed not less than five systems of comparable size and type that have served their Owners satisfactorily for not less than five years.

C. A specialist in this field and have the personnel, experience, training, skill, and the organization to perform the work.

D. The balancing agency shall furnish all necessary calibrated instrumentation to adequately perform the specified services. An inventory of all instruments and devices in possession of the balancing agency may be required by the engineer to determine the balancing agency's performance capability.

E. The balancing agency shall have operated for a minimum of five years under its current name.

F. Personnel:
   1. The project supervisor shall be a Professional Engineer and have:
      a. Extensive knowledge of the work involved.
      b. At least five years of experience conducting tests of the type specified.
      c. This test and balance engineer shall be responsible for the supervision and certification of the total work herein specified.
   2. All work shall be conducted under the direct supervision of the supervising engineer.
   3. Technicians shall be trained and experienced in the work they conduct.

1.6 WARRANTY

A. Provide (AABC) guarantee in writing.

B. Extended warranty.
   1. Include an extended warranty of 2 years after completion of test and balance work, during which time the Architect/Engineer may request a retest or resetting of any outlet or other items as listed in the test report.
   2. Provide technicians and instruments to assist the Architect/Engineer in making any tests he may require during this period.
   3. The balancing agency shall perform an inspection of the HVAC system during the opposite season from that which the initial adjustments were made. The balancing agency shall make any necessary modifications to the initial adjustments to produce optimum system operation.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION

3.1 TAB TOLERANCES

A. The water, outside air, supply air, return air, and exhaust air for each system shall be adjusted to within +/- 5% of the value scheduled on the drawings.

3.2 SITE VISITS

A. During construction, the balancing agency shall inspect the installation of the piping systems, sheetmetal work, temperature controls, energy management system, and other component parts of the heating, ventilating, and air conditioning systems. One inspection shall take place when 60% of the ductwork is installed and another inspection shall take place when 90% of the equipment is installed. The balancing agency shall submit a brief written report of each inspection to the architect and engineer.

B. Upon completion of the installation and start-up of the mechanical equipment by the mechanical contractor, the balancing agency shall test and balance the system components to obtain optimum conditions in each conditioned space of the building. If construction deficiencies are encountered that preclude obtaining optimum conditions, and the deficiencies cannot be corrected by the mechanical contractor within a reasonable period of time, the balancing agency shall cease testing and balancing services and advise the architect, engineer, general contractor and owner, in writing, of the deficiencies.

C. Note proper piping installation, location of valves, and flow measuring instruments.

D. Make one series of visits, phased as required by construction progress, prior to installation of the ceiling. Note proper installation of balancing dampers.

E. Continue the site visits up to completion of project. In each succeeding report, list corrections made from previous reports.

3.3 TESTING INSTRUMENTS

A. Submit a list of all instruments to be used for the test and balance procedures.
   1. Catalog sheets
   2. Certificate of last calibration
   3. Calibration within a period of six months prior to balancing

B. Testing equipment shall be in good working order and tested for accuracy prior to start of work.

3.4 COORDINATION WITH OTHER SPECIFICATION SECTIONS

A. Review the related ductwork shop drawings and piping shop drawings. Make recommendations concerning suitability with respect to the testing, balancing and adjusting work.

B. Make tests to verify proper placement of the static pressure sensors for the variable air volume fan system control.

C. In cooperation with the work specified in Building Management and Control System section, a systematic listing of the testing and verification shall be included in the final TAB report. The TAB firm shall provide a laptop computer to operate with the Building Management and Control System. Building Management and Control System shall provide all necessary software and special interface cables, as required, to communicate with the DDC system:

1. Work with the temperature control contractor to ensure the most effective total system operation within the design limitations, and to obtain mutual understanding of the intended control performance.
2. Verify that all control devices are properly connected.
3. Verify that all dampers, valves, and other controlled devices, are operated by the intended controller.
4. Verify that all dampers and valves are in the position indicated by the controller (open, closed or modulating).
5. Verify the integrity of valves and dampers in terms of tightness of close-off and full open positions. This includes dampers in multizone units, terminal boxes and fire/smoke dampers.
6. Observe that all valves are properly installed in piping system in relation to direction of flow and location.
7. Observe the calibration of all controllers.
8. Verify the proper application of all normally opened and normally closed valves.
9. Observe the locations of all thermostats and humidistats for potential erratic operation from outside influences such as sunlight, drafts or cold walls.
10. Observe the location of all sensors to determine whether their position will allow them to sense only the intended temperatures or pressures of the media. Control contractor will relocate as deemed necessary by the Engineer.
11. Verify that the sequence of operation for any control mode is in accordance with the approved shop drawings and specifications. Verify that no simultaneous heating and cooling occurs.
12. Verify the correct operation of all interlock systems and installation is per the manufacturer recommendations.
13. Check all dampers for free operation.
14. Verify that all controller setpoints meet the design intent.
15. Perform variable volume system verification to assure the system and its components track with changes from full flow to minimum flow.

D. Upon completion of the testing and balancing, submit three days prior notice that the systems are ready for a running test. A qualified representative of the test and balance organization shall be present, with a representative from the engineer's office, to field verify TAB report readings. Specific and random selections of data recorded in the certified test and balance report will be reviewed.

3.5 INSTRUMENT TEST HOLES

A. When it is required to make holes in the field to measure temperature, static pressure or velocity in the ducts:
   1. Drill holes, plug, and tape external duct insulation.
   2. Repair damaged insulation to Engineer's approval.

3.6 TESTING THE AIR DISTRIBUTION SYSTEM

A. The TAB agency shall verify that all ductwork, dampers, grilles, registers, and diffusers have been installed per design and set full open. The TAB agency shall perform the following TAB procedures in accordance with the AABC National Standards and all results shall be recorded in the TAB report:
   1. Supply Fans:
      a. Fan speeds: Test and adjust fan RPM to achieve design CFM requirements.
      b. Current and Voltage: Test and record motor voltage and amperage. Then, compare data with the nameplate limits to ensure fan motor is not in or above the service factor.
      c. Pitot-Tube Traverse: Perform a Pitot-Tube traverse of the main supply and return ducts, as applicable, to obtain total CFM. If a Pitot-Tube traverse is not practical, an explanation of why a traverse was not made must appear on the appropriate data sheet. Measurements must be recorded with an Inclined Manometer or an Inclined/Vertical Manometer.
      d. Outside Air: Test and adjust the outside air on applicable equipment using a Pitot-Tube traverse. If a Pitot-Tube traverse is not practical, an explanation of why a traverse was not made must appear on the appropriate data sheet. If a traverse is not practical, use the mixed air temperature method, if the inside and outside temperature difference is at least 20°F, or use the difference between Pitot-tube traverse of the supply and return ducts.
      e. Static Pressure: Test and record system static pressure, including the static pressure profile of each supply fan.
   2. All Other Fans:
      a. Fan speeds: Test and adjust fan RPM to achieve design CFM requirements.
      b. Current and Voltage: Test and record motor voltage and amperage. Then, compare data with the nameplate limits to ensure fan motor is not in or above the service factor.
      c. Pitot-Tube Traverse: Perform a Pitot-Tube traverse of the main return ducts, as applicable, to obtain total CFM. If a Pitot-Tube traverse is not practical, an explanation of why a traverse was not made must appear on the appropriate data sheet. Measurements must be recorded with an Inclined Manometer or an Inclined/Vertical Manometer.
      d. Static Pressure: Test and record system static pressure, including the static pressure profile of each return fan.
   3. VAV Terminal Units:
      a. Set and record volume regulators on all terminal boxes to meet

design maximum and minimum CFM requirements.
   b. Identification: Identify the type, location, and size of each terminal unit. This information must be recorded on the terminal box data sheets.
4. Diffusers, Registers and Grilles:
   a. Tolerances: Test, adjust, and balance each diffuser, grille, and register to within 5% of design requirements. Minimize drafts. Observe throws are in direction as indicated on drawings.
5. Coils (including electric coils):
   a. Air Temperature: Once air flows are set to acceptable limits, take wet bulb (cooling coil only) and dry bulb air temperatures on the entering and leaving side of each coil. Calculate the sensible and latent (cooling coil only) capacity of the coil. Provide information in TAB report.

B. Record preliminary air handler data, including fan RPM and static pressures across filter, fans and coils.

C. Perform a velocity traverse of the main supply ducts using a pitot-tube and inclined manometer to establish initial air delivery. Perform a Pitot-tube traverse of main supply and return ducts, as applicable, to obtain total CFM. If a pitot-tube traverse is not practical, a detailed explanation of why a traverse was not made must appear on the appropriate data sheet.

D. Where air measuring stations are installed, use pitot tube traverse readings to verify and record the correct calibration of the stations output.

E. Make adjustments in fan RPM and damper settings, as required, to obtain design supply air, return air, and outside air.

F. Measure and adjust all supply and return branches to design air delivery.

G. Measure and adjust all diffusers to design air delivery to +/- 5% of design requirements.

H. Make a set of recordings showing final system conditions.

3.7 TESTING THE HYDRONIC SYSTEMS

A. The TAB agency shall, as applicable, verify that all hydronic equipment, piping, and coils have been filled and purged; that strainers have been cleaned; that water has been flushed and is in a clean condition, and that all balancing valves (except bypass valves) are set full open. As applicable, check air vents and expansion or compression tank for proper operation. The TAB agency shall perform the following testing and balancing functions in accordance with the AABC National Standards and all results shall be recorded in the TAB report:
1. Record preliminary pump data.
   a. Pump RPM.
   b. Pump shut-off differential head.
   c. Pump operating differential head.

d. Check and verify pump alignment.
e. Verify impeller diameter.

B. Adjust balancing valves in the pump discharge lines to obtain design water quantity as read from the manufacturer's pump curve and from a flow meter.

C. In variable flow systems, the water flow of the pump shall be set at the scheduled gpm, not the total of all the valves. Determine the diversity of the system and balance the individual coils with the maximum pump water quantity flowing in the system.

D. Balance flow through:
1. Chillers.
2. Coils.
3. Boiler.
4. Pumps
6. Cooling tower.
7. Heat Exchanger.

E. Use flow meters, differential pressures and temperature relationships as required.

F. Balance by-pass lines to obtain the same pressure drop with systems on by-pass as full flow through the coil including the valve.

G. Repeat steps, as required, to obtain a final systems balance and make a set of recordings showing final systems conditions.

H. Pumps:
1. Test and adjust pumps to meet design water flow requirements. Check pumps for proper operation. Pumps shall be free of vibration and cavitation Record appropriate gauge readings for final TDH and Block-Off\Dead head calculations. Check and verify pump alignment.

2. Current and Voltage: Test and record motor voltage and amperage, and compare data with the nameplate limits to ensure pump motor is not in or above the service factor.

I. Coils:
1. Tolerances: Test, adjust, and balance all chilled water and hot water coils within 5% of design flow requirements.
2. Verification: Verify the type, location, final pressure drop and water quantity (GPM) of each coil. Calculate the actual capacity of all coils. This information shall be recorded on coil data sheets.

J. Boilers:
1. Verify that boilers have been filled and started by others, and are in operation.
2. Current and Voltage: As applicable, test and record motor voltage and amperage, and compare data with the nameplate limits to ensure motor is not in or above the service factor.

3. Test, adjust and record water flows through water boilers.
4. Test and record water temperature profiles of each boiler.

K. Chillers:
1. Verify that chillers have been started by the manufacture and are in operation. Test and adjust chiller water flows to within 5% of the design requirements by using a U-TUBE manometer and setting balancing valves.
2. Current and Voltage: Test and record motor voltage and amperage, and compare data with the nameplate limits to ensure compressor motor is not in or above the service factor.
3. Test and record temperature profiles of each chiller at design water flow.

L. Cooling towers:
1. Verify that cooling towers have been filled and started by others and are in operation.
2. Current and Voltage: Test and record motor voltage and amperage, and compare data with the nameplate limits to ensure cooling tower fan motor is not in or above the service factor.
3. Test and adjust water flows to balance tower cells and flows between towers.
4. Test and record water temperature profiles of each condenser at design water flow for water and air side operation.

M. Heat exchangers:
1. Verify that heat exchangers have been filled and started by others, and are in operation.
2. Test and record temperature and pressure profiles of water and steam heat exchangers.

3.8 EQUIPMENT POWER READINGS

A. Record the following information for each motor:
1. Equipment designation.
2. Manufacturer.
3. Unit model number and serial number and frame.
4. Motor nameplate horsepower; nameplate voltage; phase and full load amperes.
5. Heater coil in starter.
   a. Rating in amperes.
   b. Manufacturer's recommendation.
6. Motor RPM/driven equipment RPM.
7. Power reading (voltage, amperes of all legs at motor terminals).

3.9 BOILERS

A. Check for proper operation and with operation at near design conditions, record the following:
1. Manufacturer, model number, serial number and nameplate.

2. If water type, water flow in GPM, entering and leaving water temperature and water pressure drop in feet.
3. Type of fuel and heating value.
4. Rate of fuel consumption.
5. Capacity in MBH.
6. Efficiency.
7. Flue gas analysis.
8. Motor data.

B. Observe demonstration that all controls and safety devices are functioning properly. Record observations.

3.10 CHILLERS (Water Cooled)

A. Balance flow of water thru each evaporator and condenser to be within a range of 100% to 110% of design flow with all pumps operating. With only one pump operating, the maximum flow shall not exceed the maximum tube velocity recommended by the manufacturer.

B. Verification of safety interlocks and controls are the responsibility of the manufacturer.

C. With each chiller operating at near design temperature and water flow conditions, measure and record the following:
1. Manufacturer, model number, serial number and all nameplate data.
2. Evaporator water entering temperature, leaving temperature, pressure drop (ft.) and water quantity (GPM).
3. Condenser water entering temperature, leaving temperature, pressure drop (ft.) and water quantity (GPM).
4. Evaporator and condenser refrigerant temperatures and pressures (using instruments furnished with the machine by the manufacturer).
5. Volts and amps for each phase.
6. Power factor.
7. KW input.
8. Tons of cooling.
9. KW per ton of cooling.

D. Reference chiller specification for additional requirements.

3.11 CHILLERS (Air Cooled)

A. Balance flow of water through each evaporator to be within a range of 100% to 110% of design flow with all pumps operating. With only one pump operating, the maximum flow shall not exceed the maximum tube velocity recommended by the manufacturer.

B. Verification of safety interlocks and controls are the responsibility of the manufacturer.

C. With each chiller operating at near design temperature conditions, measure and record the following:
1. Manufacturer, model number, serial number and all nameplate data.
2. Evaporator water entering temperature, leaving temperature, pressure drop (ft.) and water quantity (GPM).
3. Condenser air entering temperature, leaving temperature.
4. Evaporator and condenser refrigerant temperatures and pressures (using instruments furnished with the machine by the manufacturer).
5. Volts and amps for each phase.
6. Power factor.
7. KW input.
8. Tons of cooling.
9. KW per ton of cooling.

D. Reference chiller specification for additional requirements.

3.12 TESTING THE VARIABLE AIR VOLUME SYSTEM

A. All VAV boxes used are to be calibrated to produce the rated air quantity.

B. Set and record the supply air static pressure controller to provide actual design air flow at the most resistive terminal.

C. Measure and adjust the design air delivery at the inlet of each VAV box.

D. Measure and record the air quantity from each VAV box at its maximum flow. Manipulate the controller to achieve maximum flow.

E. Reset each box to yield and record minimum primary air flow.
1. DDC controllers record the correction factor required to establish actual desired air quantity as designed.
2. Pneumatic controllers adjust velocity controller as required to establish actual desired air quantity as designed.

F. If the box is operating with inlet static pressure in excess of the minimum cataloged pressure specified by the manufacturer and is not producing rated air quantity, field adjust the box to produce rated air quantity. Retest until approved results are obtained.

G. Position the VAV boxes to the proportion of maximum fan air volume to total installed box maximum volume.

H. Set the fan to deliver the AHUs scheduled design airflow.

I. Perform and record a total air traverse.

J. With the system terminal boxes set for full flow or diversity, the system will be delivering the scheduled design CFM with the most restrictive box in control. Make a speed increase if either or both static and volume are low.

K. Set the boxes to minimum and adjust the inlet vanes and or speed controllers to prevent excessive static in the system.

L. Coordinate with the work specified in Building Management and Control System on the final location of the sensors for the static pressure controller. Locate in the supply duct far enough from the fan discharge to be truly representative of the average static pressure in the system.

M. Modulate the fan speed on the supply fan. Adjust as required to coordinate with the static pressure sensing network.

N. Make a set of recordings showing final system conditions including system duct static pressures and control system setpoint.

3.13 DUCT TEST

A. Test and Balancing Contractor shall verify and record the duct test results. A copy of the duct test results, as completed, shall be submitted to the engineer for review within five days. Provide a complete report of all the duct test results in the final TAB report.

3.14 DIRECT EXPANSION EQUIPMENT

A. With each unit operating at near design conditions, measure and record the following:
   1. Manufacturer, model number, serial number and all nameplate data.
   2. Ambient temperature, condenser discharge temperature.
   3. Amperage and voltage for each phase.
   4. Leaving and entering air temperatures.
   5. Suction and discharge pressures and temperatures.
   6. Tons of cooling.
   7. Verification that moisture indicator shows dry refrigerant.

3.15 COOLING TOWERS

A. A complete CTI certified test of the cooling tower will be performed by others at the expense of the cooling tower manufacturer. A copy of this test (provided by others) shall be included in the final TAB Report. Balance the flow over and through bypass connections of the tower.

3.16 TAB REPORT

A. The activities described in this specification shall be recorded in a report form; and four individually bound copies shall be provided to the Architect and Engineer. Neatly type and arrange data. Include with the data the date tested, personnel present, weather conditions, nameplate record of the test instruments used and list all measurements taken after all corrections are made to the system. Record all failures and corrective action taken to remedy any incorrect situation. The intent of the final report is to provide a reference of actual operating conditions for the Owner's operations personnel. Provide a "Preface" which shall include a general discussion of the system and any abnormalities or problems encountered.

B. All measurements and recorded readings (of air, water, electricity, etc.) that appear in the report must have been recorded on site by the permanently employed technicians or engineers of the TAB firm.

C. Submit reports on forms approved by the engineer that will include the following data as a minimum:
1. Title Page
    a. Company Name
    b. Company Address
    c. Company telephone number
    d. Project name
    e. Project location
    f. Project Manager
    g. Project Engineer
    h. Project Contractor
    i. Project Identification Number
2. Summary of the TAB report data
3. Index
4. Instrument List
    a. Instrument
    b. Manufacturer
    c. Model
    d. Serial Number
    e. Range
    f. Calibration Date
    g. What test instrument is to be used for:
5. Fan Data
    a. Location
    b. Manufacturer
    c. Model
    d. Air flow, specified and actual
    e. Total static pressure (total external) specified and actual
    f. Inlet pressure
    g. Discharge pressure
    h. Fan RPM
6. Return Air/Outside Air Data
    a. Identification/location
    b. Design return air flow
    c. Actual return air flow
    d. Design outside air flow
    e. Actual outside air flow
    f. Return air temperature
    g. Outside air temperature
    h. Required mixed air temperature
    i. Actual mixed air temperature
7. Electric Motors

a. Manufacturer
b. HP/BHP
c. Phase, voltage, amperage, nameplate, actual
d. PM
e. Service Factor
f. Starter size, heater elements, rating

8. V-Belt Drive
   a. Identification/location
   b. Required driven RPM
   c. Drive sheave, diameter and RPM
   d. Belt, size and quantity
   e. Motor sheave, diameter and RPM
   f. Center-to-center distance, maximum, minimum and actual
9. Duct Traverse
   a. System zone/branch
   b. Duct size
   c. Area
   d. Design velocity
   e. Design air flow
   f. Test velocity
   g. Test air flow
   h. Duct static pressure
   i. Air correction factor
10. Air Monitoring Station Data
    a. Identification/location
    b. System
    c. Size
    d. Area
    e. Design velocity
    f. Design air flow
    g. Test velocity
    h. Test air flow
11. Air Distribution Test Sheet
    a. Air terminal number
    b. Room number/location
    c. Terminal type
    d. Terminal size
    e. Correction factor
    f. Design velocity
    g. Design air flow
    h. Test (final) velocity
    i. Test (final) air flow
12. Pump Data
    a. Identification/number
    b. Manufacturer
    c. Size/model
    d. Impeller
    e. Service
    f. Design flow rate, pressure drop, BHP
    g. Actual flow rate, pressure drop, BHP
    h. Discharge pressure

i. Suction pressure
j. Total operating head pressure
k. Shut off, discharge and suction pressures
l. Shut off, total head pressure
m. Pressure differential settings

13. Cooling Coil Data
    a. Identification/number
    b. Location
    c. Service
    d. Manufacturer
    e. Entering air DB temperature, design and actual
    f. Entering air WB temperature, design and actual
    g. Leaving air DB temperature, design and actual
    h. Leaving air WB temperature, design and actual
    i. Water pressure flow, design and actual
    j. Water pressure drop, design and actual
    k. Entering water temperature, design and actual
    l. Leaving water temperature, design and actual
    m. Air pressure drop, design and actual
    n. Capacity - sensible and latent
14. Heating Coil Data
    a. Identification/number
    b. Location
    c. Service
    d. Manufacturer
    e. Entering air DB temperature, design and actual
    f. Leaving air DB temperature, design and actual
    g. Water pressure flow, design and actual
    h. Water pressure drop, design and actual
    i. Entering water temperature, design and actual
    j. Leaving water temperature, design and actual
    k. Air pressure drop, design and actual
    l. Capacity
15. Electric Coil Data
    a. Identification/number
    b. Location
    c. Service
    d. Manufacturer
    e. Entering air DB temperature, design and actual
    f. Leaving air DB temperature, design and actual
    g. Electrical Characteristics
    h. Capacity
16. Sound Level Report
    a. Location (Location established by the design engineer)
    b. N C curve for eight (8) bands-equipment off
    c. N C curve for eight (8) bands-equipment on
17. Vibration Test on equipment having 10 HP motors or greater in size.
    a. Location of points:
        1) Fan bearing, drive end
        2) Fan bearing, opposite end
        3) Motor bearing, center (if applicable)

4) Motor bearing, drive end
5) Motor bearing, opposite end
6) Casing (bottom or top)
7) Casing (side)
8) Duct after flexible connection (discharge)
9) Duct after flexible connection (suction)

b. Test readings:
1) Horizontal, velocity and displacement
2) Vertical, velocity and displacement
3) Axial, velocity and displacement

c. Normally acceptable readings, velocity and acceleration
d. Unusual conditions at time of test
e. Vibration source (if non-complying)

18. Control verification indicating date performed and any abnormalities identified.
a. Point Location/Description
b. EMS Readout (Setpoint and Actual)
c. Actual Readout of all points
d. Interlocks
e. Safeties
f. Variable speed drive tracking with EMS input
g. Variable speed drive Bypass operation
h. Sequence of operation

END OF SECTION 230593

SECTION 230594 - COORDINATION OF TESTING AND BALANCING

PART 1 - TESTING, BALANCING AND ADJUSTING

1.1 WORK INCLUDED

A. Balancing and adjusting of the environmental systems is specified in Section 23 05 93.

B. Coordination of the work is specified in this Section.

PART 2 - PRODUCTS / NOT USED

PART 3 - EXECUTION

3.1 COORDINATION

A. Bring the work to a state of readiness for testing, balancing, and adjusting.
1. Install air terminal devices.
2. Provide specified filters in air handling equipment. Install clean filters just prior to the start of the test and balance work.
3. Verify lubrication of equipment.
4. Install permanent instrumentation.
5. Clean piping systems and fill with clean water.
6. Complete "Start-up" of equipment.
7. Check rotation and alignment of rotating equipment and tension of belted drives.
8. Verify ratings of overload heaters in motor starters.
9. Verify that safety and operating control set points are as designed and automatic control sequences have been checked.
10. Provide control diagrams and sequence of operation.
11. Collect material for maintenance manuals and prepare one manual especially for use in testing and balancing.
12. Verify that graphic operational data such as start/stop instructions, valve tag schedules, and piping identification schedules have been provided where needed.
13. Verify that equipment and piping identification work has been completed with valve tags, schedules, and piping identification system.
14. Comb out fins on extended-surface heat transfer coils where damaged.
15. Clean all strainers as required.
16. Remove construction strainers after water is cleaned and treated.
17. Remove all temporary filters from HVAC equipment.
18. Provide start-up reports listing all start-up information and manufacturer’s information attached.

B. Provide and install new pulleys and belts as required to effect the correct speed ratio. Adjustments where no belt or pulley change is required, is specified in Section 23 05 93.

C. Verify that the systems are ready for balancing and adjusting.

D. Submit a letter stating:
   1. The specified pieces of equipment have been checked, started, and adjusted by the manufacturer.
   2. Other equipment has been checked and started.
   3. The systems have been operated for the specified period of time.
   4. The automatic controls system has been adjusted, calibrated, and checked, and is operating as specified.

E. Provide the services of a technician full time at all times at the project when testing, balancing and adjusting work is being conducted.

F. Provide instrumentation and services to take readings of the required data for the refrigerant circuits.

G. Provide and install volume dampers required for balancing by the TAB Contractor.

3.2 START-UP OF EQUIPMENT

A. Pre-start & Start-up equipment using the procedures as recommended by the manufacturers.

B. Complete start-up of equipment prior to start of testing & balancing.

C. Submit start-up procedures as outlined by the manufacturers and complete the "HVAC FAN / AIR HANDLING / START-UP REPORT FORM" to Engineer.

HVAC FAN / AIR HANDLING UNIT / START-UP REPORT FORM														
Equipment Description	*Actual*			*Disc. Switch Wired*	*Rotation Correct*	*Belt*		*RPM Correct Submittal*	*Vibration Isolation Correct*	*Attachment To Roof Curb*	*List Of Damage Parts*	*Bearings Lubricated*	*Filter Installed*	*Interlocks & Dampers Operational*
	Voltage	*Amps*	*HP*			*Condition & Part #*	*Tension Correct*							

END OF SECTION

SECTION 230713 - EXTERNAL DUCT INSULATION

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install external insulation on supply, return, exhaust and outside air ductwork.

B. External insulation of concealed and exposed ducts is included in this Section. Internal acoustic duct lining is specified under ductwork and not included in this Section.

1.2 RELATED WORK

A. Division 9 - FINISHES. Painting and Color Coding.

B. Division 23 - MECHANICAL.
1. Air Handling Units. Internal insulation for air units is specified in the sections on air handling units. The units do not require external insulation.
2. Internal Duct Liner. Internal duct liner is specified in the section on ductwork.
3. Insulation. Refer to specific sections on individual insulation types.
4. Refer to insulation and liner plan detail.

1.3 QUALITY ASSURANCE

A. The intent of insulation specifications is to obtain superior quality workmanship, resulting in an installation that is absolutely satisfactory in both function and appearance. Provide insulation in accordance with the specifications for each type of service and apply as recommended by the manufacturer and as specified.

B. An approved contractor for this work under this Division shall be:
1. A specialist in this field and have the personnel, experience, training, skill, and the organization to provide a practical working system.
2. Able to furnish evidence of having contracted for and installed not less than 3 systems of comparable size and type that have served their Owners satisfactorily for not less than 3 years.

C. All duct insulation used on the project inside the building must have a flame spread rating not exceeding 25 and a smoke developed rating not exceeding 50 as determined by test procedures ASTM E84, NFPA 255 and UL 723. These ratings must be as tested on the composite of insulation, jacket or facing, and adhesive. Components such as adhesives, mastics and cements must meet the same individual ratings as the minimum requirements and bear the UL label.

D. Condensation on any insulated system is not approved.

E. Replace insulation damaged by either moisture or other means. Insulation that has been wet, whether dried or not, is considered damaged. Make repairs where condensation is caused by improper installation of insulation. Also repair any damage caused by the condensation.

F. Where existing insulated ductwork or other services are tapped, remove existing insulation back to undamaged sections and replace with new insulation of the same type and thickness as existing insulation. Apply as specified for insulation of the same service.

1.4 APPROVALS

A. Submittals. Submit product data on each insulation type, adhesive, and finish to be used in the work. Make the submittal as specified in Division 1 General Requirements and obtain approval before beginning installation. Include product description, list of materials and thickness for each service and location, and the manufacturer's installation instructions for each product.

B. Sample Application. Make an application of each type of insulation to display the material, quality and application method. Obtain approval of the sample application before proceeding with installation of the work.

PART 2 - PRODUCTS

2.1 INSULATION

A. Glass fiber rigid duct insulation.
   1. Minimum density of 3 pcf, installed R value to be 6.0 (when located in a conditioned plenum) and minimum density of 0.75 pcf, installed R value to be 8.0 (when located in an unconditioned plenum) at 75°F mean, facing of 0.7 mil aluminum foil reinforced with glass yarn mesh and laminated to 40 lbs. fire-resistant Kraft. R-value to be indicated on exterior side of insulation to be verified by City inspector.
   2. Acceptable Manufacturers
      a. Schuller 814 spin-glas FSK.
      b. Owens-Corning Type 703 board RKF.
      c. Knauf 3 PCF FSK.

B. Glass fiber blanket duct insulation.
   1. Minimum density of 1.0 pcf, installed R value to be 6.0 (when located in a conditioned plenum) and minimum density of 0.75 pcf, installed R value to be 8.0 (when located in an unconditioned plenum) at 75°F mean, facing of 0.35 mil foil reinforced with glass yarn mesh and laminated to 40 lbs. fire resistant Kraft. R-value to be indicated on exterior side of insulation to be verified by City inspector.
   2. Acceptable Manufacturers
      a. Manville R-series Microlite FSKL.
      b. Owens-Corning ED100 RKF.
      c. Knauf 1.0 PCF FSK.

C. Fiberglass reinforcing cloth mesh.
   1. Acceptable Manufacturers
      a. Perma Glass Mesh.
      b. Alpha Glass Mesh.
      c. Childers Chil-Glas #10

d. Foster Mast a Fab
e. Vimasco.

D. Mastics, sealants, coatings and adhesives.
1. Acceptable Manufacturers
a. Childers.
B. Foster.
c. Vimasco.

E. Fireboard Insulation
1. Totally encapsulated with foil facing.
2. Two hour rated fire protection.
3. Zero clearance to combustible protection.
4. System shall be listed and labeled by an NRTL.
5. Tested per ISO 6944, Type A Duct and achieve a 2 hour rating for stability, integrity and insulation.
6. Provided system is subject to the approval of the Local Authority Having Jurisdiction.
7. Acceptable Manufacturers
a. Unifrax ON Fyrewrap Elite 1.5
b. Partak Insulation, Inc. Paroc Fireboard
c. Thermal Ceramics FireMaster 3M
d. Premier Refractories International, Pyroscat.

F. Rigid Closed Cell Insulation
1. Acceptable Manufacturers
a. Dow Trymer.
b. Phenolic Foam.

G. Reinforced Foil Tape
1. Acceptable Manufacturers
a. Venture 1525CW
b. 3” FSK
2. Thickness 6.5 mils
3. Color: silver

2.2 COATING AND ADHESIVE

A. Coating. Provide Childers CP-38 or Foster 30-80 vapor barrier coating. Coating must meet MIL Spec C-19565C, Type II and be QPL Listed. Permeance shall be 0.013 perms or less at 43 mils dry. Tested at 100ºF and 90% RH per ASTM E96.

B. Outdoors: Provide as insulation coating Childers Encacel X or Foster Monolar 60-90. Permeance shall be 0.03 perms or less at 30 mils dry. Tested at 100ºF and 90% RH per ASTM F 1249.

C. Adhesive. Provide Childers CP-82 or Foster 85-20 vapor barrier adhesive.

D. Reinforcing Mesh. Provide 10 x 10 white glass or polyester reinforcing mesh.

2.3 OUTDOOR DUCT LAMINATED JACKETING

A. Rubberized bitumen compound material:

1. Ultraviolet resistant
2. Weatherproof
3. Vapor retarding jacketing
4. Laminated jacketing
5. Cross-laminated high strength polyethylene film
6. Laminated to aluminum foil
7. Minimum 60-mil thickness

B. Acceptable Manufacturers:
1. Alumaguard 60
2. Flex Clad 400
3. Venture Clad 1577CW

PART 3 - EXECUTION

3.1 FIRE SAFETY REQUIREMENTS

A. Do not extend duct coverings through walls or floors required to be fire-stopped or required to have a fire resistance rating. Interrupt duct coverings in the immediate vicinity of heat sources such as electric resistance or fuel-burning heater.

3.2 CONCEALED DUCT

A. Provide flexible glass fiber insulation with factory-applied, reinforced UL labeled Foil-Skrim-Kraft (FSK) facing.

B. Standing Seams. Insulate standing seams and stiffeners, which protrude through the insulation with 0.6 lb. per cubic foot density, 1-1/2” thick, faced, flexible blanket insulation. Insulation shall not prevent adjustment of damper operators.

C. Insulation shall be wrapped tightly on the ductwork with all circumferential joints butted and longitudinal joints overlapped a minimum of 2”. In addition, secure insulation to the bottom of rectangular ductwork by the use of either weld pins with washers or cup-head pins welded to the ductwork or perforated based insulation hangers glued to the duct on twelve inch centers to prevent sagging of insulation.

D. On circumferential joint, the 2” flange on the facing shall be stapled with 9/16” outward clinch steel staples on 2” centers, and taped with a minimum 3” wide strip of glass fabric embedded in coating. Cover all seams, joints, pin penetrations and other breaks with vapor barrier coating reinforced with reinforcing mesh. Fabric shall not be visible after coating.

D. On circumferential joint, the 2” flange on the facing shall be stapled with 9/16” outward clinch steel staples on 2” centers and taped using 3” wide foil tape applied with additional adhesive of Foster 85-75. Cover all seams, joints, pin penetrations and other breaks with foil tape and glue.

E. Ductwork in mechanical rooms is considered concealed spaces.

3.3 EXPOSED DUCT INSULATION

A. Ductwork in exposed locations is to be insulated with fiberglass rigid / semi-rigid board insulation.
   1. Apply fabric and mastic to provide a smooth surface for painting.

B. Standing Seams: Insulate standing seams and stiffeners which protrude through the insulation with 0.6 lb per cubic foot density, 1-1/2 inch thick, faced insulation. As a vapor seal, use reinforcing mesh with vapor barrier coating. Insulation shall not prevent adjustment of damper operators.

C. Insulation shall be wrapped tightly on the ductwork. Adhere insulation to ductwork with adhesive. In addition, secure insulation to the bottom of rectangular ductwork by the use of either weld pins with washers or cup-head pins welded to the ductwork or perforated based insulation hangers glued to the duct on 12 inch centers to prevent sagging of insulation.

D. Cover all seams, joints, pin penetrations and other breaks with coating reinforced with reinforcing mesh. Fabric shall not be visible after coating.

3.4 OUTDOOR DUCTWORK COVERING

A. Cover all supply and return ductwork outdoors:
   1. 1-1/2” thick, rigid closed cell insulation with reinforced foil facing.

B. Install a high point in center and slope in both directions so water will not stand on horizontal surfaces.

C. Impale the insulation over mechanical fasteners and washers.
   1. A minimum of 2 rows of fasteners per side on 12-inch centers.
   2. Seal all breaks, joints and punctures by applying a 1/8” thick vapor barrier mastic coating, embedded in open mesh reinforcing mesh.

D. Standing S, or flanged connections shall be covered with the same thickness of insulation overlapped a minimum of 4”.

E. Apply a tack coat of Childers CP-10/11 or Foster 46-50 weather barrier mastic over the entire surface.
   1. While this coat is still tacky, Childers #5 glass fiber reinforcing mesh shall be smoothly applied and pressed into the mastic. The cloth shall be taut with adjacent edges overlapped a minimum of 4”.
   2. After the first coat of mastic has taken its set, the second coat shall be applied over the cloth by palm, trowel, or spray to sufficient thickness that, when dried, the combined thickness of mastic and cloth is not less than 1/8”.
   3. Upon completion, the openings in the cloth shall be completely sealed and the yarn shall not be visible. The completed work shall be completely smooth and present a plane surface.
   4. Aluminum gray or white finish as approved by the Architect.

F. Standing water on horizontal surfaces is not approved.

G. Apply outdoor duct laminated jacketing protection over entire insulation surface. Apply rubberized bitumen compound, applied to a cross-laminated high strength polyethylene film, laminated to aluminum foil.

3.5 KITCHEN GREASE EXHAUST DUCTWORK / KILN DUCTWORK / FUME HOOD DUCT

A. Secure fireboard insulation to duct with impaling pins and 3” square speed clips. In addition, provide a wire mesh support system and additional sealing or support as required by the code enforcing authority. The insulation support system shall include framed access to allow the insulation to be removed and replaced without damage at the access doors in the duct system for inspection and cleaning. Coordinate location of access openings to correspond accurately. Provide stainless steel banding on 12” centers.

3.6 GENERAL INSTALLATION

A. Install materials in accordance with manufacturer's instructions.

B. Apply insulation on clean, dry surfaces only.

C. Continue insulation with vapor barrier through penetrations.

D. Neatly finish insulation at supports, protrusions and interruptions.

E. Install insulation on clean, dry surfaces, and only after building is weatherproofed sufficiently to preclude any rainwater on insulation.

F. Apply mastic over the fiberglass reinforcing mesh to a thickness where fabric is not visible after completion.

G. Install fiberglass blanket duct insulation on top of supply air grilles not fire rated.

END OF SECTION 230713

SECTION 230716 - VESSEL INSULATION

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install insulation for both high and low temperature vessels.

B. Low temperature installations include expansion tanks, air eliminators, chiller nozzles, chiller heads and other vessels containing liquids 60°F and below.

C. High temperature installations include expansion tanks, air eliminators, domestic water storage tanks, boiler stack / transition and other vessels containing liquids above 60°F.

1.2 QUALITY ASSURANCE

A. The intent of insulation specifications is to obtain superior quality workmanship resulting in an installation that is absolutely satisfactory in both function and appearance. Provide insulation in accordance with the specifications for each type of service and apply as recommended by the manufacturer and as specified.

B. An approved contractor for this work under this Division shall be:
   1. A specialist in this field and have the personnel, experience, training, skill, and the organization to provide a practical working system.
   2. Able to furnish evidence of having contracted for and installed not less than 3 systems of comparable size and type that have served their owners satisfactorily for not less than 3 years.

C. All vessel insulation used on the project inside the building must have a flame spread rating not exceeding 25 and a smoke developed rating not exceeding 50, as determined by test procedures ASTM E 84, NFPA 255 and UL 723. These ratings must be as tested on the composite of insulation, jacket or facing, and adhesive. Components such as adhesives, mastics and cements must meet the same individual ratings as the minimum requirements and bear the UL label.

D. Condensation on any insulated vessel system is not acceptable.

E. Replace insulation damaged by either moisture or other means. Insulation that has been wet, whether dried or not, is considered damaged. Make repairs where condensation is caused by improper installation of insulation, also repair any damage caused by the condensation.

F. Where existing insulated vessel, or other surfaces are tapped, remove existing insulation back to undamaged sections for hot surfaces or to nearest insulation stop for cold surfaces, and replace with new insulation of the same type and thickness as existing insulation. Apply as specified for insulation of the same service.

1.3 APPROVALS

A. Submit product data on each insulation type, adhesive, and finish to be used in the work. Make the submittal as specified in Division 1 General Requirements and obtain approval before beginning installation. Include product description, list of materials and thickness for each service and location and the manufacturer's installation instructions for each product.

B. Make an application of each type of insulation to display the material, quality and application method. Obtain approval of the sample application before proceeding with installation of the work.

1.4 RELATED WORK

A. Division 9 Finishes. Painting and color-coding

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Glass fiber pipe & tank insulation:
   1. Schuller Type 817
   2. Owens-Corning Type 705
   3. Knauf 2.8 PCF

B. Closed cell, non-wicking pipe & tank insulation:
   1. Armaflex FS, 2” thickness

C. Aluminum Jacketing:
   1. Childers
   2. Pabco
   3. RPR

D. Monel Staples
   1. Bostich Monel
   2. Duo-Fast Monel
   3. Markwell Monel

E. Fiberglass reinforcing cloth mesh:
   1. Perma Glass Mesh

2. Alpha Glass Mesh
3. Childers Chil-Glas
4. Foster Mast a Fab

F. Weather Resistant Coating:
   1. WB Armaflex Finish

2.2 CEMENT, MASTICS, SEALANTS, ADHESIVES AND COATINGS

A. Adhesive: Provide Childers CP-127 or Foster 85-60 fiberglass adhesive to seal insulation for low temperature vessels.

B. Adhesive / Joint Sealant: Provide Armaflex 520 adhesive to seal insulation for low and temperature vessels.

C. Lagging Adhesive / Coating: Furnish Childers CP50AHV2 or Foster 30-36 lagging adhesive / coating to provide a finish coat and to secure finish cloth for high temperature vessels.

D. Insulation Joint Sealant: Use Childers CP-76 or Foster 95-50 to seal the joints of insulation on low temperature vessels.

E. Metal Jacketing Sealant: Use Childers CP-76 or Foster 95-44 on all metal jacketing laps outdoors.

F. Vapor Barrier Coating: Indoors - Use Childers CP-38 or Foster 30-80 vapor barrier coating finish to coat the canvas finish on low temperature vessels. Permeance shall be 0.013 perms or less as tested by ASTM E96. Coating must comply with MIL-C-19565C, Type II and be QPL listed. Permeance shall be 0.03 perms or less at 30 mils, dry. Tested at 100°F and 90% RH per ASTM F 1249 and by Hypalon rubber based.

G. Weather Barrier Mastic: Furnish Childers CP-10/11 or Foster 46-50 weather barrier mastic and reinforcing mesh for outdoor finish.

H. Reinforcing Mesh: Furnish 10 X 10 white glass or polyester reinforcing mesh.

PART 3 - EXECUTION

3.1 LOW AND HIGH TEMPERATURE VESSELS (FIBERGLASS)

A. Apply a first layer of insulating board. Band the board on immediately after application, using bands on 12” centers, drawn tight and securely fastened.

B. Apply successive layers of insulation as specified for the first layer, with joints staggered. After insulation has been applied, finish with Childers CP-38 or Foster 30-80 vapor barrier coating reinforced with glass or polyester reinforcing mesh per manufacturer's recommendations. Provide a flood coat of Childers CP-10/11 or Foster 46-50 with Foster Mast a Fab polyester or Chil Glas #10 reinforcing mesh.

C. To insulate removable heads, provide two equal sections of heavy-gauge, galvanized sheet metal covers, angle reinforced and lined with insulation board. Make covers easily removable to allow free access to the heads for inspection, cleaning and dismantling. Provide suitable flanges on the sections with neoprene gaskets between them, permitting a tight seal when the two sections are bolted together. Fill the voids with glass fiber wall cavity insulation.

3.2 LOW TEMPERATURE VESSELS (CLOSED CELL)

A. Apply a layer of insulating board. Band the insulation on immediately after application, using bands on 12” centers, drawn tight and securely fastened.

B. To insulate removable heads, provide two equal sections of heavy-gauge, galvanized sheet metal covers, angle reinforced and lined with insulation board. Make covers easily removable to allow free access to the heads for inspection, cleaning and dismantling. Provide suitable flanges on the sections with neoprene gaskets between them, permitting a tight seal when the two sections are bolted together. Fill the voids with closed cell insulation.

C. Apply weather protective finish on closed cell insulation. Provide a minimum of three coats.

3.3 ALUMINUM JACKETING (Insulated vessels outdoors above grade)

A. Apply aluminum jacket on vessels according to manufacturer's recommendations using aluminum strapping and metal jacketing sealant to provide weather tight covering.

B. Aluminum jacketing is not considered as contributing to the vapor barrier or the insulation jacket. The vapor barrier must be sufficient in itself for this function.

C. Install straps on 12” centers.

3.4 VESSEL INSULATION REQUIREMENTS

A. Insulate all low and high temperature vessels located exterior (outside) of the building, including the following:
   1. Air separators
   2. Expansion Tanks
   3. Chemical feeders

4. Chilled water system volume tanks
5. Insulation thickness shall match thickness of adjoining pipe insulation

B. Insulate all low temperature vessels located interior (inside of the building, including the following:
1. Air separators
2. Chemical feeders
3. Chilled water system volume tanks
4. Insulation thickness shall match thickness of adjoining pipe insulation

C. Insulate the following high temperature vessels located interior (inside the building).
1. Air Separators
2. Insulation thickness shall match thickness of adjoining pipe insulation

D. As indicated on the drawings

END OF SECTION 230716

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install piping insulation, jackets, accessories and covering of specified materials. The insulation shall be used for high and low temperature piping applications including chilled water, hot water, condenser water, refrigerant lines, condensate piping and make-up water.

1.2 QUALITY ASSURANCE

A. The intent of insulation specifications is to obtain superior quality workmanship resulting in an installation that is absolutely satisfactory in both function and appearance. Provide insulation in accordance with the specifications for each type of service and apply as recommended by the manufacturer and as specified.

B. An approved contractor for this work under this Division shall be:
   1. A specialist in this field and have the personnel, experience, training, skill, and the organization to provide a practical working system.
   2. Able to furnish evidence of having contracted for and installed not less than 3 systems of comparable size and type that have served their owners satisfactorily for not less than 3 years.

C. All piping insulation used on the project inside the building must have a flame spread rating not exceeding 25 and a smoke developed rating not exceeding 50, as determined by test procedures ASTM E 84, NFPA 255 and UL 723. These ratings must be as tested on the composite of insulation, jacket or facing, and adhesive. Components such as adhesives, mastics and cements must meet the same individual ratings as the minimum requirements and bear the UL label.

D. Condensation on any insulated piping system is not acceptable.

E. Replace insulation damaged by either moisture or other means. Insulation that has been wet, whether dried or not, is considered damaged. Make repairs where condensation is caused by improper installation of insulation. Also repair any damage caused by the condensation.

F. Where existing insulated piping, or other surfaces are tapped, remove existing insulation back to undamaged sections for hot surfaces or to nearest insulation stop for cold surfaces, and replace with new insulation of the same type and thickness as existing insulation. Apply as specified for insulation of the same service.

1.3 SUBMITTALS

A. Submit product data on each insulation type, adhesive, and finish to be used in the work. Make the submittal as specified in General Requirements and obtain approval before beginning installation. Include product description, list of materials and thickness for each service and location and the manufacturer's installation instructions for each product.

B. Make a field application of each type of insulation to display the material, quality and application method. Obtain approval of the sample application before proceeding with installation of the work.

1.4 RELATED WORK

A. Finishes. Painting and color-coding

B. Pipe Heat Tracing

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Glass fiber pipe insulation:
1. Johns-Manville Micro-Lok AP-T
2. Owens-Corning ASJ/SSL
3. Knauf ASJ/SSL

B. Cellular Glass Insulation (Foamglass):
1. Pittsburg Corning
2. Cell-U-Foam

C. Rigid Foam Insulation:
1. Kingsapan Tarec
2. Dow Trymer
3. Tarec Ecophen – Phenolic Foam

D. Aluminum Jacketing:
1. ITW Lock-on (Childers)
2. ITW Z-lock (Pabco)

E. Fiberglass reinforcing cloth mesh:
1. Perma Glass Mesh
2. Alpha Glass Mesh
3. Childers Chil-Glas
4 Foster Mast a Fab
5. Vimasco

F. Mastics, Sealants, Coatings and Adhesives
1. Childers
2. Foster
3. Vimasco
4. Armacell 520 Adhesive

G. Elastomeric Insulation
1. Armacell

H. Weather Resistant Coating
1. WB Armaflex Finish
2 Foster 30-64

I. Glass fiber blanket insulation

1. Manville R-series Microlite FSKL
2. Owens-Corning eD75 or ED100 RKF
3. Knauf 0.75 PCF FSK

J. Fire Barrier Plenum Wrap Insulation
   1. Totally encapsulated with foil facing
   2. Single layer fire protection
   3. Plenum Protection System UL910
   4. Acceptable Manufacturers
      a. FyreWrap 0.5 Plenum Insulation
      b. 3M Fire Barrier Plenum Wrap 5A

2.2 RIGID FOAM PIPE INSULATION

A. Polyisocyanurate pipe insulation or phenolic foam pipe insulation, with all service reinforced vapor barrier jacket having integral laminated vapor barrier.
   1. Polyisocyanurate: Thermal conductivity 0.14 @ 75°F mean (ASTM C518).
   2. Phenolic Foam: Thermal conductivity 0.13 @ 75°F mean (ASTM C 518); minimum 2.5# density.
   3. Polyisocyanurate is not to be used inside of buildings without 25/50 rating.

2.3 FIBERGLASS PIPE INSULATION

A. Heavy density, dual temperature fiberglass insulation with factory applied, all service, reinforced vapor barrier jacket having integral laminated vapor barrier. Provide with a factory applied pressure sensitive tape closure system and matching butt strips. Supply in thickness as shown.
   1. Thermal conductivity 0.23 @ 75°F mean (ASTM 335).

2.4 ELASTOMERIC INSULATION

A. Insulation material shall be flexible, closed-cell elastomeric insulation in tubular or sheet form. Material shall have a flame spread rating of 25 or less and a smoke developed rating of 50 or less when tested in accordance with ASTM E84, latest revision. Sheet material with a thickness greater than ¾” shall have a flame spread rating of 25 or less and a smoke developed rating of 100 or less when tested in accordance with ASTM E84, latest revision. In addition, the product, when tested, shall not melt or drip flaming particles, and the flame shall not be progressive. In addition, all materials shall pass simulated end-use fire test.
   1. Thermal conductivity 0.27 at 75°F mean (ASTM C177 or C518)

2.5 CELLULAR GLASS INSULATION

A. ASTM C552:
   1. "k" value of 0.35 @ 75°F ("ksi" value of 0.047 @ 24°C);
   2. 8.0 lb/cu.ft. (128 kg/cu.m.) density

2.6 INSULATION/SHIELD AT HANGERS

A. Field fabricated: Use 360° sections of rigid foamglass insulation that will support the bearing area at hangers and supports. Further support insulation at hangers and supports with a shield of galvanized metal covering at least half of the pipe circumference, and conforming to the schedule. Insulation shall extend at least 1” beyond metal shield on each end. When pipe is guided at top and bottom, metal shields shall cover the whole pipe circumference. Adhere metal shield to insulation so that metal will not slide with respect to insulation with ½” aluminum bands (2) per shield.

1. Sections of foam glass insulation may be used of the same outside diameter of the adjoining pipe insulation.
2. Minimum thickness of foam glass insulation shall not be less than 1” thick.

B. Pipe saddles: Formed galvanized sheets at each support point for insulated pipe, shaped to fit pipe, and covering bottom half of pipe. Length at saddle shall be not less than twice the insulation outside diameter or more than 22”. Provide 18 gauge through 4” pipe and 16-gauge 5” pipe and above.

2.7 SEALANT, ADHESIVE AND FINISH

A. Lap Adhesive. Provide Childers CP-82 or Foster 85-20 adhesive.

B. Vapor Barrier Finish:

1. Indoors: Provide as insulation coating Childers CP-38 or Foster 30-80, white. Coating must meet MIL Spec C-19565C, Type II and be QPL Listed. Permeance shall be 0.013 perms or less at 43 mils dry. Tested at 100ºF and 90% RH per ASTM E96.
2. Outdoors: Provide as insulation coating Childers Encacel X or Foster 60-90. Permeance shall be 0.03 perms or less at 30 mils dry. Tested at 100ºF and 90% RH per ASTM F 1249 and must be Hypalon rubber based.
3. Underground: Provide Childers CP-22/24 or Foster 60-25/26 for fittings and areas. Pittwrap cannot be used.

C. Insulation Joint Sealant. Provide Childers CP-76 or Foster 95-50 vapor barrier sealant.

D. Metal Jacketing Sealant. Provide Childers CP-76 or Foster 95-44 metal jacketing sealant for all outdoor metal jacketing laps.

E. Lagging Adhesive. Provide Childers CP-50AMV1 or Foster 30-36.

F. Other products of equal quality will be acceptable only upon approval.

2.8 ALUMINUM JACKETING

A. Finish insulated piping outdoors with a smooth prefabricated Z-lock aluminum jacket 0.016” thick with factory applied 1 mil polyethylene/40 lb and Fab strap. Kraft moisture barrier.

B. Valves, Fittings and Flanges. For finishing valves, fittings, flanges and similar installations, provide formed aluminum covers, 0.024” thick.

C. Straps and Seals. Provide ½” x 0.020 stainless steel strapping and seals for jackets and covers according to manufacturer's recommendations.

2.9 GLASS FIBER BLANKET INSULATION

A. Minimum density of 1.0 PCF, 2” thick, installed R value to be 6.0 or better at 75°F mean, facing of 0.35 mil foil reinforced with glass yarn mesh and laminated to 40 lbs fire resistant kraft.

2.10 FIRE BARRIER PLENUM WRAP

A. High temperature insulation blanket specifically designed to provide a single layer, flexible enclosure around combustible items located within fire rated return air plenums.

B. Use of this method is subject to approval of the Local Authority Having Jurisdiction.

PART 3 - EXECUTION

3.1 INTERIOR PIPING

A. Cover all piping with glass fiber, heavy density, dual temperature pipe insulation with a vapor barrier jacket. Apply insulation to clean, dry pipes. Longitudinal seams shall be joined firmly together and sealed with self-sealing lap joints. Butt insulation joints firmly together and seal with a 3” wide ASJ butt strip seal. Longitudinal seams and butt strip laps shall be coated and sealed with CP-38 or Foster 30-80 vapor barrier coating for chilled water piping applications.

B. Install hanger with protective shield, on the outside of all insulation.

C. Where domestic water pipes (1/2” & ¾” pipe sizes) are installed on trapeze type hangers, provide galvanized sheet metal protection shields at these locations. Place insulation jacket directly on hanger. Incompressible, load bearing insulation segments are not required.

D. Pipe Saddles: Formed galvanized sheets at each support point for insulated pipe, shaped to fit pipe, and covering bottom half of pipe. Length at saddle shall be not less than twice the insulation outside diameter. Provide 18-gauge through 4” pipe and 16-gauge for 5” pipe and above.

E. Seal ends of pipe for chilled water insulation with vapor barrier mastic at valves, flanges, fittings and every 21' on straight runs of piping. Mastic should extend on top of ASJ jacket, across the glass, down onto the pipe making a complete seal.

F. Apply a smooth flood coat of white lagging adhesive Foster 30-35 or Childers CP-35 over all exposed insulation within mechanical rooms.

G. Piping to be insulated as specified above:
1. Chilled water and heating water
2. Domestic hot and cold water
3. Make-up water
4. Horizontal sanitary drain piping that receives condensate
5. Exposed to view storm drainage system including roof and overflow drain bodies, vertical piping from drain body to elbow, all horizontal rain leaders, and first elbow turning down
6. Condenser water

3.2 REFRIGERANT AND CONDENSATE PIPING

A. Cover all pipe with elastomeric insulation by slitting tubular sections or sliding unslit sections over the open ends of piping or tubing. Seams and butt joints shall be adhered and sealed using Foster 85-75, Childers CP-82 or Armstrong 520 Adhesive.

B. All fittings shall be insulated with the same insulation thickness as the adjacent piping. All seams and mitered joints shall be adhered with Foster 85-75, Childers CP-82 or 520 Adhesive.

C. Pipe Saddles: Formed galvanized sheets at each support point for insulated pipe, shaped to fit pipe, and covering bottom half of pipe. Length at saddle shall be not less than twice the insulation outside diameter.

D. Outdoor exposed piping shall be painted with two coats of either WB or SB Armaflex finish or Foster 30-64 elastomer foam coating. All seams shall be located on the lower half of the pipe.

3.3 PIPING OUTDOORS ABOVE GRADE

A. Insulate all water piping exterior of building above grade with rigid foam insulation and aluminum jacketing.

B. Adhere the vapor barrier jacket longitudinal seam with vapor barrier adhesive.

C. Cover all valves, fittings and flanges with factory made molded or field fabricated segments of pipe insulation of a thickness and material equal to the adjoining insulation. Adhere segments together with no voids, using Childers CP-82 or Foster 85-20 adhesive. Secure fitting insulation covers and segments in place with ½” wide glass filament tape.

D. Apply a tack coat of fitting vapor barrier coating over the insulation and tape.

E. Neatly embed with 10 x 10 fiberglass or polyester reinforcing mesh into the tack coat.

F. Apply coating over the fiberglass cloth to a thickness where the mesh is not visible after completion.

G. Seal ends of pipe insulation with vapor barrier coating at valves, flanges, fittings and every 21' on straight runs of piping. Mastic should extend on top of ASJ jacket, across the foam, down onto the pipe, making a complete seal.

H. Finish with aluminum jacketing as specified.

3.4 UNDERGROUND PIPE COVERING

A. Cover chilled and hot water piping underground with cellular glass insulation.

B. Butter insulation joints with Childers CP-76 or Foster 95-50 vapor barrier sealant. Secure with stainless steel bands or ½” fiberglass reinforced tape on 9” centers.

C. Cover valves and flanges with fabricated fittings of thickness and material equal to the adjoining insulation. Fasten fittings in place with stainless steel bands or ½” fiberglass reinforced tape.

D. Apply a tack coat of fitting mastic Childers CP-22/24 or Foster 60-25/26 over the insulation and bands.

E. Neatly embed with 10 x 10 fiberglass or polyester reinforcing mesh into the tack coat.

F. Apply mastic over the fiberglass cloth to a thickness where the fabric is not visible after completion.

G. Seal ends of pipe insulation with vapor barrier mastic at all valves, fittings, flanges and every 21' on straight run piping. Mastic should extend on top of ASJ jacket, across the glass, down onto the pipe, making a complete seal.

H. Finish with 125 mil thickness Pittwrap jacket applied in accordance with manufacturer's instructions. At contractor's option, cover insulation with Servi-Wrap P-500 installed in accordance with manufacturer's instructions.

3.5 FLANGE, VALVE AND FITTING INSULATION

A. Cover valves and flanges with fabricated segments, fittings with two-piece factory molded fittings, and both of matching pipe insulation type and thickness equal to that of the adjoining pipe. Fittings and fabricated segments shall be securely held in place.
   1. Apply a tack coat of insulating coating/mastic to the insulated fitting to produce a smooth surface.
   2. After mastic is dry, apply a second coat of vapor barrier coating/mastic. Neatly embed with 10 x 10 fiberglass or polyester reinforcing mesh into the tack coat.
   3. Overlap coating/mastic and fiberglass/polyester reinforcing mesh by 2” on adjoining sections of pipe insulation.
   4. Apply a second coat of coating/mastic over the fiberglass/polyester reinforcing mesh to present a smooth surface.
   5. Apply coating/mastic to a wet film thickness of 3/64”.
   6. Fabric shall not be visible after completion.
   7. Vapor seal flanges, valves and fittings with Childers CP-38 or Foster 30-80. Coating must meet MIL Spec C-19565C, Type II and be QPL Listed. Permeance shall be 0.013 perms or less at 43 mils dry. Tested at 100ºF and 90% RH per ASTM E96.

B. PVC fitting covers are not acceptable.

3.6 ALUMINUM JACKETING (Insulated Piping Outdoors Above Grade)

A. Apply smooth aluminum jacket on piping, valves, fittings and flange covers according to manufacturer's recommendations, using stainless steel strapping and seals, to provide weather tight covering and to shed water.

B. Aluminum jacketing is not considered as contributing to the vapor barrier or the insulation jacket. The vapor barrier must be sufficient in itself for this function. Lap each adjoining jacket section a minimum of 3” to make a weather tight seal with the application of 1/8” bead of Childers CP-76 or Foster 95-44 metal jacketing sealant.

C. Install straps on 9” centers and at each circumferential lap joint.

D. Cover and seal all exposed surfaces.

E. The use of screws and rivets is not approved.

F. Provide isolation (30# felt) between the aluminum jacket and the sheetmetal protection shield at each pipe support point.

3.7 MISCELLANEOUS

A. Insulate pumps.

B. Install materials after piping has been tested and approved.

C. Apply insulation on clean, dry surfaces only.

D. Apply weather protective finish on elastomeric insulation installed in non-conditioned spaces. Provide a minimum of three coats.

3.8 INSULATION THICKNESS

INSULATED UNIT	THICKNESS (Inches)
Refrigerant Piping	1-1/2
Chilled Water Piping (through 2” pipe)	1-1/2
Chilled Water Piping (2-1/2” pipe and Larger)	2
Condensate Drains	1
Exterior Condenser Water Piping	2
Heating Water Piping 2” Pipe and Larger	2
Heating Water Piping 1-1/2” Pipe and Smaller	1-1/2
Exterior Chilled and Hot Water Piping, 5” Pipe and Larger	2
Exterior Chilled and Hot Water Piping 4” Pipe and Smaller	1-1/2
Underground Piping Covering, 1-1/2” Pipe and Smaller	1
Underground Pipe Covering 2” Pipe and Larger	1-1/2

END OF SECTION 230719

SECTION 23 09 33 - BUILDING MANAGEMENT AND CONTROL SYSTEM

PART 1 - GENERAL

1.1 SCOPE

A. Provide and install a complete Building Management and Control System (BMCS), including industrial instrumentation necessary to obtain functions and results specified. A complete system includes items such as sensors, valves, dampers, valve and damper operators, DDC panels, relays, terminal equipment controllers, mounting brackets and thermowell, etc. Integrate all components to provide a complete and functioning system.

B. Temperature Control System components:
   1. Electronic instruments as specified
   2. Electric instruments as specified
   3. Microcomputer instruments as specified

C. All control devices of the same type product shall be of a single manufacturer.

D. Control, power and interlock wiring necessary to accomplish sequences specified in this Section shall be provided and installed by the Control Subcontractor. Materials and methods of execution as specified in Division 26, Electrical.
   1. Coordinate current characteristics of all electrical instruments and equipment with Division 26 of the specifications and related electrical drawings.

E. The entire Building Management and Control System (BMCS) shall be installed by the Automation System Manufacturer or Authorized Distributor.
   1. All components and elements
   2. The testing and acceptance procedure

F. The manufacturer of the building automation system shall provide documentation supporting compliance with ISO-9002 (Model for Quality Assurance in Production, Installation, and Servicing). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a Quality System and Framework that will assure consistency in the products delivered for this project.

G. The entire Building Management and Control System (BMCS) shall be installed, Commissioned, and tested; all performed by the Automation System Manufacturer or Authorized Distributor if approved by engineer.
   1. All components and elements.
   2. Start-up and point verification.
   3. The testing and acceptance procedure.

H. The cost of the work specified in this section is included in an allowance.
   1. Selection of subcontractor will be determined at a future date.

1.2 RELATED WORK

A. Division 23, Mechanical

B. Division 26, Electrical

1.3 SUBMITTALS

A. Submit items of the Building Management and Control System (BMCS).
   1. Temperature control equipment & Field devices.
   2. Wiring & Flow diagrams.
   3. Sequence of operation.
   4. Complete, detailed, control and interlock-wiring diagram.
   5. Indicate mechanical and electrical equipment furnished and electrical interlocks, indicating terminal designation of equipment. Respective equipment manufacturers shall furnish through the Mechanical Contractor, approved drawings of equipment to be incorporated in this diagram.
   6. Submit Input / Output summary of all points.
   7. Submit an outline of testing procedures from section Testing and Acceptance.
   8. Mark up a copy of the specifications for the product. Indicate in the margin of each paragraph the following: “Comply, “Do Not Comply”, or “Not Applicable”. Explain all “Do Not Comply” statements.
   9. Submit sample of space temperature sensor and guards for review prior to purchase or installation.

1.4 COOPERATION WITH OTHER TRADES

A. Furnish control valves, temperature sensing element wells, flow and pressure sensing devices, dampers and other similar devices to the Mechanical Contractor in a timely manner for installation under the Building Management and Control System (BMCS), Subcontractor's supervision.

1.5 WARRANTY

A. Provide with a manufacturer’s parts and labor warranty for a period of two years from substantial completion.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Automated Logic Branch Office - WebCTRL

B. Siemens Building Technologies - APOGEE

C. Delta by Team Solutions

D. Reliable by Unify Energy Solutions

2.2 SYSTEM ARCHITECTURE

A. The Building Management and Control System (BMCS) shall consist of an information-sharing network of stand-alone Direct Digital Control Panels (DDCP) to monitor and control equipment as specified of the control sequence and input/output summary.

B. "Information sharing" shall be defined as: The function of each DDCP to exchange data on the network trunk with other DDCP's without the need for additional devices such as network managers, gateways or central computers.

C. "Stand-alone" shall be defined as: The function of each DDCP to independently monitor and control connected equipment through its own microcomputer.

2.3 COMMUNICATIONS PROCESSING

A. The BMCS shall operate as a true token-pass peer-to-peer communication network. Resident processors in each DDCP shall provide for full exchange of system data between other DDCP's on the network trunk. Systems that limit data exchange to a defined number of system points are not acceptable.

B. Systems that operate via polled response or other types of protocols that rely on a central processor or similar device to manage DDCP to DDCP communications may be considered only if a similar device is provided as a stand-by. Upon a failure of malfunction of the primary device, the stand-by shall automatically, without any operator intervention, assume all BMCS network management activities.

C. The failure of any DDCP on the network shall not affect the operation of other DDCP's. All DDCP failure shall be annunciated at the specified alarm printers and terminals.

D. Network shall support a minimum communications speed of 115.2 Kbps.

E. The network shall support a minimum of 100 DDC controllers and PC workstations.

F. Each PC workstation shall support a minimum of 4 peer-to-peer networks, either by hardwired connection or dial up.

G. The system shall support integration of third party systems (fire alarm, security, lighting, PCL, chiller, boiler) via panel mounted open protocol processor. This processor shall exchange data between the two systems for inter-process control. All exchange points shall have full system functionality as specified herein for hardwired points. Provide examples of 5 reference projects utilizing gateways required for this project.

2.4 DDCP HARDWARE

A. Each DDCP shall consist of a 32-bit microprocessor and controller, power supply, input / output boards and communication board. All program and point databases shall be stored in battery-backed RAM. Provide a minimum of 1.2 MEG RAM in each DDCP to allow for point expansion and trend data storage.

B. Each DDCP shall incorporate a real-time clock.

C. Each DDCP shall be provided with two RS232 communications port. Connecting an operator terminal, whether portable or stationery, shall allow the user to communicate with the entire network.

D. Each DDCP shall provide for input / output connections to field equipment. The following point types shall be supported:
   1. Analog inputs - for measuring sensed variables. Inputs shall be capable of accepting voltage, resistance, current or pressure signals.
   2. Analog outputs - for controlling end devices. Outputs shall be capable of producing voltage, resistance, current or pressure signals. Pneumatic outputs shall be provided with a manual override for adjusting outputs in the event of a power loss at the DDCP.
   3. Digital inputs - for monitoring dry contacts such as relays, switches, pulses, etc.
   4. Digital outputs - to control two position devices such as starters, actuators, relays, etc.

E. Each DDCP shall be listed under UL916 (Energy Management Systems), and shall be tested to comply with sub-part J of Part 15 FCC rules for Class A computing equipment.

F. Each DDC Controller shall have sufficient memory to support its own operating system and databases, including:
   1. Control processes
   2. Energy management applications
   3. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
   4. Historical/trend data for points specified
   5. Maintenance support applications
   6. Custom processes
   7. Operator I/O
   8. Dial-up communications
   9. Manual override monitoring

G. Operator shall have the ability to manually override automatic or centrally executed commands at the DDC Controller via local, point discrete, on-board hand/off/auto operator override switches for digital control type points and gradual switches for analog control type points.

1. Switches shall be mounted either within the DDC Controllers key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides.
2. DDC Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. DDC Controllers shall also collect override activity information for reports.

H. DDC Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. Status indication shall be visible without opening the panel door.

I. In the event of the loss of normal power, there shall be an orderly shutdown of all DDC Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

1. Upon restoration of normal power, the DDC Controller shall automatically resume full operation without manual intervention.
2. Should DDC Controller memory be lost for any reason, the user shall have the capability of reloading the DDC Controller via the local RS-232C port, via telephone line dial-in or from a network workstation PC.
3. Upon restoration of normal power, the DDC Controller shall automatically resume full operation without manual intervention.

2.5 PROGRAMMING FUNCTIONS

A. Resident software in each DDCP shall provide custom programming of control strategies.

1. Point database
2. Operator interface
3. Network communications
4. Facilities and energy management functions

B. Programming of control and energy management strategies shall be accomplished via a high-level computer language such as BASIC, JC BASIC, C, or Powers Process Control Language. A standard math processor shall be part of the programming language. All analog loops shall be capable of proportional, integral and derivative control.

C. Each DDCP shall incorporate an operator interface program (OIP) that provides an English language user interface. The OIP shall allow the user to program, interrogate, command and edit the BMCS via a self-prompting method. Operator terminals, whether textual or graphical, shall be able to access the entire network from any DDCP. Access shall be accomplished in a transparent fashion; that is, the operator shall not be required to address specific DDCP's in order to display or command system points.

2.6 FACILITY MANAGEMENT SOFTWARE

A. The BMCS shall be provided with standard and custom report generation functions that include:
   1. Alarm summaries
   2. Motor status summaries
   3. Point displays by type, system, status, overrides, failures, location, equipment and enabled/disabled.
   4. Program listings

B. All reports shall be either displayed or printed by:
   1. Operator request.
   2. Time of day.
   3. Event conditions (such as in response to an alarm, interlock, etc.).

C. All reports shall be time and date stamped.

D. An alarm-processing program shall be provided to annunciate those points designated as alarmable. Alarm points shall, upon alarm occurrence, be displayed or printed at designated terminals.

E. Historical trend data shall be collected and stored at each DDCP for later retrieval. Retrieval shall be manual or automatic. Any point, physical or calculated, may be designated for trending. The system shall allow for two methods of trend collection: Either by a pre-defined time interval sample or upon a pre-defined change of value. Trend data shall be presented in a columnar format. Each sample shall be timed stamped. Trend reports may be a single point or may be a group of points, up to a maximum of (8) points in any single group. Any point, regardless of physical location in the system may become part of a multiple point group.

F. Each BMCS network shall provide a point-monitoring function that can display single or multiple points in a continuous updated fashion for dynamic displays of point values.

G. A database and configuration report program shall be provided that allows the user to interrogate BMCS status. As a minimum, the user shall be able to: Verify available RAM at each DDCP, verify DDCP status (on-line, off-line, and failed) and set the system clock.

H. Any invalid operator entry shall result in an error message.

I. DDCP's shall contain a password access routine that will assign an operator to one of three level of access. Level 1 shall permit display function only, level 2 shall additionally permit commanding of system points and level 3 shall additionally permit full program and database editing.

J. DDCP's shall provide for the accumulation of totalized values for the purposes of run-time or energy totalization. Totalized values may be displayed or printed automatically or by operator request.

2.7 ENERGY MANAGEMENT SOFTWARE

A. The BMCS shall be provided with an optimal start program such that the building may be divided into ten zones for optimum start. Warm-up and cool-down shall occur in sequence with succeeding zones starting only after the preceding zone has completed its warm-up or cool-down.
   1. The optimum start-up time of assigned equipment shall be determined based on a software calculation that takes into consideration outdoor air conditions, space conditions, and building thermal characteristics ("U" factor).
   2. The optimum start program shall control start-up of the cooling and heating equipment to achieve the target occupancy space temperature at the precise time of building occupancy.
   3. A built-In "learning" technique shall cause the BMCS to automatically adjust itself to the most affective time to start equipment based on historical data.

B. The BMCS shall be provided with an operator interactive time of day (TOD) program. TOD programming and modifying shall be accomplished in a calendar-like format that prompts the user in English language to specify month, year, day and time and associated point commands. It shall be possible to assign single points or groups of points to any on or off time. Appropriate time delays shall be provided to "stagger" on times.
   1. TOD shall incorporate a holiday and special day schedule capability, which will automatically bring up a pre-defined holiday or special day schedule of operation. Holidays or special days can be scheduled up to one year in advance.
   2. In addition to the time dependent two-state control, TOD also provides time dependent setpoint control. This control provides the capability to output assignable, proportional setpoint values in accordance with the time of day and day of week. This program shall be used to accomplish night setback, morning warm-up and normal daily operating setpoints of all control system loops controlled by the BMCS. As with the two-state control, time dependent setpoint control shall be subject to the holiday schedule. The setpoints desired shall be user definable at any operator terminal.
   3. The operator shall be capable of reading and/or altering all sorted data pertaining to time of day, day of week, on/off times, setpoint values, and holiday designation.
   4. The TOD program shall also provide an override function that allows the user to conveniently change a start or stop time for any point up to one week in advance. The override command shall be temporary. Once executed the TOD program shall revert to its original schedule.
   5. The TOD program shall interface with the optimal start program (OSP) such that stop times may be assigned by OSP.

C. Additional Program functions required are to be installed and programmed as requested by end user at no additional cost:

1. Enthalpy optimization.
2. Supply air reset.
3. Hot water reset.
4. Chilled water reset.
5. Volumetric control.
6. Dead band control. Install dual set points as requested by user.
7. All specified energy management programs, whether or not applicable to this project shall be provided such that the owner may enable the program at a future date without the need to purchase additional software or modify existing software.

2.8 WEB SERVER ACCESSIBILITY

A. Industry leading encryption technology to provide accessibility through a web browser.

B. Building Manager's ability to access, view and command critical building information in real time over the intranet or internet.
   1. Alarm Display
   2. Point Commanding
   3. Graphic Display
   4. Scheduling
   5. Running Reports
   6. Point Details

2.9 REMOTE NOTIFICATION

A. Remote notification sends Alarm and System Event information to various notification devices as indicated below but not limited to. Operators can receive their building automation system alarms without restricting them to dedicated workstations.
   1. Alphanumeric pagers
   2. Numeric pagers
   3. Email
   4. Phones via voice or short message service (SMS)

2.10 POINT EXPANSION MODULES

A. Capable of extending its input/output capabilities via special purpose modules.
   1. Modules may be mounted remote from the DDCP.
   2. Shall communicate with the DDCP over a pair of twisted cables.

2.11 TERMINAL EQUIPMENT CONTROLLERS

A. Provide for control of each piece of equipment, including, but not limited to, the following:
   1. Variable Air Volume (VAV) boxes

2. Constant Air Volume (CAV) boxes
3. Dual Duct Terminal Boxes
4. Unit Conditioners
5. Heat Pumps
6. Unit Ventilators
7. Room Pressurization
8. Fan Coil Units

B. Include the following items:
1. All input and outputs necessary to perform the specified control sequences.
   a. Analog outputs shall be industry standard signals such as 24V floating control.
2. Sufficient memory to accommodate point database, operating programs, local alarming and local trending.
3. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM, or minimum of 100-hour battery backup shall be provided.
4. Return to full normal operation without user intervention after a power outage of unlimited duration.
5. Operation programs shall be field selectable for specific applications.
6. Specific control strategy requirements, allowing for additional system flexibility.
7. Controllers that require factory changes of all applications are not acceptable.

2.12 ELECTRONIC DAMPER ACTUATORS

A. Two position damper operators:
1. Spring return to full travel position.
2. Built in auxiliary switches (motor end switches)
   a. Switch shall be fully adjustable so that cut-in/cut-out points may be preset at any point within angular travel of the motor.
3. Minimum torque 60-in-lb

B. Modulating damper operators:
1. Sized with sufficient reserve power to provide smooth modulating action and tight close off against the system pressure
2. Select the operator with available torque to exceed the maximum required operating torque by not less than 100%
3. Minimum torque 100 in-lb

2.13 ETHERNET CARD

A. Ethernet Card:
1. Local area network connection interface card.

2.14 CONTROL CABINETS

A. Fully enclosed NEMA 1 for indoors, NEMA 4 for outdoors.
   1. Powder coat painted on all sides
   2. Cabinet with continuously piano type hinged door
   3. Locking latch
   4. All locks shall use a common key
   5. Devices on the panel face must be identified with engraved nameplates.
   6. Panels or termination panels must be identified with engraved nameplates.
   7. Provide enamel beige finish and extruded aluminum alloy frame UL 50 certified.

2.15 REFRIGERANT MONITOR **(USE IN CENTRAL PLANT APPLICATIONS)**

A. Infrared Halogen Gas monitoring system for low level continuous monitoring of numerous CFC, HFC and HCFC halogen gases used in most refrigeration and air conditioning systems.

B. Two years parts and labor warranty.

C. Analyzer:
   1. Microprocessor based
   2. Infrared (IR) sensor technology
   3. Sensing down to 1 (PPM)
   4. Monitor multiple compounds
   5. Automatic calibration
   6. Synchronous 2 wave length infrared filtometer
   7. Insensitive to vibration and temperature variations.
   8. Response Time: Min.5 sec / Max. 90 sec.
   9. Sampling Mode in Auto and Manual operation

D. Multi-Point Sampling System:
   1. Minimum of six sample points
   2. Adjustable sampling time, with optional skip and hold features for each point.
   3. Sample lines up to 500' in length
   4. Three stage alarms for each point
   5. Flow loss and malfunction indicators
   6. Individual relay contacts for each set of channel alarms.
   7. Infrared detection

E. Alarming and Display:
   1. Digital display in PPM/PERCENTAGE
   2. Provide a 0-10V and 4-20mAmp output for direct input into the Building Management System or Direct Digital Control System.
   3. Adjustable three level alarm for each point shall and be supplied with common alarm output contacts.
   4. Provide local digital indication of PPM level for each sample point.
   5. Loss of any sample flow
   6. Identify alarm point by flashing display and actual PPM.

7. Automatic zero mechanism and malfunction indicators.
8. Silence audible alarm switch with re-activation after adjustable time delay.

F. Power requirement:
   1. 120 VAC

G. Audible sound pressure level of at least 15Dba above the operating ambient noise level within machine room and providing a distinctive strobe type visual alarm both inside and out side machine room at each entrance. Ceiling mounted rotating beacon in center of machine room. Strobes shall be provided immediately adjacent to and outside of each refrigeration machinery room exit. A clearly identified switch of the break-glass type shall be provided immediately adjacent to and outside of each refrigeration machinery room exit.

H. Acceptable manufacturers:
   1. General Analysis Corporation
   2. Yokogawa Corporation
   3. MSA
   4. Sherlock
   5. Vulcain

2.16 AUTOMATIC CONTROL VALVES

A. Pressure ratings: Minimum 125 psig or 1.25 times maximum system operating pressure.

B. Construction:
   1. 2" and smaller:
      a. Screwed.
      b. Bodies and internal parts: Bronze, stainless steel or other approved corrosion-resistant metal.
   2. 2-1/2" and larger:
      a. Flanged.
      b. Bodies: Cast iron or cast steel.
      c. Seats and parts exposed to fluid: Bronze, stainless steel or other approved corrosion-resistant metal.
   3. Characterized port ball valves are acceptable for VAV terminal units only.

C. Modulating straight through water valves: Equal percentage contoured throttling plugs.

D. Three Way Mixing Valves: Linear throttling plugs allowing total flow through valve to remain constant regardless of position.

E. Sizes: By Automatic Control System Manufacturer for fully modulating operation.
   1. Minimum pressure drop: Equal to pressure drop of coil or exchanger.
   2. Maximum pressure drop: 5.5 psi.
   3. Relief and bypass valves: Sized according to pressure available.
   4. 2-position valves: Line size.
   5. Manual by-pass operator.

F. Electronic Actuator:
1. Direct coupled installation
2. Visual and electronic stroke indicator
3. Die-cast aluminum housing
4. Manual override
5. Self-lubricating bearing and gear train
6. Automatic calibration
7. Automatic duty cycle protection
8. Overload and stall protection
9. Non-spring return
10. Floating /0-10 VAC / 4-20mA operation
11. UL approved
12. Provide smooth modulating action and tight close off against the system pressure.
13. Torque to exceed the maximum required operating torque by not less than 150%.
14. Actuator input signal shall be compatible with output DDC controller.
15. Provide weatherproof enclosure (exterior use).
16. Damper actuators not acceptable for valves.

G. Cooling Tower By-Pass and Chiller / Cooling Tower Isolation Valves & Actuators:
1. Valve Bray (Series 31 or NYL)
    a. Line Size Valve
    b. Under-cut disk for smooth operation
    c. Full Lug Valve
    d. Cast Iron Body
    e. EPDM - Seat
    f. 416 Stainless Steel Stem
    g. Nylon Coated Ductile Iron Disc
    h. Disc-to-stem connection shall utilize a double “D” or key design requiring no screws or pins to connect stem to disc.
2. Electronic Actuator: Bray (Series 70)
    a. Fully configurable without need for software or handheld settings device
    b. Direct Mount
    c. Solid state speed control
    d. Visual and electronic stroke indicator.
    e. Anti-Condensation Heater (exterior actuators)
    f. Die-cast aluminum housing.
    g. Manual override by means of hand wheel
    h. Self-lubricating bearing and gear train.
    i. All steel self-locking output gearing to be provided
    j. Continuous Duty Rated Motor
    k. Overload and stall protection.
    l. Floating /0-10 VAC / 4-20mA operation.
    m. Mechanical Travel stops
    n. UL approved.
    o. Smooth modulating action.
    p. Tight close off against the system pressure.
    q. Sized to exceed 150% of the maximum required operating torque

of the valve while under the maximum rated shut-off pressure
r. Actuator input signal shall be compatible with output DDC controller.
s. Provide weatherproof enclosure
t. Damper actuators not acceptable for valves.

H. Variable Primary Flow By-Pass Control Valve:
1. Modulating straight through control valve with equal percentage contoured throttling plug and electronic operator.
2. Maximum pressure drop: 10 psi
3. Sized for minimum flow of one chiller
4. Torque to exceed the maximum required operating torque by not less than 150%.

2.17 FLOW SWITCHES

A. Wetter parts made of type 316 stainless steel.
1. Designed for mounting in pipe tee.
2. Watertight, dust-tight, and corrosion resistant enclosure.
3. Paddle shall be factory fabricated to accommodate pipe sizes used.
4. Switching action shall be single pole double throw.

B. Approved manufacturer:
1. ITT McDonald Miller #FS7-4WL for piping over 8", FS7-4W for chilled water.
2. ITT McDonald Miller #FS7-4L for piping over 8", FS7-4 for hot and condenser water.

C. Remote Flow Solid-State Flow Detection:
1. Extended length flow probe
2. Cabinet-mounted control monitor
3. Wetted parts, 316 stainless steel probe
4. Optional temperature and wire-break outputs
5. Flow and temperature switch points
6. LED bar graph display for status indication

B. Approved Manufacturer:
1. IFM Effector

2.18 DIFFERENTIAL PRESSURE SWITCHES

A. Wet/wet differential pressure switch
1. Integral Mounting Frame
2. Watertight, dust-tight, and corrosion resistant enclosure.
3. Wetted materials of brass and flouroelastomer.
4. Externally adjustable set point

B. Approved manufacturer:
1. Square D #9012GGW4

2. Dwyer #DXW-11-153-1
3. Carrier #HK06ZC033

2.19 TEMPERATURE LOW LIMIT SWITCH

A. Responsive to the coldest 1' section of its length.
   1. Double pole single throw switch
   2. 20' capillary
   3. Line voltage with bellows actuated switch
   4. Auto reset for outdoor installation
   5. Manual reset for indoor installation

2.20 TEMPERATURE AND HUMIDITY SENSORS

A. Space Temperature Sensors
   1. Thermister with resistance of 10,000 ohms at 77°F.
   2. Accuracy shall be +/-1/2°F.
   3. Range of 55° to 95° F.
   4. Surface Mounted (edit for each project)
      a. Digital temperature display (edit for each project)
      b. Setpoint slide adjustment (edit for each project)
      c. Override button (edit for each project)
      d. Color to be approved by Architect / Owner, submit sample for review
   5. Flush mounted (edit for each project)
      a. Stainless steel flush mount sensor, submit sample for review.
   6. Location and height to be approved by Architect/Engineer prior to installation.
   7. Provide metal guards in the following locations: (edit for each project)
      a. Corridors
      b. Cafeteria
      c. Kitchen
      d. Gymnasium
      e. Dressing Rooms
      f. Industrial Labs

B. Space / Duct Humidity Sensor
   1. Capacitance element in the space or duct as required and output a 4 to 20 MA signal proportional to 0 to 100% RH to the DDC.
   2. Capacitance element shall be field replaceable and not require calibration.
   3. Accuracy shall be +/-2% in the range from 20 to 95% RH.
   4. Relative humidity sensors shall have the sensing element of inorganic resistance media.
   5. Provide locking metal covers suitable for institutional use. Submit sample for review. (edit for each project)
   6. Provide manufacturers calibration certificate.
   7. Provide metal guards in the following locations: (edit for each project)

a. Corridors
b. Cafeteria
c. Kitchen.
d. Gymnasium.
e. Dressing Rooms.
f. Industrial Labs.

C. Duct Temperature Sensors
1. Range of 20° to 120°F.
2. Single point sensing of temperature.
3. Averaging elements of sufficient length to sense temperature across 2/3 duct width.
4. Averaging elements of sufficient length to provide accurate, representative indication and control.
5. Averaging elements of sufficient length to prevent variances in temperature or stratification.

D. Liquid Immersion Temperature Sensors
1. Platinum type resistance temperature detector (RTD).
2. Match sensor range to medium being monitored.
   a. Hot water range 30° to 250°F.
   b. Chilled Water 20° to 70°F.
3. Furnish stainless steel wells for installation by Mechanical Contractor.
4. Locate all sensors in field with Owner/Engineer present.
5. System accuracy for liquid temperature sensing shall be +/-1/2°.
6. Sensors must be removable from wells.

E. Outside Air / Freezer / Cooler Sensors
1. Range of –58° to 122°F.
2. Weatherproof sun shield.
3. External trim material corrosion resistant with all parts assembled into water tight, vibration-proof, heat resistant assembly.
4. Minimum of 8' long leads.
5. Encapsulated into Type 304 stainless steel tubes with low conductivity moisture proofing material and lag extension for thickness of insulation.

2.21 CURRENT SENSITIVE RELAYS

A. Ensure compatibility with VFD applications for variable speed motor status.
1. Provide with adjustable set point.
2. Relays must be mounted and not hung by power wires thru CT.
3. Provide split-core type current sensors.
4. Loop powered.
5. LED Status.
6. Acceptable Manufacturer: Veris Industries / Hawkeye
7. Relays shall close status contacts in response to current flow in power leads to the equipment being monitored.

2.22 DIFFERENTIAL PRESSURE TRANSDUCER

A. Transducers to convert differential pressures to 4-20 MA analog outputs.
1. Solid state pressure sensor with accuracy of +/- 1% of calibration range.
2. Factory calibrated and have zero and span trimmers for field calibration.
3. Range shall be selected to match the medium being monitored.
4. Pressure snubbers to protect from pressure pulses and a 3-way bypass / valve assembly to protect the transducer from overpressure damage during start-up.
5. LCD Display
6. Acceptable Manufacturer: Rosemount 1151 or 3051 Pressure Transmitter

2.23 FLOW DIFFERENTIAL PRESSURE SWITCH **(EDIT FOR SPECIAL APPLICATIONS)**

A. The pressure sensing element shall be of the convoluted diaphragm type for sensitivity to system differential pressure.
1. Select the pressure range based on the sensed differential pressure.
2. The unit shall be protected against overpressure to the full static pressure rating.
3. Accuracy: +/- 2% of full scale.

B. Switch assembly.
1. Reed switch.
2. NEMA-4 enclosure.
3. Threaded boss conduit entrance.
4. SPST action.
5. Voltage and rating as required for the control circuit.

C. Wetted parts shall be made of type 303 stainless steel.

D. Install an isolation valve in each sensing pipe leg to permit servicing without shutting the system down.

2.24 ELECTRIC REMOTE BULB THERMOSTAT

A. Two position remote bulb thermostat:
1. Bimetal controlled.
2. Sealed mercury switches.
3. Provide specified control action.
4. Adjustment can be made by removing unit cover.
5. Element with capillary length as required for the location.

2.25 ELECTRIC SPACE THERMOSTAT

A. Two position space thermostat.
1. Single Pole switch actuated by bi-metal sensing element.
2. Range shall be 60°F to 90°F.
3. Removable external knob adjustment means.

2.26 HIGH STATIC PRESSURE SWITCH

A. With manual reset switch
   1. Approved manufacturer: Cleveland AFS-460.

2.27 INSERTION FLOW SENSORS

A. Turbine Flow Meter
   1. Retractable hot tap flow sensor
   2. Accuracy: +/- 1% of full scale
   3. Dual Turbine
   4. Custom thread-o-let 400 psi / 250°F rated
   5. Line size from 2-1/2 to 72 inch
   6. Metering range from 0.3 to 15 f/sec.
   7. Remote NEMA 4 wall mounted LCD display
   8. Field Pro Software & Communicator
   9. Warranty two years
   10. Approved Manufacturer: Onicon Flow Meter F1200 Series

B. Electromagnetic Flow Meter
   1. Retractable hot tap flow sensor
   2. Accuracy: +/- 1% of full scale
   3. Electromagnetic
   4. Custom thread-o-let 400 psi / 250 degree F rated.
   5. Line size from 1-1/4 to 72 inch
   6. Metering range from 0.3 to 15 f/sec.
   7. Remote NEMA 4 wall mounted LCD display
   8. Field Pro Software & Communicator
   9. Warranty two years
   10. Approved Manufacturer Onicon Flow Meter F3500

2.28 CONTROL DAMPERS

A. Opposed blade dampers.
   1. Frames of 13-gauge galvanized sheet metal.
   2. Provisions for duct mounting.
   3. Damper blades not exceeding 8" in width.
   4. Blades of two sheets of 16-gauge galvanized sheet metal.
   5. Blades suitable for high velocity performance.
   6. Bearings of nylon or oil-impregnated, sinthered bronze.
   7. Shafts of 1/2" zinc-plated steel
   8. Leakage does not exceed 1/2% based on 2000 fpm and 4" static pressure.
   9. Replaceable resilient seals along top, bottom and sides of frame and blade edge.
   10. Submit leakage and flow characteristics data with shop drawings.
   11. Linkage shall be concealed out of the air stream within damper frame.

12. Acceptable Model is Ruskin Model CD60.

2.29 PHOTO CELL CONTROL

A. Light Sensitive Resistor.
   1. 4-20 output or switch.
   2. On = 3.0 / fc. Off 10.0 / fc.
   3. UL Approved.

2.30 DRAIN PAN FLOAT SWITCH

A. Rated at 10 Amps.
   1. Shuts off equipment if water level becomes too high.
   2. DPDT Contacts.

2.31 BY-PASS AUTOMATIC SHUT-OFF TIMERS

A. Rated at 10 Amps, 125 VAC
   1. Shuts off equipment with timed switch
   2. White decorated timer
   3. Without hold feature
   4. Time Cycle 60 minutes

2.32 CO_2 SENSOR

A. Telaire Model T5100 CO_2/Temperature Sensor or approved equal
   1. Local visual indication of CO_2 levels in enclosed spaces.
   2. Pre-calibrated with factory default settings of 1000 ppm and 1500 ppm CO_2 levels
   3. Bright LED indicator transitions between green, yellow, and red as the CO_2 threshold is exceeded.
      a. Accuracy: +/- 30 ppm @ 72°F
      b. Output: 0-10 V (100Ω output impedance) and NTC 20k Thermister

2.33 AIR FLOW SENSING SWITCH

A. The pressure sensing element shall be of the convoluted diaphragm type for sensitivity to system positive, negative, or differential pressure.
   1. Select the pressure range based on the sensed differential pressure.
   2. The unit shall be protected against overpressure to the full static pressure rating.
   3. Accuracy: +/- 2% of full scale

B. Switch assembly:
   1. Reed switch
   2. Field adjustable setpoint

3. Threaded boss conduit entrance
4. SPST Action
5. Voltage and rating as required for the control circuit

2.34 LCD TOUCH-SCREEN DISPLAY (EDUCATIONAL KIOSK)

A. Wall mounted, large screen 42” LCD touch screen monitor.

B. Steel enclosure for durability in high traffic applications.

C. Touch-screen sensor technology.

D. High performance and optic definition.

2.35 SERVER/CPU (EDUCATIONAL KIOSK)

A. Minimum performance characteristics:
1. 1.8 GHz AMD Mobile Turion 64 X2 Processor.
2. 2.0 GB RAM.
3. 500 GB 2.5” Hard Drive.
4. Windows 7 32 bit operating system.
5. PS/2 Mouse and Keyboard.

2.36 HVAC SHUTDOWN STATION

A. Lockdown Switch:
1. Mushroom Red Button within a clear plastic cover
2. Latches when depressed
3. Twist reset
4. Sign “HVAC SHUTDOWN”
5. Manufactured by STI Model #SS2031HV-EN

PART 3 - EXECUTION

3.1 INSTALLATION

A. The control system shall be installed and final adjustments made by full-time employees of the factory-approved BMCS Building Management Control Subcontractor.

B. The contractor shall collaborate through Architect / Engineer and Owner to determine the Owner's preference for naming conventions, etc. before entering the data in to the system.

C. Due to actual operational or space conditions, it may be necessary for the Contractor to make sequence of operation modifications and/or controller adjustments, change the location or type of sensor to obtain proper operation and coverage of the system in each room or space. These change, if requested by the Owner or Engineer, shall be performed at no additional cost to the Owner. Therefore labor allowances should be made for such changes and adjustments if requested.

D. Points listed within this section are to be connected to the BMCS system as hard-wired points to cards and not connected through BacNet integration. The BacNet interface is for read only points not included within sequences of this specification.

3.2 INTERLOCK AND SAFETY CIRCUITS

A. Close the outdoor air dampers when the related HVAC unit supply or exhaust fan is de-energized:
   1. The damper and actuators are specified in this section.
   2. Outdoor air damper shall be fully opened before related air handling unit fan is energized for 100% outside air use.
   3. Provide motorized outside air dampers for the following:
      a. Supply fans
      b. AHUs
      c. Exhaust fans (except kitchen exhaust)

B. Close the chilled and hot water valves to the coil when the related unit is de-energized.

C. Interlock each chiller to start its dedicated chilled and condenser water pumps. Interlock flow switch and pump auxiliary contacts in series to chiller safety terminal strip.
   1. On shutdown provide a circuit to permit the chilled water pumps and condenser water pumps to run while the chillers pump down as required by the manufacturer.
   2. As per manufacturer’s recommendations

D. Primary chilled water control:
   1. Operating and safety controls are furnished as an integral part of the water-chilling unit and not specified in this section.
   2. Provide flow switches located in the chilled water and condenser water piping to each water-cooled liquid chiller.
      a) Interlock to prevent operation in the absence of flow.
      b) This may not be the prime controller to start/stop the chiller.
      c) Interlock thru pump auxiliary contacts.
   3. Provide a high limit temperature sensor in each primary chilled water pump loop.

E. Exhaust/Supply Fans:
   1. Interlock the related exhaust and supply fans and the related outside air damper.

2. Interlock the exhaust fans with the related air-handling unit through software.
3. Interlock related exhaust fan for dishwasher with time delay off relay.
4. Interlock related exhaust fan for kiln with time delay off relay
5. Interlock kitchen hood related supply and exhaust fans.
6. Provide additional interlocks as indicated on fan schedule and on drawings.
7. Interlock electrical and mechanical room exhaust fans with thermostat.
8. Interlock refrigerant monitor with mechanical room purge system.
9. Interlock science room related supply and exhaust fans.
10. Interlock outside air supply fans for VAV air-handling unit with air-handling unit status point.

F. Cooling Tower Fan Safety Interlock: Provide interlock wiring for the vibration sensor, oil level switch and oil pump on each cooling tower fan.

G. Freeze Protection:
1. Provide a freeze protection sequence to ensure proper operation of equipment during a freeze condition not limited to the following:
    a. Outside Air Handling Units & Supply Fans with heating and cooling coils: If unit is in occupied or unoccupied mode, upon the triggering of software point indicating a freeze condition or the low temperature sensor (freeze stat) indicates a freeze condition, the system will be disabled, close the outside air damper, open both heating and cooling valves to enable full flow condition. If heating coil discharge air sensor indicates a failure to control and is below setpoint then enable software point indicating a freeze condition, disable unit, close outside air damper, and open both heating and cooling valves to enable full flow condition. Ensure HW & CHW pumps are operational.
    b. Boilers - Enable during a freeze condition.
    c. Chillers – Open isolation valves then command by-pass valve to dump water into basin or by-pass tower. Enable condenser water pumps during a freeze condition.
    d. Air Cooled Chillers – Open isolation valves, then enable pumps, run cycle for 15 minutes per hour, open all chilled water valves.
    e. Protect coils downstream of DX cooling coil with freeze protection. If unit is in occupied or unoccupied mode, upon the triggering of software point indicating a freeze condition or the low temperature sensor (freeze stat) indicates a freeze condition, the system will be disabled, close the outside air damper, disable the DX cooling coil. If coil discharge air sensor indicates a failure to control and is below setpoint then enable software point indicating a freeze condition.
2. Temperature low limit switch wired with double pole single throw switch with one switch leg hard-wired to de-energize fan and one switch leg to signal BMCS.

H. Drain Pan Float Protection:
1. Interlock to shut down unit and close valves.
2. Cooling Coils mounted above ceiling and in roof mounted units.

3. Provide for each cooling coil location.
4. Signal BMCS alarm point

I. Domestic Water System:
  1. Interlock in-line circulating pumps at water heaters with return water pipe mounted thermostat to cycle pump with return water temperature.
  2. Interlock high temperature entering water solenoid valve with thermostat on discharge side of tempered water mixing valves.

J. Emergency Shutdown Station:
  1. Provide an emergency mushroom style push / pull station shutdown switch in the Administration Area or as directed by Owner / Architect.
  2. Signal the building automation system to de-energize the HVAC equipment.
  3. This is to stop exhaust fans and outside air units immediately.
  4. Other air handling units, chillers and equipment shall be shut down in an orderly manner so as to not damage the equipment.
  5. Once stopped, the system may only be restarted with a key operated switch located adjacent to the shutdown switch.

K. Science Room Utility Controllers:
  1. Interlock the utility controllers with related air-handling unit through software.

L. Copper Tube Boiler:
  1. Interlock each boiler to start its dedicated primary circulating pump. Interlock flow switch and pump to boiler safety terminal strip.
  2. On startup enable boiler and primary pump prior to starting secondary system pump until primary loop temperature reaches 105 degrees as per manufacturer’s recommendations.
  3. Disable secondary pump if boiler goes into alarm or fails to produce heating water within 30 minutes.

M. Hydronic Heating Boiler:
  1. Interlock each boiler to start its dedicated pump.
  2. On startup enable boiler prior to starting primary pump. Boiler should reach operating temperature prior to starting system pump as per manufacturer’s recommendations.
  3. Disable system pump if boiler goes into alarm or fails to produce heating water within 30 minutes.

N. Condensing and Non-Condensing Hot Water Boilers:
  1. Interlock each boiler to start its dedicated pump.
  2. Install communication cable between each boiler and master controller specified by boiler manufacturer.

O. Intrusion Alarm System:
  1. Interlock the intrusion alarm system for status of building occupancy.
  2. Disable HVAC system when building is in the unoccupied mode and alarm system is enabled. Either Time of Day Schedule and/or contact from the intrusion alarm system shall disable HVAC system.

3.3 GRAPHICS

A. Furnish as-built drawings indicating finally corrected "as installed" diagram(s) of the complete Building Management Control System.
   1. Modification of existing control systems shall be included.
   2. These must be as-built and any changes during the warranty period drawings must be revised and updated.
   3. Provide final sequence of operation in written format.

B. Provide a set of the "as installed" diagram(s) of the complete control system laminated in plastic and hung in the main mechanical room or as directed by Owner.

C. Provide a color-coded floor plan of the building showing the location of each system, and the area served by each AHU or related zone. These must be of professional quality. Floor plan is to hang in main mechanical room near central control panel.

D. Provide computer graphics for each system.

E. Provide final graphic room numbers as selected by District. Any changes during the warranty period shall be included.

3.4 IDENTIFICATION

A. Provide a laminated engraved nameplate on all control panels and devices shown on the "as installed" control diagrams. Coordinate engraving with nomenclature used on the diagrams.

B. A black-white-black laminated plastic engraved identifying nameplate shall be secured to each terminal cabinet, and control panels. Identifying nameplates shall have ½ inch high, engraved letters.

C. A red-white-red 2"x8" laminated plastic engraved identifying nameplate shall be secured to each audible/visual alarm and emergency shutdown device. Provide identification and location of each A/V device laminated in plastic and hung at refrigerant monitor with identification, location of devices and proper operation of system in a graphic floor plan with written sequence of operation. Identifying nameplates shall have ½ inch high, engraved letters. A red-white-red 12"x12" laminated plastic engraved identifying name plate shall be secured to outside of each door to machine room with "A REFRIGERANT LEAK HAS BEEN DETECTED IN THIS BUILDING WHEN AUDIBLE/VISUAL ALARM IS ENABLED. DO NOT ENTER. CONTACT MAINTENANCE DEPARTMENT."

D. A black-white=black laminated plastic engraved identifying nameplate shall be secured to ceiling grid directly below the control panel. Identifying name plates shall have ½" inch high engraved letters. White with black letters.

3.5 WIRING FOR BUILDING MANAGEMENT AND CONTROL SYSTEMS

A. Furnish and install all wire, conduit, raceways and cable systems required for the complete operation of the Building Management and Control System.

B. All wiring for the Building Management and Control System is specified in this section and includes, but is not limited to:
   1. Wiring of interlock system.
   2. Wiring of control instruments.
   3. Wiring of control panels.
   4. Wiring of related power supplies, i.e. transformers.
   5. Wiring of 120 VAC power circuits for control panels and devices.

C. All materials and methods specified in this section shall comply with the requirements specified in Division 26 of this specification.

D. All power supply requirements shall be connected to the building electrical distribution system in an approved manner. Do not connect control equipment of circuits common with other building loads or devices.

E. Temperature control wiring shall be jacketed cables installed with or without conduit as specified below or single conductors installed in conduit. Control wiring shall have minimum 300V insulation for low voltage wiring and 600V insulation for line voltage wiring.

F. All line voltage control wiring, all low voltage control wiring which is exposed in the central plant, penthouse, and other similar spaces; all low voltage control wiring which is routed through concealed inaccessible locations shall be installed in conduit.

G. All low voltage control wiring which is routed through concealed accessible locations may be run without conduit provided that the wiring run without conduit is properly supported from the building structure on maximum 5' centers and does not depend upon the ceiling grid or the ceiling support system for support. Wiring run in plenum spaces shall be plenum rated. Support all plenum wiring in accessible locations in bridle rings, J-hooks, D rings. Plenum wiring is not to be supported within building structure or attached to conduit raceways. All low voltage wiring must be installed through supports. Wires shall be supported on 5' centers and identified at each termination point and at 50' centers minimum. Install wire parallel or perpendicular to the structural features of the building.

H. Line and low voltage control wiring shall not be installed in the same conduit with control wiring and shall not be installed in the same conduit with power wiring.

I. All wiring associated with building management and control system cover shall be as follows:
   1. Sensor jacket color, Green
   2. LAN communications, Yellow
   3. All THHN wiring shall comply with Division 26 insulation color identification

3.6 EXHAUST AND SUPPLY FANS

A. Provide interlocks as scheduled on the plans unless shown on the electrical drawings.

B. Provide BMCS override to disable operation of all exhaust and supply fans interlocked and/or specified throughout project.

C. Provide by-pass timers for fans indicated in Fan Schedule and in the following locations:
   1. Fume Hoods
   2. Science Room exhaust fans

POINT DESCRIPTION	TYPE	DEVICE
Start/stop	DO	Control Relay
Outside Air Damper	DO	Electronic Operator
Fan Status	DI	Current Sensitive Relay

3.7 SYSTEM OVER-RIDE

A. Provide manual over-ride push buttons and pilot lights installed in a single control panel at the main central plant for all functions.
   1. Overrides shall be located within a locked panel.
   2. Provide override switch for:
      a. Chilled water central plant
      b. Hot water central plant
      c. Each Air Handling unit
      d. Existing systems
      e. Exhaust & supply fans

3.8 BUILDING ELECTRICAL USAGE

A. Provide digital monitoring of the building KVA and KWH. Coordinate with the switchgear manufacturer.

B. Electrical Quality monitoring:
   1. Monitor Watts, VA, VAR, Demand, Imbalance, and Power Factor.

3.9 MISCELLANEOUS

A. Freezer/Cooler Temperature Monitoring:

1. Provide an analog temperature sensor located in the freezer compartment and cooler compartment.

POINT DESCRIPTION	TYPE	DEVICE
Freezer Alarm	AI	RTD
Cooler Alarm	AI	RTD

B. Lighting Control:
1. Provide individual time/photo-cell and time based control of each lighting contactor specified in Division 26.
2. Provide momentary push buttons located at the central plant control panel, tennis courts, football, baseball, softball fields and/or concession stands to energize exterior lighting for a preprogrammed length of time.
    a. Provide separate control of each contactor.

POINT DESCRIPTION	TYPE	DEVICE
Lighting Contactor	DO	Control Relay
Momentary Control Switch	DI	Switch

C. Photocell: Provide a photocell mounted on the north side of the building. Location is to be approved by Owner / Architect / Engineer.

POINT DESCRIPTION	TYPE	DEVICE
Photocell	AI	Contact

D. Humidity Sensor: Provide a sensor in Library to monitor space conditions.

POINT DESCRIPTION	TYPE	DEVICE
Library Humidity	AI	Space Sensor

E. Outside Air: Provide a temperature sensor and a humidity sensor to monitor outside air conditions.

POINT DESCRIPTION	TYPE	DEVICE
Outside Temperature	AI	Thermistor
Outside Humidity	AI	Humidity Sensor

F. Solar Power Generation: Provide digital monitoring and logging of the solar power generation in KVA.

POINT DESCRIPTION	TYPE	DEVICE

G. Wind Power Generation: Provide digital monitoring and logging of the wind power generation in KVA.

POINT DESCRIPTION	TYPE	DEVICE

H. Cistern Water Level: Provide digital monitoring and logging, through the BMCS, of the cistern water level (inches). Coordinate with the cistern supplier and manufacturer.

POINT DESCRIPTION	TYPE	DEVICE

3.10 REFRIGERANT MONITORING / VENTILATION CENTRAL PLANT APPLICATIONS

A. Install refrigerant monitor in the central plant and other locations as required by code. Monitor the concentration of refrigerant through an analog input signal through the BMCS. Install (2) sensors at each chiller at opposite ends. Alarm levels of refrigerant concentrations are provided in the Code. Refrigerant levels shall be available at the BMCS.

B. Install audible and visual alarms in the area served, at locations as required by code. Audible sound pressure level of at least 15Dba above the operating ambient noise level within machine room and provide a distinctive strobe type visual alarm both inside and outside machine room at each entrance. Ceiling mounted rotating beacon in center of machine room. Strobes shall be provided immediately adjacent to and outside of each refrigeration machinery room exit. Provide visual and audible device installed at location as per local code.

C. Provide a clearly identified switch of the break-glass type immediately adjacent to inside and outside of each refrigeration machinery room exit for emergency shutdown. Label switches / buttons per Code. Provide an emergency ventilation button for control in the central plant. Upon alarm either through the sensor or by manually pushing the button, the emergency exhaust fan shall be activated and deactivating all the mechanical equipment i.e. chillers and pumps thru safety circuits upon alarm.

D. Provide ventilation control of the exhaust and supply fans and alarm the BMCS at the alarm condition number one. Provide ventilation control of the exhaust and supply fans, alarm the BMCS and signal the audible and visual alarms in the area served at alarm condition number two.

POINT DESCRIPTION	TYPE	DEVICE
Refrigerant Monitor / Sensors	AI	Control Panel
Emergency Buttons	DI	Button
Fan Start/Stop	DO	Control Relay
System Start/Stop	DO	Control Relay

3.11 INTERACTIVE INFORMATION BOARD (EDUCATIONAL DASHBOARD)

A. The “Educational Dashboard” is a data monitoring and display system. The system shall include necessary hardware, software and programming that will allow the building owner to share energy efficiency information and green building features/strategies with the occupants of the building. The dashboard is meant to educate individuals on the benefits of sustainable technologies and to create a spirit of cooperation for participation in the end.

B. The system works by feeding “real-time” utility data, such as power, gas and water consumption,

C. This system consists of two 42” diagonal, touch screen monitors mounted where shown of the drawings and a Dashboard Server as specified. The system will gather and display “real time” information from various sub-systems within the facility and other HTTP sources from the World Wide Webb.
1. There shall be no annual contract renewal or recurring cost to the school district for maintaining the system

D. The information will be indexed by touching icons depicting the information to be displayed on the monitor. The “real time” information shall include but not limited to the following:
1. Building KW accumulative usage for the day and historical daily totals for the past 30 days.
2. Building water usage for the day and historical daily totals for the past 30 days.
3. Photovoltaic panel energy production shown in kW and kWh.
4. Instantaneous building total air conditioning tonnage based on flow rate and supply and return water temperature differential.
5. Rain water cistern water level.
6. Educational Page:
   a. This page will illustrate the sustainable features of the building.

b. Page could include pictures and diagrams to illustrate features, along with descriptions of how equipment works and what the economic advantages are.

7. Dashboard capabilities could display the following features:
   a. Home page components
   b. Resource use, shown in real-time
   c. Historical comparison graphs
   d. Display building sustainable features
   e. Environmental information and tips
   f. Competition among building tenants
   g. CHPS checklist
   h. Other owner options

3.12 EXISTING AUTOMATION SYSTEM

A. The new system shall be fully integrated with the existing Building Automation System Host computer located at the School District maintenance facility. If there is no existing manufacturer's host computer reference Article 2.11 in this section.

B. The integrating shall include, but not be limited to, database additions, creation of graphics and implementing auto/answer and auto/dial telephone communications. Integration shall be consistent with District standards and practices.

C. The bid for the control work shall be based on the premise that existing control devices are operational and are not in need of repair or replacement, unless otherwise noted.

D. This subcontractor shall notify the Owner's representative of existing control devices that need to be replaced or repaired that may be noted in the process of installation of the new work.

3.13 NEW HOST COMPUTER REQUIREMENTS

A. The District presently owns and operates a Building Management and Control System host computer to support a system. The existing host computer equipment is not available for use by other manufacturers other the existing BMCS.

B. Provide a new Building Management and Control System host computer with printer located at the District's energy management office.
   1. Provide modem for management tasks.
   2. Make final connections necessary to provide a complete and functioning system.

C. Provide color graphics software. Complete graphics of all systems specified in this contract.

3.14 EXISTING SYSTEMS

A. Provide start/stop control for all the existing systems. Systems include all air-handling units, fan coil units, pumps, chillers, boilers, and fans. Provide one space temperature sensor for the optimum start/stop program for each system.

B. The integrating shall include database additions, implementing auto/answer and auto/dial telephone communications.
1. Implementation of the Districts existing facility management software is as follows:
a. Building optimum start/stop, minimum of ten zones.
b. Exterior lighting control.
c. Alarm functions.
2. Point names must be approved by Owner.

POINT DESCRIPTION	TYPE	DEVICE
System Start/Stop	DO	Control Relay
Space Temperature	AI	Space Thermistor
Water Temperature	AI	Pipe sensor

3.15 FAN POWERED TERMINAL UNIT COORDINATION

A. Equipment furnished in this section and installed by Section 23 36 16:
1. Automatic temperature control card (DDC).
2. Damper Actuator

B. Equipment furnished and installed by Section 23 36 16:
1. Damper.
2. Multi-point flow sensor.
3. Power transformer.
4 Controller enclosure.

3.16 VARIABLE FREQUENCY DRIVE INTERFACE

A. Interface to the VFD directly

B. Interface may be hardwired or via RS-485

C. The following points shall be available at a minimum:

Point Name	Type
Start-stop	DO
Drive alarm	DI
Last fault	AI
Reset drive	DO

Percent output	AI
Frequency output	AI
Speed	AI
Current	AI
Power	AI
Drive temperature	AI
KWH	AI
Run time	AI

3.17 SINGLE ZONE AIR HANDLING UNIT

A. Consists of a chilled water coil and a hot water heating coil in the REHEAT position. Control shall be as follows:

1. A room thermistor sensing space temperature shall, acting through the Direct Digital Control Panel, modulate the valve on the cooling coil and the valve on the hot water coil, in sequence, to maintain the desired space temperature. The air-handling unit shall be started and stopped from the BMCS System.
   a. If an outside air unit provides the outside air for single-zone air handling unit, the outside air unit shall be activated during the occupied periods.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
AHU Status	DI	Current Sensitive Relay
Space Temperature	AI	Space Thermistor
HW Valve	AO (1)	Electronic Operator
CHW Valve	AO (1)	Electronic Operator
Outside Air Damper	DO	Electronic Operator
Discharge Air Temperature	AI	Duct Thermistor

3.18 SINGLE ZONE AIR HANDLING UNITS WITH HUMIDITY CONTROL

A. These units are furnished with a chilled water cooling coil and a hot water coil in the reheat coil position. Controls shall be as follows:

1. A space temperature sensor shall, acting through the DDC panel, modulate the valves on the chilled water cooling coil and hot water reheat coil, in sequence, to maintain the desired space temperatures.
2. A humidity sensor, located in the space shall acting through the DDC panel, modulate the valve in the chilled water coil to maintain 55 degree

discharge air when space is above its humidity setpoint and in dehumidification.

a. The space temperature sensor shall modulate the valve on the hot water reheat coil to maintain space temperature.

3. The Space Humidity Sensor shall monitor the space relative humidity at all times. If the space relative humidity rises above the setpoint when the system is de-energized, over-ride the BMCS.
   a. Energize Air Handling Unit and Central Plant Equipment.
   b. Outside air damper shall remain closed and related exhaust fans de-energized.
4. If an outside air unit provides the outside air for single-zone air handling unit, the outside air unit shall be activated during the occupied periods.
5. Provide a CO_2 monitor located in the inlet side of the air-handling unit.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
AHU Status	DI	Current Sensitive Relay
Space Temperature	AI	Space Thermistor
CHW Valve	AO	Electronic Operator
Chilled Water Coil Discharge	AI	Duct Thermistor
Outside Air Damper	DO	Electronic Operator
Space Humidity	AI	Humidity Sensor
HW Valve	AO	Electronic Operator
Return Air Humidity	AI	Humidity Sensor
Discharge Air Temperature	AI	Duct Thermistor
CO_2 Concentration	AI	CO_2 Monitor

3.19 SINGLE ZONE AIR HANDLING UNIT WITH OUTSIDE AIR DEHUMIDIFICATION

A. Outside Air Pre-Treat Section on these units are furnished with a chilled water coil and a hot water heating coil in the PREHEAT position. Control shall be as follows:
   1. A duct mounted sensor sensing supply air temperature shall, acting through the Direct Digital Control Panel, modulate the valve on the cooling coil and the valve on the hot water coil, in sequence, to maintain the desired discharge air temperature of 55°F. The supply fan shall be started and stopped from the BMCS System.

2. Provide a temperature low limit switch located on the discharge side of the hot water preheat coil or the entering side of the cooling coil to de-energize the air handling unit and supply fan, close the outside air damper, open the hot water valve 100%, start the boiler and hot water pump, signal an alarm to the BMCS when the temperature drops below 32°F. Device shall be manual reset.

POINT DESCRIPTION	TYPES	DEVICE
Discharge Air Temperature	AI	Duct Thermistor
CHW Valve	AO	Electronic Operator
Outside Air Damper	DO	Electronic Operator
Freeze Status	DI	Temperature Low Limit Switch
HW Pre Heat Valve	AO	Electronic Operator

B. Supply Air Section of AHU Consists of a chilled water coil and a hot water heating coil in the REHEAT position. Control shall be as follows:

1. A room thermistor sensing space temperature shall, acting through the Direct Digital Control Panel, modulate the valve on the cooling coil and the valve on the hot water coil, in sequence, to maintain the desired space temperature. The air-handling unit shall be started and stopped from the BMCS System.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
AHU Status	DI	Current Sensitive Relay
Space Temperature	AI	Space Thermistor
HW Valve	AO (1)	Electronic Operator
CHW Valve	AO (1)	Electronic Operator
Outside Air Damper	DO	Electronic Operator
Discharge Air Temperature	AI	Duct Thermistor
Space Humidity	AI	Humidity Sensor
CO_2 Sensor	AI	CO_2 Sensor

3.20 SINGLE ZONE AIR HANDLING UNIT WITH SPLIT DEHUMIDIFICATION UNIT MOUNTED ON TOP

A. Split dehumidification units are furnished with a chilled water coil and a hot water heating coil in the PREHEAT position. Control shall be as follows:

1. A duct mounted sensor sensing supply air temperature shall, acting through the Direct Digital Control Panel, modulate the valve on the cooling coil and the valve on the hot water coil, in sequence, to maintain the desired discharge air temperature of 55°F. The supply fan shall be started and stopped from the BMCS System.
2. Provide a temperature low limit switch located on the discharge side of the hot water preheat coil or the entering side of the cooling coil to de-energize the air handling unit and supply fan, close the outside air damper, open the hot water valve 100%, start the boiler and hot water pump, signal an alarm to the BMCS when the temperature drops below 32°F. Device shall be manual reset.
3. Open OA damper and start supply fan before starting Air Handling Unit. Provide end switch to ensure damper is in the open position in either the manual (hand) or auto position of the motor starter.

POINT DESCRIPTION	TYPES	DEVICE
Supply Fan Start/Stop	DO	Control Relay
AHU Status	DI	Current Sensitive Relay
Discharge Air Temperature	AI	Duct Thermistor
CHW Valve	AO	Electronic Operator
Outside Air Damper	DO	Electronic Operator
Freeze Status	DI	Temperature Low Limit Switch
HW Pre Heat Valve	AO	Electronic Operator

B. AHU Consists of a chilled water coil and a hot water heating coil in the REHEAT position. Control shall be as follows:

1. A room thermistor sensing space temperature shall, acting through the Direct Digital Control Panel, modulate the valve on the cooling coil and the valve on the hot water coil, in sequence, to maintain the desired space temperature. The air-handling unit shall be started and stopped from the BMCS System.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay

POINT DESCRIPTION	TYPES	DEVICE
AHU Status	DI	Current Sensitive Relay
Space Temperature	AI	Space Thermistor
HW Valve	AO (1)	Electronic Operator
CHW Valve	AO (1)	Electronic Operator
Outside Air Damper	DO	Electronic Operator
Discharge Air Temperature	AI	Duct Thermistor

3.21 SINGLE ZONE AIR HANDLING UNITS

A. These units consist of a chilled water coil and an electric duct heater in the supply duct. Control shall be as follows:

1. A room Thermistor sensing space temperature shall, acting through the Direct Digital Control Panel, modulate the valve on the cooling coil and stage the electric duct heater, in sequence, to maintain the desired space temperature. The air-handling unit shall be started and stopped from the BMCS System.

POINT DESCRIPTION	TYPE	DEVICE
Start/Stop	DO	Control Relay
AHU Status	DI	Current Sensitive Relay
Space Temperature	DI	Space Thermistor
Electric Duct Heater	DO	Relay each stage
CHW Valve	AO	Electronic Operator
Outside Air Damper	DO	Electronic Operator
Discharge Air Temperature	AI	Duct Thermistor

3.22 SINGLE ZONE AIR HANDLING UNITS WITH HUMIDITY CONTROL

A. These units consist of a chilled water coil and an electric duct heater in the supply duct. Control shall be as follows:

1. A space temperature sensor shall, acting through the DDC panel, modulate the valves on the chilled water cooling coil and stage the

electric duct heater in sequence to maintain the desired space temperatures.

2. A humidity sensor, located in the return air and/or in the space shall, acting through the DDC panel, modulate the valve on the chilled water coil to maintain 55 degree discharge air when space is above its humidity setpoint and in dehumidification.
    a. The space temperature sensor shall stage the duct heater to maintain space temperature.
3. The Space Humidity Sensor shall monitor the space relative humidity at all times. If the space relative humidity rises above the setpoint when the system is de-energized, over-ride the BMCS.
    a. Energize Air Handling Unit and Central Plant Equipment
    b. Outside air damper shall remain closed and related exhaust fans de-energized

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
AHU Status	DI	Current Sensitive Relay
Space Temperature	AI	Space Thermistor
CHW Valve	AO	Electronic Operator
Chilled Water Coil Discharge	AI	Duct Thermistor
Outside Air Damper	DO	Electronic Operator
Space Humidity	AI	Humidity Sensor
Electric Heater	DO	Relay
Discharge Air Temperature	AI	Duct Thermistor

3.23 SINGLE ZONE AIR HANDLING UNITS CONTROL W/VARIABLE FREQUENCY DRIVE

A. This unit is furnished with a chilled water coil, a hot water heating coil in the reheat position, and a variable frequency drive. Control shall be as follows:
   1. A room Thermistor sensing space temperature through the Direct Digital Control Panel shall vary the speed of the fan to maintain room setpoint. The air volume of the fan can range from 100% to 50% of the air quantity specified. A leaving air temperature sensor in the duct through the Direct Digital Control Panel shall modulate the cooling coil control valve to maintain the 55F leaving air temperature. When the fan is at 50% of its specified air quantity and the room temperature is below the room setpoint, the room Thermistor shall modulate the valve on the cooling coil and the valve on the hot water coil in sequence to maintain the desired

space temperature. A room humidity sensor shall override the operation of the cooling coil control valve to maintain the relative humidity setpoint in the space. The room temperature sensor shall modulate the hot water reheat coil control valve to maintain the space temperature. The dehumidification sequence only applies after the fan has reached 50% of the specified air quantity.

POINT DESCRIPTION	TYPE	DEVICE
Start/Stop	DO	Control Relay
AHU Status	DI	Current Sensitive Relay
Space Temperature	AI	Space Thermistor
CHW Valve	AO	Electronic Operator
HW Valve	AO	Electronic Operator
Outside Air Damper	DO	Electronic Operator
Discharge Air Temperature	AI	Space Thermistor
Variable Speed Motor	AO	Motor Controller
Discharge Air Temperature	AI	Duct Thermistor

3.24 SINGLE ZONE AIR HANDLING UNITS WITH HUMIDITY CONTROL

A. These units are furnished with a hot water preheat coil, chilled water cooling coil, and a hot water reheat coil. Controls shall be as follows:
   1. A space temperature sensor shall, acting through the DDC panel, modulate the valves on the chilled water cooling coil and hot water reheat coil in sequence to maintain the desired space temperatures.
   2. A space humidity sensor located in the return air and/or in the space shall acting through the DDC panel, modulate the valve on the chilled water coil to maintain 55 degree discharge air when space is above its humidity setpoint and in dehumidification.
      a. The space temperature sensor shall modulate the valve on the hot water reheat coil to maintain space temperature.
   3. An averaging temperature sensor, located in the preheat discharge shall modulate the hot water control valve to maintain the desired setpoint.
   4. If an outside air unit provides the outside air for single-zone air handling unit, the outside air unit shall be activated during the occupied periods.
   5. Provide a temperature low limit switch located on the discharge side of the hot water preheat coil or the entering side of the cooling coil to de-energize the air handling unit, close the outside air damper, open the hot water valve 100%, start the boiler and hot water pump, signal an alarm to

the BMCS when the temperature drops below 37°F. Device shall be manual reset.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
AHU Status	DI	Current Sensitive Relay
Space Temperature	AI	Space Thermistor
CHW Valve	AO	Electronic Operator
Chilled Water Coil Discharge	AI	Duct Thermistor
Outside Air Damper	DO	Electronic Operator
Space Humidity	AI	Humidity Sensor
HW Valve (preheat)	AO	Electronic Operator
HW Valve (reheat)	AO	Electronic Operator
Discharge Air Temperature	AI	Temperature Sensor
Freeze Status	DI	Temperature Low Limit Switch

3.25 SINGLE ZONE DX AIR HANDLING UNIT

A. Consists of a direct expansion coil and hot water coil in the reheat position. Control shall be as follows:

1. A room thermistor sensing space temperature shall, acting through the Direct Digital Control Panel, energize the first stage of cooling, modulate the valve on the heating water in sequence, to maintain the desired space temperature. The air handling unit shall be started and stopped from the BMCS System.
    a. If an outside air unit provides the outside air for single zone air handling unit, the outside air unit shall be activated during the occupied periods.
2. A discharge air temperature sensor shall stage the electric duct heat to maintain 55°F.
3. Start/stop of the unit shall be by BMCS.
4. Provide a temperature low limit switch located on the discharge side of the hot water reheat coil to de-energize the air handling unit and supply fan, close the outside air damper, open the hot water valve 100%, start the boiler and hot water pump, signal an alarm to the BMCS when the temperature drops below 32°F. Device shall be manual reset.

POINT DESCRIPTION	TYPE	DEVICE
Start/stop	DO	Control Relay
AHU Status	DI	Current Sensitive Relay
Space Temperature	AI	Space Thermistor
HW Valve	AO(1)	Electronic Operator
Condensing Unit	DO	Control Relay(s)
Outside Air Damper	DO	Electronic Operator
Discharge Air Temperature	AI	Duct Thermistor
Freeze Status	DI	Temperature Low Limit Switch

MULTIZONE AIR HANDLING UNITS

3.26 MULTI-ZONE AIR HANDLING UNITS

A. These units consist of a chilled water cooling coil in the Cold Deck Zone, hot water heating coils in the zone ductwork and zone mixing dampers. Control shall be as follows:

1. A room thermistor sensing zone space temperature in each zone shall, acting through the Direct Digital Control Panel, modulate its zone mixing dampers and zone hot water valves, in sequence, to maintain the space temperature. The mixing damper must be in the full bypass position before the hot water valve is allowed to operate. The air-handling unit shall be started and stopped from the BMC System.
2. An averaging temperature sensor located in the cold deck discharge shall, acting through the Direct Digital Control Panel, modulate the chilled water control valve to maintain setpoint. Reference the drawing schedule for discharge temperature requirements.
3. Adjustment of damper linkages for single and multi-blade control is the responsibility of this Section.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
AHU Status	DI	Current Sensitive Relay
Cold Deck Temperature	AI	RTD Average Probe
CHW Valve	AO	Electronic Operator

POINT DESCRIPTION	TYPES	DEVICE
Zone Space Temperature	AI	Space Thermistor
Zone Damper	AO	Electronic Operator
HW Valve	AO	Electronic Operator

OUTSIDE AIR – AIR HANDLING UNITS

3.27 OUTSIDE AIR HANDLING UNIT CONTROL

A. These units are furnished with a chilled water coil and a hot water heating coil in the PREHEAT position. Control shall be as follows:
   1. A duct mounted sensor sensing supply air temperature shall, acting through the Direct Digital Control Panel, modulate the valve on the cooling coil and the valve on the hot water coil, in sequence, to maintain the desired discharge air temperature of 55°F. The air-handling unit shall be started and stopped from the BMCS System.
   2. Provide a temperature low limit switch located on the discharge side of the hot water preheat coil or the entering side of the cooling coil to de-energize the air handling unit, close the outside air damper, open the hot water valve 100%, start the boiler and hot water pump, signal an alarm to the BMCS when the temperature drops below 32°F. Device shall be manual reset.
   3. Open OA damper before starting unit. Provide end switch to ensure damper is in the open position in either the manual (hand) or auto position of the motor starter.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
AHU Status	DI	Current Sensitive Relay
Discharge Air Temperature	AI	Duct Thermistor
CHW Valve	AO	Electronic Operator
Outside Air Damper	DO	Electronic Operator
Freeze Status	DI	Temperature Low Limit Switch
HW Pre Heat Valve	AO	Electronic Operator

3.28 OUTSIDE AIR – AIR HANDLING UNITS

A. These units consist of a hot water preheat coil, chilled water cooling coil and a hot water reheat coil. Control shall be as follows:
   1. A temperature sensor located in the discharge of the hot water preheat coil shall, through the Direct Digital Control Panel, modulate the hot water control valve to maintain a 55°F discharge temperature (adjustable).
   2. Provide a temperature low limit switch located on the discharge side of the hot water preheat coil to de-energize the air-handling unit when the temperature drops below 37°F. Device shall be manual reset and signal an alarm to the BMCS. Provide freeze protection sequence.
   3. A temperature sensor located in the discharge of the air handling unit shall, through the Direct Digital Control Panel, modulate the hot water reheat control valve and chilled water control valve to maintain setpoint. Reference the schedule for discharge temperature requirements.
   4. Open O.A. Damper before starting unit. Provide end switch to ensure damper is in the open position in either the manual (hand) or auto position of the motor starter.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
AHU Status	DI	Current Sensitive Relay
Discharge Air Temperature	AI	Discharge Thermistor
HW Reheat Valve	AO	Electronic Operator
HW Preheat Valve	AO	Electronic Operator
CHW Valve	AO	Electronic Operator
Outside Air Damper	DO	Electronic Operator
Freeze Status	DI	Temperature Low Limit Switch

3.29 OUTSIDE AIR HANDLING UNIT CONTROL

A. These units are furnished with a chilled water coil and an electric duct heater in the duct supplying the unit. A duct mounted sensor sensing supply air temperature shall, modulate the valve on the cooling coil and stage the electric duct heater in sequence to maintain the desired supply temperature of 55°F. The air-handling unit shall be started and stopped from the BMCS System.

B. Provide a temperature low limit switch located on the discharge side of the electric duct heater to de-energize the air-handling unit when the temperature drops below 37°F. Close the outside air damper, activate the duct heater 100%, signal an alarm to the BMCS when the temperature drops below 32°F. Device shall be manual reset. Provide freeze protection sequence.

C. Open O.A. damper before starting unit. Provide end switch to ensure damper is in the open position in either the manual (hand) or auto position of the motor starter.

POINT DESCRIPTION	TYPE	DEVICE
Start/Stop	DO	Control Relay
AHU Status	DI	Current Sensitive Relay
Discharge Air Temperature	AI	Duct Thermistor
CHW Valve	AO	Electronic Operator
Outside Air Damper	DO	Electronic Operator
Freeze Status	DI	Temperature Low Limit Switch
Electric Heater	DO	Relay each stage

3.30 DX OUTSIDE AIR UNITS

A. These units are furnished with a direct expansion coil and electric heating coil in the reheat position. Control shall be as follows:

1. An ambient temperature sensor shall energize the first stage of cooling whenever the ambient temperature rises above 56°F (adjustable) and energize the second stage of cooling whenever the temperature is above 76°F (adjustable).
2. De-energize the DX cooling whenever the ambient temperature is below 55°F (adjustable).
3. Internal unit controls shall operate the hot gas bypass and defrost safeties as required.
4. A discharge air temperature sensor shall stage the electric duct heat to maintain 55°F.
5. Start/stop of the unit shall be by BMCS.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
Condensing Unit	DO	Control Relay(s)
Discharge Air Temperature	AI	Discharge RTD
Electric Heater	AO	Relay(s)

POINT DESCRIPTION	TYPES	DEVICE
Status	DI	Air Flow Switch
Outside Air Damper	DO	Electronic Operator
Ambient Temperature	AI	Thermistor

ROOF TOP UNITS

3.31 PACKAGED ROOFTOP UNIT

A. A room thermistor sensing space temperature shall sense room temperature.

POINT DESCRIPTION	TYPES	DEVICE
Space Temperature	AI	Space Thermistor
Start/Stop	DO	Control Relay
AHU Status	DI	Current Sensitive Relay
Cooling Stages	DO	Control Relay
Heating Stages	DO	Control Relay

3.32 PACKAGED ROOFTOP VARIABLE VOLUME UNIT CONTROL

A. Each system consists of a packaged roof mounted variable volume air conditioning unit with factory-mounted controls.
   1. Discharge air temperature control specified in Section 23 74 15.
   2. Static pressure control specified in Section 23 74 15.

B. Coordinated required interlocks of factory mounted control equipment.

C. Provide BMCS start/stop control of unit.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
Discharge Air Temperature	AI	Duct Thermistor

3.33 PACKAGED ROOF MOUNTED AIR CONDITIONING UNIT WITH GAS HEAT

A. These consist of a single stage cooling unit with gas-fired heat.

B. A space sensor shall, through a direct digital control panel, stage the cooling and heating to maintain space temperature. The air-handling unit shall be started and stopped from the BMCS system.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
Space Temperature	AI	Space Thermistor
Cooling	DO	Relay
Heating	DO	Relay
Draft Blower	DO	Relay
Discharge Air Temperature	AI	Duct Thermistor

3.34 PACKAGED ROOFTOP AIR CONDITIONING UNIT

A. Each system consists of a packaged roof mounted air conditioning unit.

B. Low voltage thermostat specified in Section 23 81 19.

C. Provide BMCS start/stop control of unit.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
Discharge Air Temperature	AI	Duct Thermistor

3.35 DX ROOFTOP UNITS

A. Each roof top unit is furnished with a low voltage thermostat. The BMCS shall provide start / stop control. Provide a temperature sensor in the space to provide optimum start / stop.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay

POINT DESCRIPTION	TYPES	DEVICE
Space Temperature	AI	Space Thermistor
Discharge Air Temperature	AI	Duct Thermistor

3.36 PACKAGED ROOFTOP UNIT

A. A room thermistor sensing space temperature shall, through a direct digital control panel, stage the cooling and heating to maintain space temperature. The unit shall be started and stopped from the BMCS system.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
Space Temperature	AI	Space Thermistor
Cooling Stages	DO	Relay
Heating Stages	DO	Relay
Discharge Air Temperature	AI	Duct Thermistor

KITCHEN HOOD VENTILATION SYSTEM

3.37 KITCHEN HOOD SUPPLY AIR HEATING SYSTEM

A. This system consists of a duct mounted hot water coil.

B. A thermistor sensing discharge air from the hot water coil shall, through the direct digital control panel, modulate the hot water valve to maintain a 70°F discharge temperature (adjustable).

C. Provide an electric low temperature switch located in the discharge of the hot water preheat coil to de-energize the supply air fan and close the outside air damper, open the hot water valve 100%, start the hot water pump, and signal the BMCS, when temperature drops below 32°F. Device shall be manual reset.

D. Provide a space temperature sensor to limit the rise in temperature during unoccupied times.

E. Provide interlocks to disable the fans during unoccupied times.

POINT DESCRIPTION	TYPES	DEVICE

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
Discharge Air Temperature	AI	Discharge Thermistor
HW Valve (Preheat)	AO	Electronic Operator
Freeze Status	DI	Low Temperature Switch
Space Sensor	AI	Space Thermistor

3.38 KITCHEN HOOD SUPPLY AIR HEATING SYSTEM

A. This system consists of a duct mounted electric duct heater and a supply fan.

B. A RTD sensing discharge air from the electric duct heater shall, through the direct digital control panel, stage the electric duct heater to maintain a 70° F discharge temperature (adjustable).

POINT DESCRIPTION	TYPES	DEVICE
Supply Fan	DO	Control Relay
Discharge Air Temperature	AI	Discharge RTD
Electric Heater	DO	Relay each stage

ROOM TERMINAL UNITS

3.39 CONSTANT VOLUME / VARIABLE VOLUME TERMINAL UNITS

A. Each unit shall consist of a pressure independent variable volume damper, a constant volume fan, and a hot water heating coil. The fans shall be interlocked with the AHU fan. Constant volume terminal shall start before AHU fan starts. Controls shall be as follows:
1. A space temperature sensor shall, through the direct digital control system, modulate the variable volume damper from full open to a minimum airflow rate to maintain room setpoint. If heating is required, the temperature sensor shall modulate the hot water control valve to maintain room setpoint with the variable volume damper in the minimum airflow position.
2. Control valve, and control valve operator are specified in this section.
3. The Controls Contractor shall furnish the terminal box manufacturer with a controller to be factory mounted. The controller shall display cfm, temperature, damper position, and hot water valve position.

POINT DESCRIPTION	TYPES	DEVICE
Space Temperature	AI	Space Thermistor
Primary Air	AO	Variable Volume Damper Operator
HW Valve	AO	Electronic Operator
Start/Stop	DO	Control Relay
Discharge Air Temperature	AI	Duct Thermistor

3.40 VARIABLE VOLUME TERMINAL UNIT CONTROL

A. Each unit consists of a variable volume damper, supply fan and electric heating coil.

B. The space temperature sensor shall, through the DDC terminal equipment controller, energize the unit fan, modulate the variable volume damper and stage the electric heating coil to maintain space temperature.

C. Interlock the variable volume damper closed and the supply fan unit fan to start prior to energizing the related air-handling unit.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
Zone Space Temperature	AI	Space Thermistor
Volume Damper	AO	Electronic Operator
Electric Heat	DO	Relays
Discharge Air Sensor	AI	Duct Thermistor

<u>VARIABLE VOLUME AIR HANDLING UNITS</u>

3.41 VARIABLE VOLUME AIR HANDLING UNITS

A. Units consist of a chilled water coil, a fan, a variable speed drive, and outside air fan.

B. The unit shall be started and stopped from the BMCS system.

C. Discharge air temperature control:
   1. A sensor far enough from the fan discharge to be truly representative of the average temperature shall modulate the valve on the cooling coil to maintain setpoint. Reference drawing schedule for discharge temperature.

D. Variable air volume control:
   1. Duct static pressure sensor shall be located in the duct at a position approximately 2/3 the distance from the fan in the longest duct run. Location is to be approved by Engineer and coordinated with Section 23 05 93.
   2. The static pressure sensors shall, through the DDC panel, accept the signal from the operating control sensor to:
      a. Transmit a signal to the supply fan motor speed controller.
      b. Modulate the fan speed to maintain the desired static pressure.
      c. Coordinate signal with the fan motor speed controller.
   3. Install a static pressure high limit safety device to de-energize the system.
      a. Manual reset.

E. Outside air Fan control:
   1. Each unit will be provided with an outside air supply fan. The supply fan will be activated with the air-handling unit.
   2. A hot water coil or electric heating coil shall be supplied in the outside air ductwork. A duct mounted temperature sensor shall modulate a hot water valve or stages of heat to maintain a leaving air temperature of 55°F (adjustable).
   3. Provide a temperature low limit switch located on the discharge side of the preheating unit to de-energize the air handling unit, close the outside air damper, open the hot water valve 100%, start the boiler and hot water pump, signal an alarm to the BMCS when the temperature drops below 37°F. Device shall be manual reset.
   4. During warm-up and cool-down periods (optimum start/stop), the outside air fans shall not be activated. During occupied times, the fans shall be activated.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
AHU Status	DI	Current Sensitive Relay
Discharge Air Temperature	AI	Space Thermistor
CHW Valve	AO	Electronic Operator
Outside Air Fan	DO	Control Relay
Outside Air Preheat Valve or Electric Heating Unit	AO DO	Electronic Operator or Relay for each stage

POINT DESCRIPTION	TYPES	DEVICE
Outside Air Temperature	AI	Duct Thermistor
Duct Static Pressure	AI	Static Pressure Sensor
Variable Speed Fan	AO	Motor Controller
Freeze Status	DI	Temperature Low Limit Switch

3.42 VARIABLE VOLUME AIR HANDLING UNIT CONTROL

A. Discharge air temperature control:
   1. An electronic sensor in the unit discharge shall, through the DDC, modulate the valve on the cooling coil to maintain setpoint. Reference drawing schedule for discharge temperature.

B. Variable air volume system control:
   1. Provide two static pressure sensors at the ends of the two longest duct runs at each unit.
      a. Locate in the supply duct far enough from the fan discharge to be truly representative of the average static pressure in the system.
      b. Coordinate with the work in Division 1.

C. The static pressure sensors shall, through the DDC panel, accept the signal from the operating control sensor to:
   1. Transmit a 4-20 MA signal to the supply fan motor speed controller.
   2. Modulate the fan speed to maintain the desired static pressure.
   3. Coordinate with the fan motor speed controller specified in another section.
   4. Install a static pressure high limit safety device to de-energize the system.
      a. Manual reset.

D. Outside air volume control:
   1. Each unit will be provided with an outside air supply fan. The supply fan will be activated with the air handling.
   2. A hot water coil shall be supplied in the outside air ductwork. A duct mounted temperature sensor shall modulate a hot water valve to maintain a leaving air temperature of 55°F (adjustable).
   3. Provide a temperature low limit switch located on the discharge side of the hot water preheat coil to de-energize the air handling unit, close the outside air damper, open the hot water valve 100%, start the boiler and hot water pump, signal an alarm to the BMCS when the temperature drops below 37°F. Device shall be manual reset.

POINT DESCRIPTION	TYPES	DEVICE

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
AHU Status	DI	Current Sensitive Relay
Discharge Air Temperature	AI	Space Thermistor
CHW Valve	AO	Electronic Operator
Outside Air Fan	DO	Control Relay
Outside Air HW Valve	AO	Electronic Operator
Outside Air Temperature	AI	Duct Thermistor
Static Pressure	AI	Static Pressure Sensor
Variable Speed Motor	AO	Motor Controller
Freeze Status	DI	Temperature Low Limit Switch

3.43 VARIABLE VOLUME DUAL DUCT AIR HANDLING UNITS

A. Units consist of a chilled water coil, a hot water coil, a fan, and a variable speed drive. Controls shall be as follows:
1. An electronic averaging duct sensor in the cold duct shall, acting through the DDC System, modulate the chilled water valve to maintain desired setpoint. An electronic averaging duct sensor in the hot deck shall, acting through the DDC system, modulate the hot water valve to maintain desired setpoint. A schedule shall be set up for the hot deck temperature based on outside air temperature. The temperature of the hot deck shall modulate between the following criteria. If the temperature outside is 50°F (adjustable) or below, the hot deck temperature shall be 95°F; if the outside temperature is 75°F or above, the hot deck coil shall be deactivated.
2. The unit shall be started and stopped from the BMCS system.
3. An electronic duct static pressure sensor shall be located in the cold duct at a position approximately 2/3 the distance from the fan in the longest duct run. Location is to be approved by Engineer and coordinated with Section 23 05 93. The sensor shall transmit a signal to the supply fan motor speed controller, and modulate the fan speed to maintain a supply duct static pressure. A high limit static pressure sensor with manual reset, located at the fan discharge, shall de-energize the supply fan when sensing pressure above duct construction capabilities. Fan start-up shall be initiated at minimum air speed.

POINT DESCRIPTION	TYPE	DEVICE
Start/Stop	DO	Control Relay
AHU Status	DI	Current Sensitive Relay
Discharge Air Temperature (2)	AI	Duct Temperature Sensor, One Each Deck
HW Valve	AO	Electronic Operator
CHW Valve	AO	Electronic Operator
Duct Static Pressure (2)	AI	Static Pressure Sensor, One Each Deck
Fan Speed	AO	Motor Controller

3.44 DOUBLE DUCT VARIABLE VOLUME TERMINAL UNITS

A. Each unit shall consist of two pressure independent variable volume dampers, one on each duct inlet connection. Controls shall be as follows:
1. A space temperature sensor shall, through the direct digital control system, modulate the variable volume damper on the cold deck from full open to 40% air flow rate to maintain room setpoint. When heating is required, the temperature sensor shall first modulate the variable volume damper on the hot duct and cold deck while maintaining 40% airflow. If more heating is required, the temperature sensor shall modulate the variable volume damper on the hot deck from 40% to full open to maintain room setpoint.
2. The BMCS Contractor shall furnish the terminal box manufacturer with a controller to be factory mounted. The controller shall display cfm, temperature, and damper position.
3. The BMCS Contractor shall furnish the terminal box manufacturer the control flow diagram for correct mounting of flow measurement devices, wiring of actuators, and terminal equipment controllers.

POINT DESCRIPTION	TYPE	DEVICE
Space Temperature	AI	Space Thermistor
Primary Air (2)	AO	Variable Volume Damper Operator
CFM Flow	AI	Control Panel

FAN COIL UNITS

3.45 FAN COIL UNITS

A. Each fan coil unit is furnished with a chilled water coil and hot water coil. Control shall be as follows:
   1. A space temperature sensor shall, acting through a terminal equipment controller, modulate the valves on the chilled water cooling coil and hot water reheat coil in sequence to maintain the desired space temperatures.
   2. Start/stop of fan coil unit shall be by terminal equipment controller.
   3. The outside air units providing the outside air shall be activated when the fan coil units are operating during the occupied periods.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
CHW Valve	AO	Electronic Operator
Space Temperature	AI	Space Thermistor
HW valve	AO	Electronic Operator
Discharge Air Temperature	AI	Duct Thermistor

3.46 DX FAN COIL UNITS

A. Each fan/coil unit is furnished with a direct expansion coil and hot water heating coil. Control shall be as follows:
   1. A space temperature sensor shall, acting through a terminal equipment controller, stage the DX cooling and modulate the hot water heating coil control valve in sequence, to maintain the desired space temperature.
   2. Start/stop of fan coil unit shall be by terminal equipment controller.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
Condensing Unit	DO	Control Relay
Space Temperature	AI	Space Thermistor
Heating Coil	AO	Electronic Operator
Status	DI	Air Flow Switch
Discharge Air Sensor	AI	Duct Thermistor

3.47 DX FAN COIL UNITS

A. Each fan/coil unit is furnished with a direct expansion coil. Control shall be as follows:
1. A space temperature sensor shall, acting through a terminal equipment controller, stage the DX cooling coil to maintain the desired space temperature.
2. Start/stop of fan coil unit shall be by terminal equipment controller.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
Condensing Unit	DO	Control Relay
Space Temperature	AI	Space Thermistor
Status	DI	Current Relay
Discharge Air Sensor	AI	Duct Thermistor

HEATERS

3.48 ROOM HEATERS

A. Each room heater is furnished with a fan and a hot water coil. Controls shall be as follows:
1. A space temperature sensor with an adjustable setpoint on the sensor shall, acting through a terminal equipment controller, activate the unit and modulate the hot water valve to maintain the desired space temperatures.
2. Start/stop of fan coil unit shall be by terminal equipment controller.
3. The fan for the room heater shall be interlocked with the outside air unit that serves the room heater such that any time the outside air unit is activated the room heater shall also be activated.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop	DO	Control Relay
Space Temperature	AI	Space Thermistor
HW valve	AO	Electronic Operator

3.49 CORRIDOR HEAT

A. Where the corridors are served from the outside air units and heat is provided in the corridor from a duct mounted hot water coil, provide a temperature sensor to control the hot water control valve.

POINT DESCRIPTION	TYPES	DEVICE
Space Temperature	AI	Space Thermistor

3.50 ELECTRIC UNIT HEATERS

A. An electric thermostat shall activate the unit and stage the electric coil to maintain room setpoint.

3.51 ENERGY RECOVERY UNIT

A. Each ERU has its own controls. BMCS shall enable unit and open outside air and exhaust air damper. Interlock ERU with the related air handling units.

B. The BMCS controls for energy recovery unit shall function as follows:
1. The system shall be automatically started and stopped by the BMCS panel whenever the hand-off-automatic switch is in the automatic position, and manually started and stopped by the hand position. The unit shall run when either AHU is enabled.
2. The energy recovery unit's internal controls shall be energized, and the dampers shall open prior to starting the energy recovery unit outside air and exhaust fans.
3. The internal controls shall start the energy recovery unit wheel rotation and modulate the wheel speed to maintain a leaving outside air temperature of 56° F in the winter mode and 79° F in the summer mode but not exceeding 50% relative humidity.
4. The energy recovery unit's internal controls shall shut down fans upon receiving a signal from the BMCS panel showing the AHU's are disabled.
5. On power interruption or fan shutdown, all the dampers shall close.
6. Smoke detector in the outside air duct downstream of the energy recovery unit shall automatically shut down the fans.

POINT DESCRIPTION	TYPES	DEVICE
Start/Stop OA Fan	DO	Control Relay
Status OA Fan	DI	Current Relay
Start/Stop EF Fan	DO	Control Relay
Status EF Fan	DI	Current Relay

POINT DESCRIPTION	TYPES	DEVICE
Energy Recovery Wheel VFD	DO	Control Relay
Energy Recovery Wheel VFD Status	DO	Control Relay
Entering OA Temp	AI	Thermistor
Entering OA Humidity	AI	Relative humidity sensor
Leaving OA Temperature	AI	Thermistor
Leaving OA Humidity	AI	Relative humidity sensor
Entering EA Temperature	AI	Thermistor
Entering EA Humidity	AI	Relative humidity sensor
Leaving EA Temperature	AI	Thermistor
Leaving EA Humidity	AI	Relative humidity sensor
Differential Across Filters	DI	High / Low limit Switch
EA & OA Dampers	DO	Control Relay

SCIENCE ROOM FANS

3.52 LABORATORY HOOD FANS

A. The laboratory hoods fans shall be provided with a lighted switch mounted on the face of the hood. The BMCS shall have disable and enable capabilities.

B. Interlock outside air damper and exhaust and supply fans.

POINT DESCRIPTION	TYPES	DEVICE
Enable/Disable	DO	Control Relay
Fan Status	DI	Current Sensitive Relay

3.53 LABORATORY PURGE FANS

A. The laboratory purge fan system shall consist of an exhaust fan and an interlocked supply fan. The system shall be activated by an emergency push button. The BMCS shall have fan status and provide an alarm if a purge system is activated.

B. Interlock outside air damper and exhaust and supply fans.

POINT DESCRIPTION	**TYPES**	**DEVICE**
Fan Status Alarm	DI	Current Sensitive Relay
Enable/Disable	DO	Control Relay

AIR COOLED CHILLERS

3.54 CHILLED WATER COOLING SYSTEM

A. Systems consist of **a single** packaged air-cooled chiller with dedicated chilled water pump.

B. Whenever there is a call for cooling in the system energize the system.

C. Reference interlock and safety circuits for interlocks and shut down.

POINT DESCRIPTION	TYPE	DEVICE
Chiller Start/Stop	DO	Control Relay
Chiller Status	DI	Safety Alarm Relay
Pump Start/Stop	DO	Control Relay
Pump Status	DI	Current Sensitive Relay
Building Supply/Return	AI	Temperature Sensors

3.55 CHILLED WATER COOLING SYSTEM

A. This system consists of a single packaged air-cooled chiller with dedicated chilled water pump.

B. Whenever there is a call for cooling in the system energize the system.

C. Reference interlock and safety circuits for interlocks and shut down.

POINT DESCRIPTION	TYPE	DEVICE
Chiller Start/Stop	DO	Control Relay

POINT DESCRIPTION	TYPE	DEVICE
Status (Chiller)	DI	Safety Alarm Relay
Pump Status	DI	Current Sen. Relay
Pump Start/Stop	D0	Control Relay
Building Supply/Return	AI	Temperature Sensors

3.56 CHILLED WATER SYSTEM CONTROL

A. Sensors each located in the common chilled water supply header and the common chilled water return header shall, through a DDC controller, provide appropriate signals:
   1. Signal #1 - Chilled water return temperature drop to 47°F (adjustable).
   2. Signal #2 - Chilled water supply temperature rise above 44°F (adjustable).

B. System A shall run continuously, during hours of operation, meeting all loads.

C. Signal #1 shall de-energize System B.
   1. Signal #2 shall energize System B.

D. Provide lead/lag sequencing to alternate lead chiller on a daily basis, based on total run time.

POINT DESCRIPTION	TYPE	DEVICE
Chiller Start/Stop	DO	Control Relay (each chiller)
Common Chiller water supply	AI	Pipe RTD
Common Chiller water return	AI	Pipe RTD
Status (Chiller)	DI	Safety Alarm Relay (each chiller)
Condenser water supply Temp.	AI	Pipe RTD (each chiller) Temp.
Chilled water supply	AI	Pipe RTD (each chiller) Temp.

3.57 CHILLED WATER SYSTEM CONTROL

A. The system consists of EDIT two packaged air-cooled chiller and two dedicated chilled water pumps.

B. The lead chilled water pumping system will be energized whenever there is a call for cooling in the building system. The lag-chilled water pumping system will be energized whenever the return water temperature is higher than 52°F. The lag-chilled water pumping system will be deactivated when the return water temperature is less than 46°F.

C. The lead/lag position shall be alternated every 24 hours based on total run time.

D. Reference interlock and safety circuits for interlocks and shut down.

POINT DESCRIPTION	TYPES	DEVICE
Chiller Start/Stop	DO	Control Relay
Pump Start/Stop	DO	Control Relay
Chiller Status	DI	Run Contact
Chiller Alarm	DI	Safety Alarm Contact
Pump Status	DI	Current Sensitive Relay
Building Supply/Return Temperature	AI	Pipe RTD (2 each)
Chiller Supply Temperature	AI	Pipe RTD

3.58 CHILLED WATER SYSTEM CONTROL

A. Temperature sensors located in the building common chilled water supply and return piping and the turbine flow meter located in the building chilled water common supply piping shall, acting through the DDC system, be used to calculate the building BTUH requirements.

B. Chillers 1 & 2 with their respective pumps shall be System 1. Chillers 3 & 4 with their respective pump shall be System 2. Chillers 5 & 6 with their respective pumps shall be System 3.

C. During start-up, System 1 primary pumps shall start. After flow has been indicated from the flow switch for an adjustable time period, the System 1 chillers shall be activated.

D. When the load calculated from the temperature sensors and flow meter exceeds the capacity of System 1 for an adjustable time period, the System 2 primary pumps and chillers shall be activated. When the load calculated from the temperature sensors flow meter exceeds the capacity of System 1 and System 2 for an adjustable time period, the System 3 primary pumps and chillers shall be activated.

E. If the load drops to below half the capacity (adjustable) of one system, then the lag chillers will be deactivated. The primary pumps serving the chillers will remain on for 3 minutes (adjustable) and then be deactivated.

F. A temperature sensor located in the chiller by-pass piping shall send an alarm to the host computer and shall start the lag chillers after an adjustable time delay, if the temperature in the by-pass is above 3 degrees (adjustable) higher than the temperature in the common supply from the chillers. This indicates the flow is moving from the primary loop to the secondary loop.

G. Provide time delays between pump starts and stops to allow system to stabilize.

H. Change lead/lag rotation on a weekly basis.

POINT DESCRIPTION	TYPES	DEVICE
Chiller Start/Stop	DO	Control Relay
Chilled Water Supply Temperature	AI	Pipe RTD (1 each)
Pump Start / Stop	DO	Control Relay
Pump Status	DI	Current Sensitive Relay
Building Flow	AI	Turbine Flow Meter
Building Supply/Return Water Temp.	AI	Temperature Sensors
Bypass Temperature	AI	Temperature Sensor
Common Chiller Supply Temperature	AI	Temperature Sensor
Common Chiller Return Temperature	AI	Temperature Sensor

3.59 CHILLED WATER SYSTEM CONTROL (GYMNASIUM PLANT)

A. The system consists of a single package air-cooled chiller and dedicated chilled water pump.

B. The chilled water pumping system will be energized whenever there is a call for cooling in the building system.

C. Reference interlock and safety circuits for interlocks and shut down.

POINT DESCRIPTION	TYPES	DEVICE
Chiller Start/Stop	DO	Control Relay
Chiller Status	DI	Safety Alarm Relay
Pump Start / Stop	DO	Control Relay
Pump Status	DI	Current Sensitive Relay
Building Supply/Return Temperature	AI	Pipe RTD (2 each)
Chilled Water Supply Temperature	AI	Pipe RTD (1 each)

3.60 CHILLED WATER SYSTEM CONTROL

A. Temperature sensors located in the building common chilled water supply and return piping and the turbine flow meter located in the building chilled water common supply piping shall, acting through the DDC system, be used to calculate the building BTUH requirements.

B. During start-up, the lead primary pump shall start. After flow has been indicated from the flow switch for an adjustable time period, the lead chiller shall be activated.

C. When the load calculated from the temperature sensors and flow meter exceeds the capacity of the lead chiller for an adjustable time period, the second primary pump and chiller shall be activated. When the load calculated from the temperature sensors and flow meter exceeds the capacity of the lead and second chiller for an adjustable time period, the third primary pump and chiller shall be activated.

D. If the load drops to by 125% of the capacity (adjustable) of <u>one</u> chiller, then the lag chillers will be deactivated. The primary pumps serving the chillers will remain on for 3 minutes (adjustable) and then be deactivated.

E. Provide time delays between pump starts and stops to allow system to stabilize.

F. Change lead/lag rotation on a weekly basis.

G. Interlock chillers to start / stop chilled and condenser water pumps.

POINT DESCRIPTION	TYPES	DEVICE

POINT DESCRIPTION	TYPES	DEVICE
Chiller Start/Stop	DO	Control Relay
Chiller Water Supply Temperature	AI	Pipe RTD (1 each)
Status (Chiller)	DI	Safety Alarm Relay
Pump Start / Stop	DO	Control Relay
Pump Status	DI	Current Sensitive Relay
Building Flow	AI	Turbine Flow Meter
Building Supply/Return Water Temp.	AI	Temperature Sensors
Chiller Supply Temperature	AI	Temperature Sensor

3.61 VARIABLE PRIMARY CHILLED WATER SYSTEM CONTROL

A. Chilled Water Central Plant consists of two air cooled chillers and two variable flow primary chilled water pumps. Each primary chilled water pump is sized for the maximum design flow rate of each chiller. Control shall be as follows:
1. On a call for cooling in the building the lead chiller's chilled water isolation valve shall open slowly. Travel time from fully closed to fully open shall be two minutes. The Indexed lead chilled water pump shall be energized and ramp up to full flow as required corresponding with the isolation valve travel. When internal chiller controls prove chilled water flow, lead chiller shall be energized. Chiller controls shall maintain leaving chilled water supply temperature set point of 42^{o}F (adjustable).
2. Two-system differential pressure sensors shall modulate the energized pump(s) speed controller to maintain the required system pressure in the building.
    a. Location of the building differential pressure system sensors shall be approved by the engineer and contractor specified in Section 23 05 93.
    b. Coordinate with the pump motor speed controller specified in another section.
3. On a daily basis change the chilled water pump lead/lag indexing. Daily lead pump indexed to run with the daily lead chiller, daily lag pump indexed to run with the daily lag chiller.
4. Measure the chilled water pressure drop across each chiller evaporator to monitor chiller minimum flow.
    a. Minimum flow as recommended by the chiller manufacturer.
    b. As the sensed differential pressure falls below the pressure drop associated with the chiller recommended minimum flow rate (3

psi, adj), modulate the variable primary flow by-pass control valve to maintain minimum flow through each chiller.

c. Provide control valve and actuator capable of tight close-off against system differential pressure. Size the by-pass valve for the minimum flow of one chiller.

5. Upon a rise in common chilled water supply temperature to 45.5°F (adjustable) for period of 15 minutes (adjustable), the lag chiller and related pump shall be energized.
   a. Prior to energizing, ramp the lead chilled water pump to 50% of flow (adjustable) and demand limit the lead chiller to 60% capacity (adjustable).
   b. Open lag chiller's chilled water isolation valve slowly with two minute travel time from fully closed to fully open and ramp up to 50% flow the indexed lag chilled water pump (adjustable). When internal chiller controls prove chilled water and condenser water flow, lag chiller shall be energized. Chiller controls shall maintain leaving chilled water set point of 42°F (adjustable). Release constraints on chiller limits and chilled water pump speed controller to allow system to automatically meet the building requirements.
6. Upon a decreasing load condition, de-energize lag chiller in the opposite order that they were energized.
   a. Through an interface with the chiller controls, monitor percentage of running load amps (% RLA) of each chiller. When the total of both chiller % RLA drops to 90% (adjustable) of one chiller for 15 minutes (adjustable) de-energize the lag chiller. Allow lag chilled water pump to operate for 5 minutes (adjustable), then de-energize pump and close the chiller's chilled water isolation valve.
7. Alternate the lead/lag chiller on a daily basis.

POINT DESCRIPTION	TYPES	DEVICE
Chiller Start/Stop (Each chiller)	DO	Control Relay
Chiller LWT Temperature Reset	AO	Chiller Control Module
Chiller % RLA (Each chiller)	AI	Chiller Control Module
Chiller Alarm	AI	Chiller Control Module
Chiller Status	DI	Chiller Control Module
Chiller Isolation Valve (Each Chiller)	AO	Electronic Operator
Chilled Water Supply Temperature (Each chiller)	AI	Pipe RTD
Chilled Water Return Temperature	AI	Pipe RTD

POINT DESCRIPTION	TYPES	DEVICE
(Each chiller)		
Chiller Differential Water Press. (Each chiller)	AI	Pressure Differential Sensor
Pump Start / Stop (Each of two pumps)	DO	Control Relay
Pump VFD (Each of two pumps)	AO	Motor Controller
Pump Status (Each of three pumps)	DI	Current Sensitive Relay
Minimum Flow By-Pass Valve	AO	Electronic Operator
Building Common Supply Water Temperature	AI	Pipe RTD
Building Common Return Water Temperature	AI	Pipe RTD
Building Flow Meter	AI	Turbine Flow Meter
Building Pressure Differential (Two required)	AI	Pressure Sensor

3.62 CONDENSER WATER CONTROL

A. A sensor located in the condenser water supply shall, through a DDC panel:
1. Modulate the three-way valve located in the condenser water piping.
2. Enable the variable frequency drive (VFD).
3. Maintain minimum speed for proper gearbox lubrication and motor cooling.
4. Control the variable speed of the fan.
5. Maintain entering water temperature to each condenser as recommended by the chiller manufacture. (85°F adjustable)

B. Controller sequence:
1. Throttling range: - 20°F.
2. Set point: - 85°F (adjustable)
3. At 4° below set point, the condenser water shall be full flow to the tower riser.
4. At setpoint the VFD is to be enabled at minimum speed.
5. Upon a continued rise in temperature, the VFD should increase the speed of the cooling tower fan as required to maintain setpoint.
6. Decrease or increase the speed of the cooling tower fan as required to maintain temperature setpoint.
7. The VFD should be disabled at 7° below setpoint (adjustable).

C. Provide full automatic control of the entering condenser water temperature on initial chiller start-up.

D. Close 3-way control valve to by-pass when pumps are disabled.

POINT DESCRIPTION	TYPE	DEVICE
Start/Stop Pump	DO	Control Relay
Start/Stop VFD	DO	Control Relay
VFD speed	AO	Electronic output
Tower Bypass Valve	AO	Electronic Operator
Tower Isolation Valve	AO	Electronic Operator
Chiller Isolation Valve	AO	Electronic Operator
Status (Pumps)	DI	Current Sensitive Relay
Status (Tower Fan)	DI	Current Sensitive Relay

3.63 CHILLED WATER SYSTEM CONTROL

A. The system consists of one air-cooled chiller and with a dedicated chilled water pump.

B. Start/stop the chilled water system upon a call for cooling in the system.

POINT DESCRIPTION	TYPE	DEVICE
Pump Start/Stop	DO	Control Relay
Pump Status	DI	Current Sensitive Relay
Building supply/return Temp.	AI	Pipe RTD (2 each)
Chiller Status	DI	Safety Alarm Relay

HEATING SYSTEM

3.64 HYDRONIC HEATING SYSTEM

A. The system consists of one heating water boiler, and dedicated pump.

B. Energize the pump whenever there is a call for heating in the building.

C. Heating water temperature reset

1. A temperature sensor located in the building heating water supply piping shall:
    a. Signal the DDC panel.
    b. Modulate the three-way valve in the boiler water piping to maintain the desired building heating water temperature.
2. A temperature sensor sensing outdoor air shall reset the control point of the DDC inversely with the outside air temperature.
    a. Maintain 180°F when the outside air temperature is 20°F.
    b. Maintain 140°F when the outside air temperature is 70°F and above.

D. Enable the boiler throughout the year with an override option to disable the boiler, as Owner requires.

E. Interlock the boiler circulating pump with the related boiler. Provide a time delay relay off to disperse the heat in the boiler as required by manufacturer. Disable the related pump if boiler fails to produce heating water or boiler goes into alarm.

POINT DESCRIPTION	TYPES	DEVICE
Boiler Enable/Disable	DO	Control Relay
Boiler Alarm Status	DI	Safety Relay
Pump Start/Stop	DO	Control Relay
Pump Status	DI	Current Sensitive Relay
Building Supply/Return Temperature	AI	Pipe RTD
Hot Water Mixing Valve	AO	Electronic Operator
Boiler discharge water Temperature	AI	Pipe RTD
Ambient Temperature	AI	Thermistor

3.65 HYDRONIC HEATING SYSTEM

A. The system consists of two heating water boilers and dedicated pumps. Control of the hot water heating system is as follows:
1. Energize the building hot water heating system whenever there is a call for heating in the building.
2. Energize the boiler(s) and boiler water circulating pump(s) whenever there is a call for heating and based on the following schedule:
    Outside temperature at 50°F or above - lead boiler only.
    Outside temperature below 50°F - lead and lag boiler.

Return water temperature drops below 140° F lag boiler.

3. Interlock the boiler circulating pump with the related boiler. Provide a time delay relay off to disperse the heat in the boiler as required by manufacturer. Disable the related pump if boiler fails to produce heating water or boiler goes into alarm.
4. A temperature sensor sensing outdoor air temperature shall reset the hot water temperature inversely with the outdoor air temperature using the mixing valve at each boiler.
   a. Maintain 180°F when the outdoor temperature is 20°F.
   b. Maintain 140°F when the outdoor temperature s 70°F and above.
5. Provide lead/lag sequencing to alternate lead boiler on a daily basis.
6. Enable the boilers throughout the year with an override option to disable the boilers, as Owner requires.

POINT DESCRIPTION	TYPES	DEVICE
Boiler Enable/Disable	DO	Control Relay
Boiler Alarm Status	DI	Safety Relay
Pump Start/Stop	DO	Control Relay
Pump Status	DI	Current Sensitive Relay
Building Supply/Return Temperature	AI	Pipe RTD
Hot Water Mixing Valve	AO	Electronic Operator
Boiler discharge water Temperature	AI	Pipe RTD
Ambient Temperature	AI	Thermistor

3.66 HYDRONIC HEATING SYSTEM

A. System consists of two heating water boilers and dedicated variable speed pumps. Control of the hot water heating system is as follows:

1. Energize the boiler(s) and boiler water circulating pump(s) whenever there is a call for heating and based on the following schedule:
   Outside temperature at 50°F or above - lead boiler only.
   Outside temperature below 50°F - lead and lag boiler.
   Return water temperature drops below 140° F lag boiler.
2. A system differential pressure sensor shall sequence the pumps and signal the heating water pump speed controllers.
   a. Stage the pumps to maintain desired system differential pressure.
   b. Modulate the pump speed controllers to maintain desired system differential pressure.

c. Coordinate with the pump motor speed controller specified in another section.
d. Location and quantity of sensors to be approved by Engineer / Section 23 05 93.
e. Alternate the lead pump on a daily basis.

3. A temperature sensor sensing outdoor air temperature shall reset the hot water temperature inversely with the outdoor air temperature using the mixing valve at each boiler.
   a. Maintain 180°F when the outdoor temperature is 20°F.
   b. Maintain 140°F when the outdoor temperature s 70°F and above.
4. Provide lead/lag sequencing to alternate lead boiler on a daily basis.
5. Enable the boilers throughout the year with an override option to disable the boilers, as Owner requires.
6. Interlock the boiler circulating pump with the related boiler. Provide a time delay relay off to disperse the heat in the boiler as required by manufacturer. Disable the related pump if boiler fails to produce heating water or boiler goes into alarm.

POINT DESCRIPTION	TYPES	DEVICE
Boiler Enable/Disable	DO	Control Relay
Boiler Alarm Status	DI	Safety Relay
Pump Start/Stop	DO	Control Relay
Pump Status	DI	Current Sensitive Relay
System Differential Pressure	AI	Pressure Sensor
Pump Speed Controller	AO	Motor Controller
Building Supply/Return Temperature	AI	Pipe RTD (2 each)
Hot Water Mixing Valve	AO	Electronic Operator
Boiler Shell Water Temperature	AI	Pipe RTD in boiler shell
Ambient Temperature	AI	Thermistor

3.67 HYDRONIC HOT WATER HEATING SYSTEM

A. This system consists of two condensing hot water boilers with constant flow primary boiler pumps and variable flow hot water secondary pumps. Control of the hydronic hot water heating system is as follows:
   1. Energize the hydronic hot water heating system whenever there is a call for heating in the building.

a. Monitor all control valves to determine if a heating requirement exists.

2. Energize the hybrid sequence controller specified elsewhere.
   a. The hybrid sequence controller shall control all functions and sequencing of the hot water heating boilers.
   b. Connect all boilers to the master boiler controller specified elsewhere with communication cable as required.
3. Hydronic hot water heating system supply temperature reset.
   a. A temperature sensor sensing outdoor temperature shall provide an input to the hybrid sequence controller to reset the hot water supply temperature.
      1) Maintain 130°F supply water temperature whenever the ambient temperature is 20°F and below.
      2) Maintain 110°F supply water temperature whenever the ambient temperature is 60°F and above.
      3) All reset temperatures shall be adjustable through the BMCS.
4. Secondary hot water pump control:
   a. A system differential pressure sensor shall modulate the hot water pump variable frequency drives and stage pumps A and B to maintain system differential pressure.
   b. This system shall be completely adjustable in the field.

POINT DESCRIPTION	TYPES	DEVICE
Hybrid Sequence Controller	DO	Control Relay
Boiler Alarm Status	DI	Safety Relay (Each Boiler)
Secondary Hot Water Pump Start/Stop/Modulation	AO	Variable Frequency Drive (Each Pump)
Pump Status	DI	Current Sensitive Relay
Building Hot Water Supply/Return Temperature	AI	Pipe RTD
Boiler Discharge Water Temperature	AI	Pipe RTD (Each Boiler)
Ambient Temperature	AI	Thermistor
Boiler Supply Water Reset	AO	Hybrid Sequence Controller

WATER COOLED CHILLERS

3.68 CHILLED WATER SYSTEM CONTROL

A. Temperature sensors located in the building common chilled water supply and return piping and the turbine flow meter located in the building chilled water common supply piping shall, acting through the DDC system, be used to calculate the building BTUH requirements.

B. Chiller 1 with its respective pump shall be System 1. Chiller 2 with its respective pump shall be System 2.

C. During start-up, System 1 primary pump shall start. After flow has been indicated from the flow switch for an adjustable time period, the System 1 chiller shall be activated.

D. When the load calculated from the temperature sensors and flow meter exceeds the capacity of System 1 for an adjustable time period, the System 2 primary pump and chiller shall be activated.

E. If the load drops to below half the capacity (adjustable) of <u>one</u> system, then the lag chillers will be deactivated. The primary pumps serving the chillers will remain on for 3 minutes (adjustable) and then be deactivated.

F. A temperature sensor located in the chiller by-pass piping shall send an alarm to the host computer and shall start the lag chiller after an adjustable time delay, if the temperature in the by-pass is above 3 (adjustable) higher than the temperature in the common supply from the chillers. This indicates the flow is moving from the primary loop to the secondary loop.

G. Provide time delays between pump starts and stops to allow system to stabilize.

H. Change lead/lag rotation on a weekly basis.

POINT DESCRIPTION	TYPES	DEVICE
Chiller Start/Stop	DO	Control Relay
Chiller Water Supply Temperature	AI	Pipe RTD (1 each)
Status (Chiller)	DI	Safety Alarm Relay
Pump Status	DI	Current Sensitive Relay
Building Flow	AI	Turbine Flow Meter
Building Supply/Return Water Temp.	AI	Temperature Sensors
Bypass Temperature	AI	Temperature Sensor
Common Chiller Supply Temperature	AI	Temperature Sensor
Common Chiller Return Temperature	AI	Temperature Sensor

3.69 CHILLED WATER SYSTEM CONTROL

A. Sensors, each located in the common chilled water supply and return piping header and the turbine flow meter located in the building return or supply piping header shall, through a DDC controller, provide appropriate building Btuh calculations.

B. Start the smallest tonnage chiller on a daily basis first as system 1.

C. When the load calculated from the temperature sensors and flow meter exceeds 90% of the capacity of System #1 for an adjustable time period, the System #2 primary pump and chiller shall be activated. After System #2 has proven to be enabled, disable System #1.

D. When the load calculated from the temperature sensors and flow meter exceeds 90% of the capacity of System #2 for an adjustable time period, the System #3 primary pump and chiller shall be activated.

E. When the load calculated from the temperature sensors and flow meter exceeds 90% of the capacity of System #2 and #3 for an adjustable time period, the System #1 primary pump and chiller shall be activated.

F. If the load drops to below 75% of the capacity (adjustable) of <u>one</u> system, then the lag chillers will be deactivated.

G. A temperature sensor located in the chiller by-pass piping shall send an alarm to the DDC controller and shall start the lag chiller after an adjustable time delay, if the temperature in the by-pass is above 3 (adjustable) higher than the temperature in the common supply from the chillers. This indicates the flow is moving from the primary loop to the secondary loop.

H. Provide time delays between pump starts and stops to allow system to stabilize.

I. Provide lead/lag sequencing to alternate lead chiller of System #2 and #3 on a daily basis, based on total run time.

POINT DESCRIPTION	TYPES	DEVICE
Chiller Start/Stop	DO	Control Relay (each chiller)
Common Chiller Water Supply	AI	Pipe RTD
Common Chiller Water Return	AI	Pipe RTD
Status (Chiller)	DI	Safety Alarm Relay (each chiller)
Condenser water supply Temp.	AI	Pipe RTD (each chiller)

POINT DESCRIPTION	TYPES	DEVICE
		Temperature
Chilled Water Supply	AI	Pipe RTD (each chiller) Temperature
Building Flow	AI	Turbine Flow Meter
Bypass Temperature	AI	Pipe RTD

3.70 CHILLED WATER SYSTEM CONTROL (MAIN CENTRAL PLANT)

A. The system consists of three water cooled chillers and three dedicated primary chilled water pumps.

B. Temperature sensors located in the building common chilled water supply and return piping and the turbine flow meter located in the building chilled water common supply piping shall, acting through the DDC system, be used to calculate the building BTUH requirements.

C. During start-up, one primary pump shall start. After flow has been indicated from the flow switch for an adjustable time period, the chiller shall be activated.

D. When the load calculated from the temperature sensors and flow meter exceeds the capacity of one chiller for an adjustable time period, the second primary pump and chiller shall be activated.

E. If the load drops to below half the capacity (adjustable) of one chiller, then the lag chiller will be deactivated. The primary pump serving the chiller will remain on for 3 minutes (adjustable) and then be deactivated.

F. A temperature sensor located in the chiller by-pass piping shall send an alarm to the host computer and shall start the lag chiller after an adjustable time delay, if the temperature in the by-pass is above 3 degrees (adjustable) higher than the temperature in the common supply from the chillers. This indicates the flow is moving from the primary loop to the secondary loop.

G. Provide time delays between pump starts and stops to allow system to stabilize.

H. Change lead/lag rotation on a weekly basis.

POINT DESCRIPTION	TYPES	DEVICE
Chiller Start/Stop	DO	Control Relay
Chilled Water Supply Temperature	AI	Pipe RTD (1 each)

POINT DESCRIPTION	TYPES	DEVICE
Status (Chiller)	DI	Safety Alarm Relay
Pump Status	DI	Current Sensitive Relay
Building Flow	AI	Turbine Flow Meter
Building Supply/Return Water Temp.	AI	Temperature Sensors
Bypass Temperature	AI	Temperature Sensor

CONDENSER WATER CONTROL

3.71 CONDENSER WATER CONTROL

A. A sensor located in the condenser water supply shall, through a DDC panel:
   1. Modulate the three-way valve located in the condenser water piping.
   2. When the three-way control valve is in the full cooling position with all the water flowing over the tower and no water being by-passed enable the tower fan.
   3. Cycle the tower fan to maintain water temperature entering each condenser at 85°F.
   4. As the temperature decreases cycle the fan to the off condition and modulate the three-way control valve towards the by-pass position.

B. Controller sequence:
   1. Throttling range: - 20°F.
   2. Set point: - 85°F (adjustable)
   3. At set point the condenser water shall be full flow to the tower riser.
   4. Maximum condenser water supply: - 85°F.
   5. Energize the tower fan at 82°F.

C. Provide wiring for vibration switch, with manual reset, to de-energize the fan in the event of a sensed malfunction.
   1. Set limits as recommended by the tower manufacturer.
   2. Vibration switch specified to be provided in Section 23 65 40.

POINT DESCRIPTION	TYPE	DEVICE
Start/Stop Pump	DO	Control Relay
Start/Stop Tower Fan	DO	Control Relay
Tower Bypass Valve	AO	Electronic Operator
Status (Pumps)	DI	Current Sensitive Relay

POINT DESCRIPTION	TYPE	DEVICE
Status (Tower Fan)	DI	Current Sensitive Relay

<u>PUMPING SYSTEM CONTROL</u>

3.72 SECONDARY CHILLED WATER PUMPING SYSTEM CONTROL

A. The system consists of EDIT three variable speed secondary chilled water pumps controlled as follows:
1. The chilled water pumping system will be energized whenever there is a call for cooling in the building system.
2. A system differential pressure sensor shall sequence the pumps and signal the chilled water pump speed controllers.
   a. Stage the pumps to maintain desired system differential pressure.
   b. Modulate the pump speed controllers to maintain desired system differential pressure.
   c. Coordinate with the pump motor speed controller specified in another section.
3. Alternate the lead pump on a daily basis.
4. Location and quantity of sensors to be approved by Engineer.

POINT DESCRIPTION	TYPES	DEVICE
Pump Start/Stop	DO	Control Relay
Pump Status	DI	Current Sensitive Relay
System Differential Pressure	AI	Pressure Sensor
Pump Speed Controller	AO	Motor Controller

3.73 CHILLED WATER SYSTEM BYPASS

A. The system consists of chilled water system pressure sensors and a system bypass valve controlled as follows:
1. A system differential pressure sensor shall modulate the chilled water bypass valve to maintain system pressure.

POINT DESCRIPTION	TYPES	DEVICE
System Differential Pressure	AI	Pressure Sensor
Bypass Valve	AO	Electronic Operator

3.74 MISCELLANEOUS

A. Central Plant Ventilation: The ventilation system consists of two exhaust fans and motorized dampers with louvers for make-up air. The fans shall be activated by a thermostat, with an emergency pushbutton on the exterior of the central plant at the entrance, or from a signal from the oxygen depletion sensor. Anytime the fans are activated the dampers on the louvers shall open. When the fans are activated by the thermostat, the fans shall be sequenced so that the first one operates at 75°F (adjustable) and the second one operates at 85°F (adjustable).

3.75 LABORATORY FUME HOOD

A. Provide start/stop pushbutton with pilot light for fume hood exhaust fan. Locate pushbutton on hood.

3.76 EMERGENCY PURGE

A. Provide start/stop pushbutton with pilot light for laboratory emergency purge. Locate pushbutton where indicated on Drawings.

3.77 DISHWASHER EXHAUST

A. Interlock exhaust fan to operate when dishwasher is operating. Provide 5 minute (adjustable) run time for fan after dishwasher stops.

3.78 CHEMICAL TREATMENT SYSTEM

A. Monitor water treatment power circuit and alarm contacts from water treatment controllers. Provide with cooling tower systems only.

3.79 EMERGENCY VENTILATION SYSTEM

A. Provide a refrigerant monitor, an emergency ventilation button, and an emergency machinery button for control in the central plant on inside & outside each of each door. Upon alarm either through the sensor or by manually pushing the emergency ventilation button, the emergency exhaust fan shall be activated. Upon alarm, either through the sensor, or by manually pushing the emergency machinery button, all the mechanical equipment, i.e. chillers and pumps, shall be deactivated. A temperature sensor located in the room shall enable exhaust fan if the temperature rises above 85F. Provide a visual and audible device. Alarm levels of refrigerant concentrations are provided in the Code. Label buttons per Code. Label each audible and visual device as specified. Provide a sign at each entrance to central plant to indicate information about system. Provide two (SCUBU) units as required by code on inside and outside of central plant.

POINT DESCRIPTION	TYPES	DEVICE
Refrigerant Sensor	DI	Control Panel
Emergency Ventilation Button	DI	Button
Fan Start/Stop	DO	Control Relay
System Start/Stop	DO	Control Relay
Emergency Machine Button	DI	Button

3.80 EMERGENCY VENTILATION SYSTEM

A. Provide a refrigerant monitor, an emergency ventilation button, and an emergency machinery button for control in the central plant on inside & outside each of doors. **A two-speed exhaust fan shall be provided for ventilation. The fan shall operate in low speed continuously**. Upon alarm either through the sensor or by manually pushing the emergency ventilation button, the emergency exhaust fan shall be go to high speed. Upon alarm, either through the sensor, or by manually pushing the emergency machinery button, all the mechanical equipment, i.e. chillers and pumps, shall be deactivated. A temperature sensor located in the room shall switch the fan to high speed if the temperature rises above 85°F. Provide a visual and audible device. Label buttons per Code. Buttons shall be break glass type. Alarm levels of refrigerant concentrations are provided in the Code. Label buttons per Code. Refrigerant levels shall be available at the BMCS. Provide two (SCUBU) units as required by code on inside and outside of central plant. Provide a sign at each entrance to central plant to indicate information about system.

POINT DESCRIPTION	TYPES	DEVICE
Refrigerant Sensor	DI	Control Panel
Emergency Ventilation Button	DI	Button
Fan Speed	DO	Control Relay
System Start/Stop	DO	Control Relay
Emergency Machine Button	DI	Button
Temperature Sensor	AI	Thermister

3.81 SWIMMING POOL PACKAGED UNIT

A. This unit is a packaged unit with controls included with the unit. The unit dehumidifies, cools, and heats the natatorium. The unit shall be started through the BMCS. The BMCS shall monitor the indoor temperature and relative humidity conditions and the display the operating mode of the packaged unit. Interlock the swimming pool heating water pump (furnished by the Pool Contractor) with the swimming pool unit. Install remote controls, outside air sensors, space sensors provided with by pool unit manufacturer. Provide interlock wiring between remote condenser and swimming pool unit. Coordinate locations and wiring with manufacturer.

POINT DESCRIPTION	TYPES	DEVICE
Start / Stop	DO	Control Relay
Status	DI	Current Sensitive Relay
Space Temperature	AI	Space Thermistor
Space Humidity	AI	Space Humidity Sensor
Swimming Pool Pump Status	DI	Current Sensitive Relay
Swimming Pool Pump	DO	Control Relay

3.82 START-UP AND POINT VERIFICATION

A. Final startup and point verification shall include the following information.
1. Field panel checkout:
   a. Verify enclosure is not mounted on vibrating surface.
   b. Verify class I and class II wiring is separated within enclosure.
   c. Check for shorts/grounds/induced voltages/proper voltages.
   d. Verify proper point terminations in accordance with as-builts.
   e. Verify that all modules are in proper place and addressed.
   f. Verify proper power voltage.
   g. Load database and programming.
   h. Startup the panel.
   i. Point and device checkout.
2. Analog input point checkout:
   a. Verify the correct wiring terminations per the design documentation package, at the field panel. Verify that all wiring and terminations are neat and dressed.
   b. Verify the point address by checking that the analog input instrument is wired to the correct piece of field equipment. Do this by altering the environment at the sensing element or by disconnecting one of the wires at the sensor, and verifying that the reading at the field panel has reacted to this change.
   c. Verify the point database to be correct, (i.e., alarmability, alarm limits, slope/intercept, engineering units, etc.). Verify that the correct change of value (COV) limit has been defined.
   d. Verify the sensor has the correct range and input signal. (i.e., 20-

120°F, 4 - 20 ma). Verify that the device is mounted in the correct location and is wired and installed correctly per the design documentation package.

e. Set-up and/or calibrate any associated equipment (i.e., panel LCD meters, loop isolators, etc.). Verify that these auxiliary devices are mounted in the correct location and are wired and installed correctly per the design documentation package.

f. Verify the correct reading at the field panel using appropriate MMI devices. Verify that any associated LCD panel meters indicate the correct measured value.

3. Digital input point checkout:
   a. Verify the device is correctly wired and terminated as shown in the design documentation package. Verify that all wiring and terminations are neat and properly secured.
   b. Verify the point address by verifying that the digital input is correctly terminated at the controlled piece of equipment.
   c. Verify the point database is correct (i.e., point name, address, alarmability, etc.).
   d. Set-up and/or calibrate the associated equipment, i.e. smoke detector, high/low temp detector, high/low static switch, flow switch, end switch, current relay, pressure switch, etc. is mounted in the correct location, and is wired and installed correctly per the control system installation drawings.
   e. With the controlled equipment running or energized as described in the digital output checkout procedures, verify the correct operation of the digital input point and associated equipment by putting the digital input monitored equipment into its two states. Verify that the proof or status point indicates the correct value at the operator's terminal and that the status led is giving the proper indication in each mode of operation (on/off).
4. Digital output point checkout:
   a. Verify that device is correctly wired and terminated as shown in the design documentation package.
   b. Verify that the correct voltage is utilized in the circuit.
   c. Verify the point database to be correct (i.e. point name, address, etc.).
   d. Check and verify that the end device responds appropriately to the digital output(s).
   e. After verifying the set-up and operation of any associated digital input/proof points, check and verify correct operation of the logical point and associated equipment by commanding the point to all possible states (i.e. off, on, fast, slow, auto, etc.). Verify that the defined proof delay is adequate for all modes of operation.
   f. If any interlocked equipment exists that has independent hand-off-auto or auxiliary control wiring, verify correct operation of same. Also check that any interlocked equipment such as EP switches for damper operation or exhaust and return fans are wired correctly and operate correctly.
   g. Verify that the controlled piece or pieces of equipment cannot be caused to change state via the digital output if an associated hand-off-auto switch is in the hand/on or hand/off mode of operation, unless specified as a fireman's override point etc.
5. Analog output point checkout:

a. Verify the correct wiring or piping terminations per the design documentation package, at the field panel. Verify that all wiring and piping terminations are neat and dressed.
b. Insure that the correct output device(s) are installed per the Control System Installation Drawings. (i.e., I/P or P/I transducers, transformers, power supply, etc.). Verify that these devices are installed, wired and piped correctly. Verify that any configuration jumpers are in the proper settings for the required application. Verify related transformers are fused in accordance with installation drawings.
c. Verify the point database to be correct. Verify that the correct COV limit has been defined.
d. Verify the point address by checking that the analog output is wired and/or piped to the correct output transducer and/or equipment.
e. Verify that the controlled device is calibrated (i.e., 3-8PSI valve, 8-13 PSI damper motor, 4-20 ma variable frequency drive, etc.) and is in the correct location, and is wired or piped and installed correctly per the design documentation package. If the controlled device is not calibrated, then a three-point (high, low and mid-point) calibration procedure must take place. Verify proper operation of the end device. When calibration has been verified, ensure that installation drawings, point database, and PPCL have been updated.
f. Set-up and or calibrate any associated equipment, (i.e., panel LCD meters, loop isolators, pneumatic gauges, etc.). Also verify that these auxiliary devices are mounted in the correct location, and are wired or piped and installed correctly per the design documentation package.
g. After verifying the set-up and operation of any associated equipment check for the correct operation of the logical point and associated equipment by commanding the analog output to the top and bottom of its range. Verify that the control device(s) responded appropriately as indicated by the design documentation package. Check to insure that all network terminals, host console devices, etc. can also command these outputs.
h. Check that all pneumatic gauges, pilot positioners and LCD panel meters indicate the correct values.

6. Terminal equipment controller checkout:
   a. Load program database
   b. Enable programs
   c. Verify sequence of operations
7. Programming checkout:
   a. Provide checkout for each system and sequence of operation.
   b. The following are sample sequence of operations tests. The intent of these procedures is to provide a plan of action to verify system operations via block checks of the project specific sequence of operations. The procedures may be used in this format, or one procedure to a page should more detail be required. The procedures outlined below should be verified for accuracy, and may be modified to meet your specific requirements.
   c. Description of Test: AHU Alarm Checkout. Verify AHU-1 discharge

air temperature alarming is operational and is received at the designated terminal.
d. Input to Trigger Test: Change discharge temperature high alarm limit through software to a value below the current discharge temperature (discharge temperature - 10°F).
e. Expected Outcome: A high temperature alarm will be received per the Alarm Definition Report at its designated terminal.
f. Provide signoff sheet with indication for test Pass, Fail, Date of test and Initials for signoff.
8. Workstation checkout:
a. Verify the operation of all trunk interface equipment.
b. Verify all workstation software, including options, based upon the installation instructions for the PC.
c. Perform software backup (site, options, etc.)
d. Complete workstation configuration report for owner signoff.
e. Provide verification that all graphics have been created, as required by project bid documents.

3.83 TESTING AND ACCEPTANCE

A. General:
1. After completion of installation and start-up procedures, commence the specified 3-phase verification and testing sequence leading to final acceptance.
a. Follow in the order specified.
b. Each testing phase shall be satisfactorily completed before entering the next phase.
2. Prior to entering each phase of the sequence, submit for approval, a written agenda describing in detail the procedure to be followed to meet the requirements for each specified verification, test or demonstration.
3. Submit for approval, a sample of the form on which the test will be reported.
a. Identify project.
b. Provide a list of all points, arrange in numerical order of point addresses.
1) Show point descriptor and location of each.
2) Indicate DDC panel that processes each point.
3) Use the list as a basis for the specified report form.
c. Signatures of participants and observers.
d. Results.
e. Description of adjustment or corrections of points in error.
f. Date.
4. Provide schedule of tests. Estimate dates of significant events.
5. Test, calibrate and adjust each point in the system as specified.
6. Provide documentation of all tests and verifications as specified.
7. Provide trend reports indicating proper control of all points for an extended period of time.

B. Phase 1 - Testing, Calibrating, and Adjusting:
1. Operate each analog point in the entire system.

a. At a point in the upper quarter of its range.
b. At a point in the lower quarter of its range.
c. At its operating point.

2. Provide personnel and diagnostic instruments at both the central and remote locations.
3. Provide testing stimulants for alarms.
4. Use digital meters of double the accuracy of the instruments being calibrated.
5. Provide an approved test device for simulating high and low temperatures.
6. When the function is performed, read values at the central control and observe the actual function at the field instrument.
7. Exercise each binary point and observe indication at console and simultaneously observe operation in the field.
8. Submit an operation report for each point in the system, in approved format, and describe any corrective or adjusting action taken.
9. Test all power transducers with a Dranetz Power Analyzer.

C. Phase 2 - Equipment and Point Verification:
1. Verify calibration or function of each point.
   a. Verify analog points at operating value.
   b. Record on specified form.
   c. Make approved adjustments to out of tolerance points.
      1) Identify these points for ready reference.
2. After verification procedure in completed:
   a. Verify corrected points.
   b. Record on specified form.
   c. Points requiring correction.
      1) Replace sensor or actuator if electrical measurements indicated components are out of specified tolerance.

D. Phase 3 - Software Verification:
1. Submit agenda and report format for software demonstrations.
2. Demonstrate to the Owner and the Engineer that all software programs and automatic control sequences function as specified.
3. Demonstrate compliance with response time specifications.
   a. Simulate normal heavy load conditions.
   b. Initiate at least ten successive occurrences on normal heavy load conditions as specified, and measure response time of typical alarms and status changes.

04. Provide written documentation of demonstration, signed by representatives of the Contractor and Engineer.

E. Provide the following reports to Engineer at final completion of all Testing:
1. List of all points.
2. List of all points currently in alarm.
3. List of all disabled points.
4. List of all points in over-ride status.
5. List of all points currently locked out.
6. List of user accounts and access levels.
7. List all weekly schedules.

8. List of holiday programming schedules.
9. List of limits and deadbands.
10. System diagnostics reports including, list of DDC panels on line and communicating, status of all DDC terminal units device points.
11. List of programs.
12. Provide trend data reports to ensure proper operation and sequence control of BMCS.

F. Substantial Completion of the BMCS will not occur until completion and acceptance of all testing and acceptance procedures.

3.84 TRAINING

A. The contractor shall provide factory-trained instructor to give full instruction to designated personnel in the operation of the system installed. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. The contractor shall provide all students with a student binder containing product specific training modules for the system installed. All training shall be held during normal working hours of 8:00 am to 4:30 PM weekdays.

B. Provide 40 hours of training for Owner's designated operating personnel. Training shall include:

Explanation of drawings, operations and maintenance manuals
Walk-through of the job to locate control components
Operator workstation and peripherals
DDC controller and ASC operation/function
Operator control functions including graphic generation and field panel programming
Operation of portable operator's terminal
Explanation of adjustment, calibration and replacement procedures
Student binder with training modules

C. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor.

3.85 PROJECT MANAGEMENT

A. Provide a designated project manager who will be responsible for the following:
1. Construct and maintain project schedule.
2. Authorized to accept and execute orders or instructions from General Contractor, Owner / Architect & Engineer.
3. Attend project meetings as necessary to avoid conflict and delays.
4. Make necessary field decisions relating to this section.
5. Coordination / Single point contact.
6. Have Internet access for project management.

END OF SECTION 230933

SECTION 230934 - COORDINATION OF BUILDING MANAGEMENT AND CONTROL SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. The Building Management and control System for the facility shall be furnished and installed under a separate contract. The items listed below shall be furnished and/or installed by this contractor.

PART 2 - PRODUCTS

A. Products provided by the Building Management and Control System (BMCS) Contractor.
   1. Control Valves
   2. Dampers
   3. Wells for sensors installed in piping system
   4. Flow Meters

PART 3 - EXECUTION

3.1 COORDINATION

A. Coordinate with the Building Management and Control System (BMCS) Contractor.
   1. Provide project-scheduling information to the BMCS Contractor to allow ample time for purchase of equipment and devices.
   2. Schedule periodic project meetings to review progress and coordination issues.
   3. Submit a written report, to the Architect/Engineer, on a monthly basis stating status of coordination effort.

B. The BMCS contractor will submit shop drawings to this contractor for review and coordination processing.

3.2 INSTALLATION

A. This Contractor will be responsible for the following:
   1. Installation of control valves for HVAC equipment.
   2. Installation of dampers for HVAC equipment.
   3. Installation of temperature sensor wells in piping.
   4. Installation of pressure taps in piping system.
   5. Installation of flow meter taps in piping system.

B. Install the above material under the direction of the Building Management and Control System (BMCS) Contractor.

END OF SECTION 230934

SECTION 232000 - HVAC PIPE AND PIPE FITTINGS - GENERAL

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install pipe and pipe fittings for piping systems specified in Division 23 - Mechanical.

1.2 RELATED WORK

A. Division 23 Mechanical:
1. Earthwork.
2. Valves, Strainers and Vents.
3. Vibration Isolation.
4. Insulation.
5. Other Piping Sections

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. The particular type of pipe and fittings for each system is specified in the individual sections.

2.2 JOINTS

A. Make screwed joints using machine cut USASI taper pipe threads. Apply a suitable joint compound to the male threads only. Ream the pipe to full inside diameter after cutting. All-thread nipples are not permitted.

B. Dissimilar Metals. Make joints between copper and steel pipe and equipment using insulating unions or couplings such as Crane Company #1259; EPCO as manufactured by EPCO Sales, Inc.; or an approved equal.

C. Solder joints.
1. Prior to making joints, cut pipe square and ream to full inside diameter. Clean exterior of pipe and socket. Apply a thin coat of suitable fluxing compound to both pipe and socket, and fit parts together immediately.
2. Heat assembled joint only as required to cause the solder to flow. Run the joint full, slightly beaded on the outside, and wipe to remove excess solder.
3. Use silver brazing alloy or Sil-Fos on refrigerant piping and on

underground piping. Use lead free solder on all other copper piping.

D. Make welded joints as recommended by the standards of the American Welding Society. Ensure complete penetration of deposited metal with base metal. Provide filler metal suitable for use with base metal. Keep inside of fittings free from globules of weld metal. The use of mitered joints is not approved.

E. Flanged.
1. Prior to installation of bolts, center and align flanged joints to prevent mechanical pre-stressing of flanges, pipe or equipment. Align bolt holes to straddle the vertical, horizontal or north-south centerline. Do not exceed 3/64" per foot inclination of the flange face from true alignment.
2. Use flat-face companion flanges only with flat-faced fittings, valves or equipment. Otherwise, use raised-face flanges.
3. Install gaskets suitable for the intended service and factory cut to proper dimensions. Secure with manufacturers recommended gasket cement.
4. Use ANSI nuts and bolts, galvanized or black to match flange material. Use ANSI 316 stainless steel nuts and bolts underground. Tighten bolts progressively to prevent unbalanced stress. Draw bolts tight to ensure proper seating of gaskets.
5. Use carbon steel flanges conforming to ANSI B16.5 with pipe materials conforming to ASTM A 105 Grade II or ASTM A 108, Grade II, ASTM A 53, Grade B. Use slip-on type flanges on pipe only. Use welding neck type flanges on all fittings. Weld slip-on flanges inside and outside.
6. Keep flange covers on equipment while fabricating piping. Remove when ready to install in system.

F. Mechanical Joints: Provide a stuffing box type mechanical joint adapted to use gasket, cast iron gland and bolts. Coat bolts with bitumastic enamel. Use joint parts similar in design to one of the following:
1. Doublex Simplex Joint manufactured by the American Cast Iron Pipe Company, Birmingham, Alabama.
2. U.S. joints manufactured by the United States Pipe and Foundry Company, Burlington, New Jersey.
3. Boltite Joint manufactured by the McWane Cast Iron Pipe Company, Birmingham, Alabama.
4. Flexlamp manufactured by the National Cast Iron Pipe Company, Birmingham, Alabama.

2.3 UNIONS

A. Use 150 lb. standard (300 lb. WOG) malleable iron, ground joint unions with bronze seat. Provide flanged joints on piping 2-1/2" and larger.
1. Where pipe material of different types join, use a dielectric union. Union shall be threaded, solder or as required for its intended use.

2.4 BRANCH CONNECTIONS

A. Pipe 2" and Smaller: For threaded piping, use straight size reducing tee. When branch is smaller than header, a nipple and reducing coupling or swagged nipple may be used.

B. 2-1/2" through 36": For welding piping, when branch size is the same as header size, use welding tee. For threaded branch connections, use 3000 lb. full coupling or Thread-o-let welded to header.

2.5 GASKETS

A. High Temperature Piping: Provide 1/16" thick ring gaskets of aramid reinforced SBR such as Garlock #3200 or 3400 or equal by Advanced Products and Systems.

B. Other Piping: Provide ring rubber gaskets, Garlock #7992 or equal by Advanced Products and Systems. Use 1/8" thick cloth reinforced neoprene gaskets. For smaller than 6", use 1/16" thick gasket.

2.6 FLOORS AND CEILING PLATES

A. Provide chrome-plated floor and ceiling plates around pipes exposed to view when passing through walls, floors, partitions, or ceilings in finished areas; size plates to fit pipe or insulation and lock in place.

2.7 DOMESTIC MANUFACTURE

A. All piping material, pipe and pipe fittings shall be manufactured in the United States of America.

PART 3 - EXECUTION

3.1 PIPE FABRICATION AND INSTALLATION

A. Make piping layout and installation in the most advantageous manner possible with respect to headroom, valve access, opening and equipment clearance, and clearance for other work. Give particular attention to piping in the vicinity of equipment. Preserve the required minimum access clearances to various equipment parts, as recommended by the equipment manufactured, for maintenance.

B. Cut all pipes to measurement determined at the site. After cutting pipe, remove burrs by reaming. Bevel plain ends of ferrous pipe.

C. Install piping neatly, free from unnecessary traps and pockets. Work into place without springing or forcing. Use fittings to make changes in direction. Field bending and mitering is prohibited. Make connections to equipment using flanged joints, unions or couplings. Make reducing connections with reducing fittings only.

D. Install piping without tapping out of the bottom of pipe.

3.2 WELD

A. Weld and fabricate piping in accordance with ANSI Standard B31.1, latest edition, Code for Pressure Piping.

B. Align piping and equipment so that no part is offset more than 1/16". Set fittings and joints square and true, and preserve alignment during welding operation. Use of alignment rods inside pipe is prohibited.

C. Do not permit any weld to project within the pipe so as to restrict flows. Tack welds, if used, must be of the same material and made by the same procedure as the completed weld. Otherwise, remove tack welds during welding operation.

D. Do not split, bend, flatten or otherwise damage piping before, during or after installation.

E. Remove dirt, scale and other foreign matter from inside piping before tying into existing piping sections, fittings, valves or equipment.

F. Bevel ends of ferrous pipe.

3.3 OFFSETS AND FITTINGS

A. Due to the small scale of drawings, the indication of offsets and fittings is not possible. Investigate the structural and finish conditions affecting the work and take steps required to meet these conditions.

B. Install pipe close to walls, ceilings and columns so pipe will occupy minimum space. Provide proper spacing for insulation coverings, removal of pipe, special clearances, and offsets and fittings.

3.4 SECURING AND SUPPORTING

A. Support piping to maintain line and grade, with provision for expansion and contraction. Use approved clevis-type or trapeze-type hangers connected to structural members of the building. Single pipe runs to be supported by approved clevis type hangers. Multiple pipe runs to be supported by approved trapeze type hangers. Do not support piping from other piping or structural joist bridging. Review structural drawings for additional information.

B. Provide supports both sides and within 12” of each horizontal elbow for pipe 6" and larger.

C. Support vertical risers with steel strap pipe clamps of approved design and size, supported at each floor. Support piping assemblies in chases so they are rigid and self-supported before the chase is closed. Provide structural support for piping penetrating chase walls to fixtures. On chilled water pipe supports shall be outside the insulation.

D. Where insulation occurs, design hangers to protect insulation from damage. Pipe saddles and insulation shields, where required, are specified in the appropriate insulation section and are sized in accordance with the schedule on the drawings.

E. Install trapeze hangers, properly sized, to support the intended load without distortion. Use hangers with 1-1/2” minimum vertical adjustment.

F. Use electro-galvanized or zinc plated beam clamps if acceptable to the structural engineer, threaded rods, nuts, washers and hangers. All hanger rods shall be trimmed neatly so that no more than 1 inch of excess hanger rod protrudes beyond the hanger nut. Use only on beams as directed by the Structural Engineer.

G. At outdoor locations, all supports, brackets and structural members shall be hot-dipped galvanized.

H. Provide hangers within 3' of pipe length from all coil connections.

I. Support spacing: As recommended by the project structural engineer and support manufacturer, but not more than listed below. Not to exceed spacing requirements of smallest pipe.

Pipe Size	Copper & Steel Max. Support Spacing, Ft.	Cast Iron Max. Support Spacing, Ft.	Minimum Rod Diameter, Inches
1" & smaller	6	5	3/8
1-1/4" & 1-1/2"	8	5	3/8
2"	10	5	3/8
3"	10	5	1/2
4" & 5"	10	5	5/8
6" and above	10		3/4

3.5 PIPE SUPPORTS

A. Provide P1001 or P 5000 Unistrut metal framing members and appurtenances for pipe support. Hot-dip galvanized members and appurtenances when located outside. Sagging of pipes or supports is not acceptable.

B. Adjustable clevis hangers shall be used for single pipe supports; Anvil Fig. 260. When oversized clevis is used, a nipple shall be placed over the clevis bolt as a spacer to assure that the lower U-strap will not move in on the bolt. Provide adjustable clevis with a nut / washer above and below the hanger on the support rod. Ring type clevis hangers are not acceptable.

C. Provide Anvil Figure 45 galvanized or primed and painted channel assembly for trapeze hangers.

3.6 PIPE SUPPORTS ON ROOF

A. Support condensate drain pipe on roof with Portable Pipe Hanger Model PP-10 with roller and fully adjustable height throughout pipe run. Base material shall be high density / high impact polypropylene with UV inhibitors and anti-oxidants. Provide with hot dip galvanized rod finish and framing. Nuts and washers shall be hot dip galvanized.

3.7 ANCHORS

A. Provide anchors as required. Use pipe anchors consisting of heavy steel collars with lugs and bolts for clamping to pipe and attaching anchor braces. Install anchor braces in the most effective manner to secure desired results. Do not install supports, anchors or similar devices where they will damage construction during installation or because of the weight or the expansion of the pipe. When possible, install sleeves in structural concrete prior to pouring of concrete.

3.8 FLOOR PENETRATIONS

A. At locations where pipe passes through floors, provide watertight concrete curb around penetration.

3.9 PIPE SLEEVES

A. Sleeves through masonry and concrete construction:
1. Fabricate sleeves of Schedule 40 galvanized steel pipe.
2. Size sleeve large enough to allow for movement due to expansion and to provide continuous insulation.

B. Sleeves through gypsum wall construction.
1. Fabricate sleeves of 16 gauge galvanized sheet metal.

C. Sleeves through elevated slab construction.
1. Fabricate sleeves of Schedule 40 galvanized steel pipe with welded center flange in floor.

D. Extend each sleeve through the floor or wall. Cut the sleeve flush with each wall surface. Sleeves through floors shall extend 2” above floor lines for waterproofing purposes. Slab on grade floors shall not be sleeved except where penetrating waterproofing membrane or insect control is required.

E. Caulk sleeves water and air tight. Seal annular space between pipes and sleeves with mastic compound to make the space water and air tight.

F. For sleeves below grades in outside walls, provide Thunderline Link-Seal or Advance Product and System Interlynx, with 316 stainless steel nuts and bolts, with cast iron pressure plate.

G. Provide chrome plated escutcheon plates on pipes passing through walls, floors or ceilings exposed to view. At exterior walls, stainless steel sheet metal is to be used.

H. For sleeves through fire and smoke rated walls, seal with a UL through-penetration firestop, rated to maintain the integrity of the time rated construction. Install in accordance with the manufacturer's installation instructions. Comply with UL and NFPA standards for the installation of firestops. Refer to Architectural drawings for all fire and smoke rated partitions, walls, floors, etc.

3.10 ISOLATION VALVES

A. Provide piping systems with line size shutoff valves located at the risers, at main branch connections to mains for equipment, to isolate central plant, and at other locations.

3.11 DRAIN VALVES

A. Install drain valves at low points of water piping systems so that these systems can be entirely drained. Install a line size drain valve for pipes smaller than 2" unless indicated otherwise. For pipes 2-1/2" and larger, provide 2" drain valves unless indicated otherwise. Drain valves shall be plugged when not in use and at completion.

3.12 CLEANING OF PIPING SYSTEMS

A. General cleaning of piping systems. Purge pipe of construction debris and contamination before placing the systems in service. Provide and install temporary connections as required to clean, purge and circulate. Flush the chilled and hot water systems utilizing the filter feeders.

B. Install temporary strainers at the inlet of pumps and other equipment as necessary where permanent strainers are not indicated. Keep strainers in service until the equipment has been tested, then remove either entire strainer or straining element only. Fit strainers with a line size blow down ball valve and pipe to nearest drain. Blow down strainers, remove and clean as frequently as necessary.

C. Phase One: Initial flushing of system. Remove loose dirt, mill scale, weld beads, rust and other deleterious substances without damage to system components. Open valves, drains, vents and strainers at all system levels during flushing procedures. Flush until "potable water clear" and particles larger than 5 microns are removed.

D. Connect dead-end supply and return headers, even if not shown on the drawings, and provide terminal drains in bottom of pipe end caps or blind flanges.

E. Dispose of water in approved manner.

F. Phase Two: Cleaning of Piping Systems. Remove, without chemical or mechanical damage to any system component, adherent dirt (organic soil), oil, grease, (hydrocarbons), welding and soldering flux, mill varnish, piping compounds, rust (iron oxide) and other deleterious substances not removed by initial flushing. Chemical shall be equal to Nalco 2578 prepping compound. Insert anti-foam compound as necessary. Circulate for 48 hours or as recommended by the manufacture. Dispose of water in approved manner. Flush system and replace with clean water. Verify compatibility of chemicals used with existing chemical treatment program on remodel projects.

G. Phase Three: Final flushing and rinsing: Flush and rinse until "potable water clear" and particles larger than 5 microns are removed. Operate valves to dislodge any debris in valve body. Dispose of water in approved manner.

H. Submit status reports upon completion of each phase of work on each system.

I. Special requirements, if any, are specified in the sections on each type of piping or in the section on Water Treatment Systems.

3.13 TESTING

A. Test piping after installation with water hydrostatic pressure of 1-1/2 times operating pressure (150 psig minimum) and carefully check for leaks. Repair leaks and retest system until proven watertight.

B. Do not insulate or conceal piping systems until tests are satisfactorily complete.

C. If any leaks or other defects are observed, suspend the test and correct the condition at once. Repeat testing until leaks are eliminated and the full test period is achieved.

D. The satisfactory completion of testing does not relieve the Contractor of responsibility for ultimate proper and satisfactory operation of piping systems and their accessories.

3.14 PIPE MARKERS

A. Identify interior exposed piping and piping in accessible chases or plenums with Opti-Code Brady Pressure Sensitive Adhesive Pipe Markers, consisting of pipe marker and direction of flow arrow tape. Clean pipe prior to installation. Background colors of markers, arrows and tape for each type of system shall be the same. Meet ANSI/OSHA standards and clearly identify each system. Provide minimum 2-1/4-inch letters through 4-inch pipe and 4-inch letters for 5-inch pipe and larger.

B. Identify exterior and mechanical room piping with Snap Around pipe markers through 4-inch pipe and Strap Around markers 5-inch pipe and larger. Pipe markers consisting of pipe marker and direction of flow arrow tape; background colors of markers, arrows and type for each type of system shall be the same. Meet ANSI / OSHA standards and clearly identify each system. Provide minimum 2-1/4-inch letters through 4-inch pipe and 4-inch letters for 5-inch pipe and larger.

C. Install identification in the following locations:
   1. both sides of penetrations through walls, floors and ceilings.
   2. Close to valves or flanges.
   3. Intervals on straight pipe runs not to exceed 50 feet
   4. Apply marker where view is obstructed.

D. Pipe markers shall meet or exceed the specifications of the ASME A13.1 “Scheme for Identification of Piping Systems”.

END OF SECTION 232000

SECTION 232123 - HVAC PUMPS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. General characteristics for pumps specified in Division 23 - Mechanical.

1.2 RELATED WORK

Requirements for pumps are specified in other sections of Division 23 - Mechanical, including the following:

A. Division 23 Mechanical - Electrical Provisions of Mechanical Work.

1.3 PUMP SELECTION

A. Select pumps conservatively for scheduled conditions. Furnish pumps that have reasonably high efficiencies, with peak efficiency at or near rated conditions. Select pumps that will operate stably at 15' suction lift despite substantial reduction in head or substantial increase in delivery.

B. If the pumps proposed are not considered suitable, submit manufacturer's data on other pumps, for review.

C. Scheduled design flow, design head, pump efficiency, and motor horsepower are the minimum acceptable.

D. The pump curve shall rise continuously from maximum flow to cut-off.

E. Shut-off head approximately 10 percent greater than design head, unless otherwise indicated in pump schedules.

F. Pump brake horsepower shall not exceed the motor horsepower rating over the entire operating range from shut-off to run-out.

G. Select the pump for operation at or near peak efficiency.

H. Cavitation-free at all points on the curve.

I. Impeller diameter shall not exceed 90 percent of the maximum published diameter.

J. Pumps shall be suitable for parallel operation. Where pumps are operated in parallel, individual pumps shall be capable of stable operation with only one pump operating in the system. Submit pump curves with single and multiple pumps operating on system curve for approval.

1.4 PUMP SIZE AND TYPE

A. Provide motor-driven pumps of the type and speed scheduled. Select pumps that are not overloaded throughout the entire range of pump operation. Provide pump connection sizes as indicated.

B. The head capacities indicated in the schedules are listed for bidding purposes only. Calculate the operating head at each pump; take into consideration the actual routing of the various lines, pressure drops in heat exchangers and coils, exact lengths of pipe, fittings, etc. Submit these calculations, together with copies of manufacturer's performance curves, as shop drawings on each pump. Clearly mark the curves for each pump to indicate the diameter of the impeller and the selection point.

1.5 CERTIFIED DATA

A. Submit factory certified pump curves showing pump performance characteristics with pump and system operating points plotted. Curves shall include as a minimum, flow (gallons per minute), head (feet of water), all available impeller diameters (inches), efficiency (percent), net positive suction head required (feet of water), brake horsepower, pump size and pump model. When multiple pumps are operating in parallel, show pump curves for one pump running, two pumps running, and so on. Show pump curves with system curve plotted.

PART 2 - PRODUCTS

2.1 HORIZONTAL PUMPS

A. Pump Construction:
1. Cast iron, designed for 175 psi working pressure
2. Bronze case wear rings
3. Grease lubricated ball bearings selected for an average life of 200,000 hours; pressure grease fittings
4. Flexible coupled
5. Hot Dipped galvanized drip-rim structural steel base extending past the pump flanges allowing all condensation to be accumulated. Galvanized integral drain pan.
6. Falk all-metal center dropout spacer coupling
7. Totally enclosed metal or high-impact polyethylene plastic (Orange Peel) coupling guard per ANSI B15.1, Section 8 and OSHA 1910.219
8. Suction and discharge flange gauge ports
9. Fully enclosed bronze impeller keyed to the shaft
10. 304 Stainless steel shaft minimum

B. End suction pump volute with integrally cast pedestal support foot for back pullout to allow pump to be serviced without disturbing the system piping. Pumps utilizing pedestal mounted bearing frames in lieu of volute will not be accepted.

C. Bearings:
1. Conform to Anti-Friction Bearing Manufacturers Association (AFBMA) Standards
2. Ball or roller bearing pillow block type
3. Self-aligning
4. AFBMA L50 rating of 200,000 hours

D. Horizontal or vertical split case pumps: Double row grease lubricated ball bearing each side.

E. Provide each pump with an internally flushed mechanical seal. If external flush line is required, provide sediment filter for each line.
   1. Use seal materials suitable for the pumped liquid
   2. Renewable bronze or stainless shaft sleeve

F. Provide each pump with a stuffing box with packing:
   1. Hardened 440C stainless steel renewable shaft sleeve
   2. Bronze gland and stainless steel gland bolts
   3. Oil graphite packing

G. Paint entire unit with two coats of machinery enamel after completion of installation.

H. Pump Motor:
   1. Premium efficiency
   2. Totally enclosed fan cooled
   3. Cast iron frame and end plate
   4. Forge steel lifting eye
   5. Over sized conduit box with ground lug
   6. So sized with relation to the pump impeller that the brake horsepower requirements will not overload the motor at any point on the pump curve
   7. Designed for Variable Frequency Drive Application
   8. Provide with factory installed shaft grounding rings by AEGIS.
   9. Minimum Efficiency

3 hp	1800 rpm	89.5%
5 hp	1800 rpm	90.2%
7.5 hp	1800 rpm	91.7%
10 hp	1800 rpm	91.7%
15 hp	1800 rpm	92.4%
20 hp	1800 rpm	93%
25 hp	1800 rpm	93.6%
30 hp	1800 rpm	94.1%
40 hp	1800 rpm	94.5%
50 hp	1800 rpm	94.5%
60 hp	1800 rpm	95%
75 hp+	1800 rpm	95.4%

I. Data plates:
   1. Provide the pump with a nameplate constructed of 300 series stainless steel securely fastened to pump casing with stainless steel pins.
   2. Locate the nameplate for easy visibility.
   3. Clearly stamp the rating conditions and other data below, as a minimum, on the nameplate.
      a. Manufacturer, address, telephone number
      b. Pump model number
      c. Pump serial number
      d. Size (including impeller diameter scheduled in inches)
      e. Type
      f. Equipment designation as listed on the pump schedule.
      g. Flow scheduled (gallons per minute)
      h. Dynamic head scheduled (feet of water)
      i. Efficiency (percent)
      j. Shut-off head (feet of water)

k. Speed (rpm)
l. Brake horsepower
m. Maximum brake horsepower with rated impeller
n. Rotation
o. Maximum allowable pressure (psig)

J. The schedule on the drawing sets forth the type of pump and GPM required.
1. The head capacities and horsepower are for bidding purposes only.
2. Make pump selection based on actual system calculations.

K. Acceptable manufacturers:
1. Armstrong
2. Amtrol/Thrush
3. Aurora
4. Bell & Gossett
5. Grundfos
6. Patterson
7. Weinman
8. TACO

2.2 VERTICAL IN-LINE (VIL) PUMPS

A. Pump Construction:
1. Pump casing, cast iron with 125 psig ANSI/PN16 flanges for working pressure below 175 psig at 150°F and ductile iron with 250 psig ANSI / PN25 flanges for working pressure to 375 psig at 150°F.
2. Suction and discharge connections shall be flanged and the same size and shall be drilled and tapped for seal flush and gauge connections.
3. Impeller: Bronze, fully enclosed type; dynamically balanced, two-plan balancing is required where installed impeller diameter is less than 6 times the impeller width.
4. Shaft: Provide stainless steel pump shaft.
5. Coupling: Rigid spacer type of high tensile aluminum alloy. Coupling is to be designed to be easily removed on site to reveal a space between the pump and motor shafts sufficient to remove all mechanical seal components for servicing and to be replaced without disturbing the pump or motor.
6. Mechanical seals shall be stainless steel multi-spring inside or outside balanced type with Viton secondary seal, carbon rotating face and silicon carbide stationary seat. Provide 316 stainless steel glad plate. Provide factory installed flush line with manual vent.
7. Split coupled pumps shall be provided with a lower seal chamber throttle bushing to ensure seals maintain positive cooling and lubrication.
8. Provide seal flush supply line to the mechanical seal with a 50 micron cartridge filter and sight flow indicator to suit the working pressure encountered. Filters shall be changed by the installing contractor after system is flushed and on a regular basis until turned over to the Owner.
9. Supply in the flush line to the mechanical seal a maintenance free sediment separator with sight flow indicator.

B. Single stage, single or double suction type, with pump characteristics which provide rising heads to shut off. Refer to pump schedule for pump flows and heads and motor speed, enclosure, efficiency and power requirements and other system conditions.

C. Pump Motor:

1. Premium efficiency
2. Totally enclosed fan cooled
3. Cast iron frame and end plate
4. Forge steel lifting eye
5. Over sized conduit box with ground lug
6. So sized with relation to the pump impeller that the brake horsepower requirements will not overload the motor at any point on the pump curve
7. Designed for Variable Frequency Drive Application
8. Minimum Efficiency

3 hp	1800 rpm	89.5%
5 hp	1800 rpm	90.2%
7.5 hp	1800 rpm	91.7%
10 hp	1800 rpm	91.7%
15 hp	1800 rpm	92.4%
20 hp	1800 rpm	93%
25 hp	1800 rpm	93.6%
30 hp	1800 rpm	94.1%
40 hp	1800 rpm	94.5%
50 hp	1800 rpm	94.5%
60 hp	1800 rpm	95%
75 hp+	1800 rpm	95.4%

D. Data plates:
1. Provide the pump with a nameplate constructed of 300 series stainless steel securely fastened to pump casing with stainless steel pins.
2. Locate the nameplate for easy visibility.
3. Clearly stamp the rating conditions and other data below, as a minimum, on the nameplate.
   a. Manufacturer, address, telephone number
   b. Pump model number
   c. Pump serial number
   d. Size (including impeller diameter scheduled in inches)
   e. Type
   f. Equipment designation as listed on the pump schedule.
   g. Flow scheduled (gallons per minute)
   h. Dynamic head scheduled (feet of water)
   i. Efficiency (percent)
   j. Shut-off head (feet of water)
   k. Speed (rpm)
   l. Brake horsepower
   m. Maximum brake horsepower with rated impeller
   n. Rotation
   o. Maximum allowable pressure (psig)

E. The schedule on the drawing sets forth the type of pump and GPM required.
1. The head capacities and horsepower are for bidding purposes only.
2. Make pump selection based on actual system calculations.

F. Acceptable manufacturers:
1. Armstrong Series 4300
2. Aurora
3. Bell & Gossett
4. Grundfos
5. Patterson
6. TACO

2.3 VERTICAL TURBINE CONDENSER WATER PUMP

A. Pump Construction:
   1. Pump bowls shall be flanged and bolted, made of cast iron. Flanges shall be of sufficient cross-section to prevent deflection.
   2. Impellers shall be bronze enclosed type, secured to the shaft with steel tapered collets.
   3. Pump bowls shall be provided with replaceable bronze wear rings.
   4. Pump shaft shall be of stainless steel, rolled or forged, ground and sized to provide minimum deflection.
   5. Belled suction of cast iron.
   6. Base plate with each pump.

B. Bearings:
   1. Bronze sleeve bearings shall be provided in each bowl and in the suction bell.
   2. Bowl bearings shall be lubricated by the pumped liquid.
   3. Suction bell bearing shall be packed permanently with non-soluble grease and fitted with a bronze sand collar.

C. Column Assembly:
   1. Discharge column pipe for 10" pumps and larger shall be steel with flanged connections.
   2. Discharge column pipe for 8" pumps and smaller shall be with flanged or threaded connections.
   3. Line shafting shall be steel, rolled or forged and ground. Shaft sections shall be connected through steel threaded couplings. Minimum shaft size is 1".
   4. Provide water lubricated cutless rubber bearings with bronze retainers at each column connection.

D. Surface Discharge Head Assembly:
   1. Above-ground mounting of close-grained cast iron with an integral discharge flange. Flange shall be 150 lb. ANSI flat face type.
   2. The discharge head base shall be of sufficient size and shall conform to ANSI flange drilling as required to span an opening of dimensions that shall permit removal of the complete pump unit connected below.
   3. Provide two lifting lugs with capacity to support the weight of the entire pump.
   4. Provide base plate.

E. Provide each pump with a cartridge-type mechanical seal.
   1. Cast iron stuffing box and stainless steel gland bolts.
   2. Bronze seal box bearing

F. Pump shall be provided with a basket type suction strainer of bronze or stainless steel. The net open area of the strainer shall be at least twice the area at the suction bell lip.

G. Pump motor:
   1. Vertical direct connected.
   2. Constant speed.
   3. Premium Efficiency TEFC suitable for use outdoors.
   4. 90% efficiency at loads of 75% through 100%.
   5. So sized with relation to the pump impeller that the brake horsepower requirement will not overload the motor at any point on the pump curve.
   6. Non-reverse ratchet

7. Provide motor internal heater for prevention of condensation.

H. Data plates:
1. Provide the pump with a nameplate constructed of 300 series stainless steel securely fastened to pump casing with stainless steel pins.
2. Locate the nameplate for easy visibility.
3. Clearly stamp the rating conditions and other data below, as a minimum, on the nameplate.
    a. Manufacturer, address, telephone number
    b. Pump model number
    c. Pump serial number
    d. Size (including impeller diameter scheduled in inches)
    e. Type
    f. Equipment designation as listed on the pump schedule.
    g. Flow scheduled (gallons per minute)
    h. Dynamic head scheduled (feet of water)
    i. Efficiency (percent)
    j. Shut-off head (feet of water)
    k. Speed (rpm)
    l. Brake horsepower
    m. Maximum brake horsepower with rated impeller
    n. Rotation
    o. Maximum allowable pressure (psig)

I. The schedule on the drawing sets forth the type of pump and GPM required.
1. The head capacities and horsepower are for bidding purposes only.
2. Make pump selection based on actual system calculations.

J. Acceptable Manufacturers:
1. Pacific & Johnston
2. Ingersoll-Rand
3. ITT Bell & Gossett
4. Aurora
5. Flo-way
6. Patterson

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install the pumps in accordance with Manufacturer's "Installation, Start-up and Service Instructions".
1. Provide access space around pumps for service.
2. Install pumps on concrete housekeeping base, with anchor bolts, set and level, and grout in place. Install stainless steel drain pan with trough under chilled water pumps only.
3. Provide air cock and drain connection piped to floor drain.
4. Lubricate pumps prior to start-up.
5. Install condenser water pumps to ensure a full flooded suction.
6. Paint entire unit with two coats of machinery enamel after completion of installation.
7. Provide a spool piece between the suction diffuser and the suction side of the pump minimum length 8" face to face.

8. Provide pressure taps with valves on each side of the pump.
9. Install hot water circulator horizontally, properly supported to wall, in an accessible location for testing and maintenance at a height not to exceed 60” above finished floor. Install line size Ernst bronze rotating wheel, flow indicator with double window, downstream of circulator.

B. Provide a line size isolation valve and strainer on the pump suction and a line size silent check valve and balancing valve on the pump discharge. Provide an automatic air vent off the pump casing. For base mounted pumps, provide a drain line the full size of the base connection and extend it to and terminate it over the nearest floor drain.

C. Support piping adjacent to the pump such that no weight is carried on the pump casing. Decrease from pipe size with eccentric reducer on suction side and concentric increaser on discharge side.

D. Ensure pumps:
1. Operate at specified system fluid temperatures without vapor binding and cavitation.
2. Are non-overloading in parallel and individual operation.
3. Operate within 25 percent of midpoint of published maximum efficiency curve.

E. Refer to pump detail on the Contract Drawings for piping accessories to be provided.

3.2 ALIGNMENT FOR BASE MOUNTED PUMPS

A. Set the pump on a concrete inertia base or concrete housekeeping pad as specified; anchor, level and grout.

B. Align the pump and driver in accordance with Hydraulic Institute Standards for centrifugal, rotary and reciprocating pumps.

C. Realign the pump and driver after initial leveling of pump base before placing the grout and again after the grout has set and the foundation bolts are tightened. Recheck the alignment after the piping has been connected.

3.3 MANUFACTURER START-UP SERVICE ALIGNMENT

A. After installation, the pumps and motors are to be aligned by the manufacturer or their representative utilizing a dial indicator. After completion, a formal report must be submitted by the Manufacturer to the Engineer prior to final acceptance. This report must include pump serial number, location, beginning and final alignment at a minimum.
1. Technicians, as required, shall be trained and experienced in the work they perform (contractor start-up / alignment is unacceptable).

B. Before starting pumps, but after connecting piping:
1. Align shafts and coupling with a precision dial indicator alignment instrument to the minimum tolerances .004 (TIR) per inch of coupling radius or as recommended by the manufacturer, whichever is the greater.
2. Tabulate the actual pump alignment reading with manufacturer's minimum tolerances.
3. Submit readings for approval.
4. Include the approved readings in the Owner's Maintenance Manual.

3.4 FINAL PUMP FLOW CALIBRATION

A. Based on the results of the final phases of the test and balance sequences, if the flow of the unthrottled pump is more than 10% above the scheduled values:
   1. Request detailed instructions from the pump manufacturer for the correct impeller diameter.
   2. Trim the impeller to the diameter recommended by the manufacturer, employing precision machinery.

B. Enter the information on the final configuration of the pump in the Owner's Manual.
   1. Modify the pump nameplate to reflect the correct head and flow data and the impeller diameter.

3.5 SPARE PARTS

A. Provide the following spare parts and material to the Owner for his use after the warranty period.
   1. A mechanical seal for each pump
   2. A set of bearings for each pump

END OF SECTION 232123

SECTION 232124 - CONDENSER WATER PIPING, VALVES AND APPURTENANCES

PART 1 - GENERAL

1.1 RELATED WORK

A. Division 23 Mechanical
   1. Pipe and Pipe Fittings - General
   2. Valves, Strainer and Vents
   3. Vibration Isolation
   4. Painting

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. Aboveground.
   1. 2" or smaller diameter pipe: Provide ASTM A #53 Grade A or B or ASTM A 120, Sch. 40 seamless or electric-resistance welded black steel pipe with 150 lb. screwed malleable iron fittings, ANSI B16.3.
      a. 2-1/2" through 6" pipe: Provide ASTM A #53 Grade A or B or ASTM A 120, Sch. 40 seamless or electric-resistance welded black steel pipe with standard weight seamless steel welding fittings, ASTM A 234, Grade WPA or WPB, ANSI B16.9.
      b. 8" through 20" pipe: Furnish ASTM A 53, Grade A or B, Sch. 20, seamless or electric-resistance welded black steel pipe with standard weight seamless steel welding fittings, ASTM A 234, Grade WPA or WPB, ANSI B16.9.
   2. 24" and larger diameter pipe: ASTM A 53, Grade A or B, 0.375" wall seamless or electric-resistance welded black steel pipe with seamless steel welding fittings, 0.375" wall, ASTM A 234, Grade WPA or WPB, ANSI B16.9. At Contractor's option, pipe sizes over 24" outside diameter can be ASTM A 134 with mitered fittings using ASTM A 285, Grade B or C steel plate.

B. Exterior Above Grade:
   1. Galvanized steel pipe, Schedule 40
   2. Fitting: Grooved

C. Underground: Same as above except provide corrosion protection as specified in Section 23 20 02.

2.2 VALVES

A. Refer to Section 23 05 23.

B. Refer to Building Management and Control System.

PART 3 - EXECUTION

3.1 TESTING

A. Apply a hydraulic pressure of 1-1/2 times operating pressure, 150 psig minimum, and check for leaks. Maintain test for a minimum of 24 hours. The piping system must remain absolutely tight during this period. The satisfactory completion of any test or series of tests will not relieve the contractor of responsibility for ultimate proper and satisfactory operation of piping systems and their accessories. The test should be observed by the Architect / Engineer before pressure is removed and the water drained.

END OF SECTION 232124

SECTION 232127 - PAINTING

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This section specifies painting of mechanical items located outdoors and inside central plant. Painting includes preparing, painting and color-coding the work. Preparation and application shall be in accordance with manufacturer's instructions. Mechanical items to be painted are piping and pumps. This shall include, but not be limited to, uninsulated chilled and hot water piping at pumps, expansion tanks, interior and exterior condenser water piping and chilled and hot water pumps.

1.2 REFERENCES

A. Section 23 21 23 – Pumps

B. Section – 23 21 13 - Hot and Chilled Water Piping, Valves and Appurtenances

C. Section 23 21 24 – Condenser Water Piping and Appurtenances

PART 2 - PRODUCTS

2.1 PIPING AND PUMPS

A. First Coat: One coat Devran 205 Universal Epoxy Primer.

B. Second Coat: Two coats Devthane 379UVA Aliphatic Urethane Gloss Enamel.

PART 3 - EXECUTION

3.1 GENERAL

A. Thoroughly clean surfaces receiving paint of dirt, grease, oil, rust and scale.

B. Unless otherwise specified, paint using three coast of selected colors. Mix and use exactly as specified by the manufacturer. Allow each coat to dry thoroughly before applying succeeding coats. Painting may be done by spraying where feasible.

C. Upon completion of painting, remove all scaffolds, surplus material, rags and trash to leave spaces neat and clean.

D. Items to be painted:
1. Uninsulated chilled water piping at pumps
2. Uninsulated heating water piping at pumps
3. Expansion tanks
4. Interior and exterior condenser water piping
5. Chilled and heating water pumps

3.2 COLORS

A. Machinery Gray

END OF SECTION 232127

SECTION 232300 - REFRIGERANT PIPING AND APPURTENANCES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install copper tubing, valves, strainers and sight glass for refrigerant piping.

1.2 RELATED WORK

A. Division 23 Mechanical.
   1. Pipe and Pipe Fittings
   2. Piping Insulation

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. Furnish refrigerant piping of Type K hard-drawn copper tubing with sweat-type, wrought copper fittings. Cast fittings are not permitted.

2.2 SERVICE VALVES

A. Provide angle or globe service valves, with sweat connections. Use packed-type, wrench operated, valves with gasketed seal cap and back seat feature. Furnish valves designed for refrigerant service, in conformance with the ARI code.

B. Place service valves at the inlet and outlet of each compressor, on both sides of each strainer and solenoid valve, and as otherwise shown and specified.

2.3 SOLENOID VALVES

A. Furnish pilot-operated, floating-piston solenoid valves suitable for operation with refrigerant.

B. Use valves with a bronze body and sweat-type connections.

C. Provide stainless steel stem and plunger assembly and a stainless steel piston.

D. Furnish sealed and moisture proof solenoid coils.

E. Use electrical characteristics of 115 volt, 60 Hertz.

2.4 SIGHT GLASSES

A. Provide suitable moisture and liquid sight glass in the liquid line leaving the condenser or receiver.

2.5 FILTER DRYER

A. Furnish replaceable core liquid line filter dryer.

B. Provide filter dryer constructed to permit the removal of the core element without removing the filter dryer from the line.

PART 3 - EXECUTION

3.1 BRAZING

A. During the brazing process, dry nitrogen shall be purged through the tubing to prevent oxides from forming.

3.2 PRESSURE TEST

A. After refrigeration and piping system items are installed, charge the system with dry nitrogen and test to 450 psig.
   1. Test joints with a Halide torch or an electronic leak detector.
   2. Repair leaks and retest each system until proved tight.

3.3 EVACUATION AND DRYING

A. After refrigerant system has been pressure-tested, connect a suitable vacuum pump and evacuate piping system, including lines and equipment.
   1. Maintain a vacuum as high as practicable for long enough to evaporate the moisture in the system (at least 48 hours).
   2. Check the humidity within the system with a wet bulb indicator, and maintain the vacuum until the wet bulb temperature is reduced to -40°F. After the system has been evacuated and dried, break the vacuum by charging proper refrigerant into the system.

3.4 PIPE SIZE

A. Pipe shall be routed and sized per condensing unit manufacturer's instructions.

END OF SECTION 232300

SECTION 232513 - CIRCULATING WATER SYSTEM CHEMICAL TREATMENT

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide equipment, chemicals and treatment materials for the complete water treatment system.

B. Determine which chemicals to use from the results of a water sample analysis taken from the building domestic water supply.

C. Provide water treatment products, holding reservoirs, equipment and labor for testing, cleaning, flushing and dispensing products to achieve the required water quality for each system specified.
1. Closed chilled and hot water systems
2. The cooling tower condenser water system
3. Closed condenser water system

1.2 SERVICE AND SUPPLIES

A. All work shall be performed by a qualified, full-time, Water Program Manager.
1. Specialist in the field of industrial water treatment.
2. Facilities include water analysis laboratory, development facilities and service department.

B. Provide a water treatment test set for each system (pH, alkalinity, hardness, chloride) for field use including test equipment and reagents as required for specific use with the treatment products employed.

C. Where specialized supplementary testing or control equipment is required, provide appropriate items.

D. Provide a water management and service program for a period of one year beginning at substantial completion. Make routine visits bi-weekly during first two months of operation and monthly during the remainder of the specified period.

E. Routing Services
1. Check and adjust water treatment system operation.
2. Instruct, train and advise operating personnel.
3. Check efficiency of chemicals and chemical applications.
4. Replenish chemicals and replace expendables.
5. Clean or replace filter in feeder.

F. Chemically clean the piping system.

G. Provide a complete laboratory analysis of water samples. Insert in the Owner's manuals.

H. Provide review of report figures in the field water testing.

1.3 QUALITY ASSURANCE

A. Acceptable program manager shall have:
   1. Research and development facilities.
   2. Regional laboratories capable of making water analysis.
   3. A service department and qualified technical service representatives located within a reasonable distance of the project site.
   4. Service representatives who are registered Engineers or factory-certified technicians with not less than 5 years of water treatment experience with the water treatment system manufacturer.

B. Ensure that all products, packaging, blow-down or other effluents do not violate local, state, or federal laws or regulations. Use only chemicals that are registered, when required, with the U.S. Department of Agriculture or the U.S. Environmental Protection Agency and that are labeled as required by law.

C. Provide electrical products that have been tested, listed and labeled by Underwriters Laboratories and comply with the National Electrical Manufacturers Association Standards.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Worth Hydrochem of Houston

B. Nalco Chemical Company

C. Allegheny Southwest

D. Garret-Callahan

E. Lakewood Instruments Uniloc Division

F. Hydro Systems, Inc.

2.2 CLOSED CHILLED AND HOT WATER SYSTEM / CLOSED CONDENSER WATER SYSTEM

A. By-pass filter feeders in the hot water and chilled water systems:
   1. Rated at 40-gpm capacity.

2. Operating conditions: 150 psig and 250°F.
3. Quick opening cap with a Buna N-O ring seal; or 1-1/2" valve and funnel.
4. 5 micron polypropylene filter bag mounted in a perforated stainless steel holder. Filter bag shall be supported from top of feeder.
    a. Filter bag and holder shall extend full length of feeder tank.
    b. Bottom feed tanks are not acceptable.
5. Fabricated hot dipped galvanized steel support legs and frame. Refer to detail drawing for requirements.
6. Provide sufficient quantity of filter bags for warranty period. Minimum of six additional bags provided to owner.

B. Acceptable Manufacturers
1. Neptune Model FTS-5
2. Efficiency Dynamics FF-100.
3. J.L. Wingert Model FHC-5HD.
4. Hydro-systems HS-800
5. Vector Industries, Inc. FA-900

C. Treatment chemicals:
1. Furnished as a concentrated liquid in 5 gallon pails
2. A corrosion inhibitor of the nitrite-borate type.
3. Maintained at a nitrite residual of 600 – 800 ppm in chilled loops and 1000-1500 in hot loops.
4. With effective copper, black iron, stainless steel and aluminum corrosion inhibitors.
5. Form a protective film to prevent corrosion and scale formation.
6. Have colored dye to indicate presence.

D. Multiple chemicals used in a common system shall be compatible.

E. Flow Indicator:
1. Bronze Construction
2. Rotating Wheel
3. Line Size
4. Double Window
5. Ernst Flow Industries Model EFIE-57-3

2.3 CONDENSER WATER SYSTEM

A. Prefabricated Panel Mounted System consisting of the following for each chiller / cooling tower:
1. 1 each Conductivity controller.
2. 3 each Chemical feed pumps.
3. Sample stream piping assembly on high-density polyethylene panel.
4. Prefabricated panel with stainless steel hardware utilized in securing system components.
5. System sample stream piping assembly shall be constructed of schedule 80 CPVC, and shall consist of inlet and outlet ball valves, clear Y strainer, sample valve, conductivity electrode, three chemical injection stations and

flow switch.

B. Conductivity Controller:
1. The Controller shall be a microprocessor based, menu driven industrial type conductivity controller.
2. With relay activated on/off control outputs.
3. 0-1000 microsiemen control range with displayable a 16 character, backlit LCD display.
4. Adjustable High/Low alarm points Option: with output relays and 4-20ma output.
5. The controller shall provide four programmable, non-concurrent operational modes for inhibitor feed using either:
    a. Feed as % of bleed.
    b. Feed and bleed with limit timer.
    c. Percent of time.
    d. Water meter triggered feed.
6. The Controller shall provide 2 two independent programmable biocide feed functions programmable in cycle modes of 1 to 4 weeks.
7. An adjustable pre-bleed function based on time or conductivity and programmable lockout feature shall be provided for each individual biocide feed.
8. Controller shall be an LMI model DC-4500111A1 or approved equivalent.

C. Chemical Metering Pumps:
1. Chemical metering pumps shall be positive displacement, Liquifram type pumps.
2. Output volume shall be adjustable while pumps are in operation from 0 to maximum capacity of 14 Gallons per day.
3. Adjustment shall be by readily accessible dial knobs, one for changing stroke length and the other for changing stroke frequency.
4. On-off switch shall be integral with frequency control.
5. Chemical pumps shall be capable, without a hydraulically backed diaphragm, of injecting chemicals against pressures.
6. Valves shall be cartridge type and renewable by replacing only the cartridge.
7. Pump head and fittings shall be of PVDF or CPVC construction.
8. Chemical pumps shall be LMI Model A141-352SI or approved equivalent.

D. Water Meter for Cooling Tower Make-Up:
1. Electric Contacting Head Water meter which shall be a multi jet design with bronze body and sealed register sized for required make-up flow.

E. Solenoid Valve/Blow-Down Assembly:
1. Solenoid shall be of brass body construction design and require 0 psi of backpressure to close.
2. Pre-fabricated Blow-down with isolation valve and “y”-strainer sized for required blow-down.

PART 3 - EXECUTION

3.1 INSTALLATION/START-UP

A. In accordance with manufacturer's recommendations.

B. Anchor the chemical filter feeder to a concrete housekeeping pad using wedge type expansion anchors.

C. Clean and flush closed loops systems.
   1. Clear water flush systems before introducing chemical cleaners.
   2. Chemical cleaner shall be introduced into the systems to remove construction related oils, greases, threading compounds, and silt.
   3. Chemical Cleaner shall passivate and pre-film pipe system.

3.2 WATER ANALYSIS

A. The chemical treatment agency shall provide the services of a testing laboratory to perform a site water analysis. As a minimum, conduct the following tests in accordance with ASTM standards and to the satisfaction of the Owner/Architect/Engineer.
   1. Silica in water and wastewater.
   2. Acidity or alkalinity of water.
   3. Iron in water.
   4. Hardness of water.
   5. Ph of water.
   6. Particulate and Dissolved Matter, Solids or Residue in Water.
   7. Turbidity in water.
   8. Corrosivity of water in absence of heat transfer.
   9. Standard practices for sampling water.

B. Take water samples in accordance with ASTM.

C. Prepare a test report in accordance with ASTM for each of the tests conducted.

D. Submit the test reports to the Architect/Engineer.

3.3 CHEMICAL TREATMENT

A. The chemical treatment agency shall provide complete services necessary for chemically cleaning and treatment the following systems:
   1. Chilled water.
   2. Hot water.
   3. Condenser water.

B. The chemical treatment agency shall provide, but not be limited to the following:
   1. Equipment and installation.
   2. Chemicals.

3. Analytical and testing work.
4. Inspection.
5. Calculations.
6. Assistance to the trade installing the piping.
7. Instruction to Owner.

C. Determine which chemicals to use from the results of site water analysis. Provide the chemical necessary to achieve the desired water condition.

D. Examine and supervise flushing and pipe cleaning operations and verify that the systems are clean, free of debris and rust and other construction materials before starting water treatment.

E. After the piping has been flushed, cleaned, rinsed and charged with chemicals, then start-up and operate the chemical treatment equipment to provide steady, stable characteristics for the systems treated.

F. During construction, instruct the Contractor in the field piping and wiring of chemical feeding equipment. If such piping and wiring details are not shown on the Contract Drawings, then provide all equipment, piping, wiring, instrumentation and chemicals to provide a complete and operating system without additional cost.

G. After the chemical treatment is functioning as intended, the chemical treatment agency shall demonstrate to the Architect/Engineer the chemical treatment operation.

3.4 OWNER TRAINING

A. A chemical treatment agency, in conjunction with the chemical treatment equipment manufacturer’s factory representative, shall train the Owner to operate and maintain the chemical treatment system as a whole and in part for each piece of equipment.

B. Furnish to the Owner a chemical treatment administration manual covering the chemical treatment program for each of the systems treated. The manual shall include, but not be limited to:
1. Name, address and telephone number of the chemical treatment agency and each of the equipment manufacturers.
2. Operation and maintenance manuals.
3. Test reports.
4. Chemical data sheets.
5. A narrative describing the chemical treatment program for each of the systems being treated.

3.5 TESTING AND INSPECTION

A. After the systems have been accepted, the chemical treatment agency shall visit the site every month during the warranty period.

B. During each visit:
1. Check and adjust the chemical treatment equipment.
2. Check the chemistry of the treated system to confirm the chemicals are maintaining the system as intended.
3. Advise and instruct the Owner on operational changes made to the chemical treatment program.
4. Take a water sample of each system being chemically treated and have the samples tested by a testing laboratory. Prepare a report for each water sample and submit it to the Owner. Include in the test report the changes that need to be made to the chemical treatment program.
5. Maintain complete records of the treatment program for each system at the project site. Keep the records in a hardbound manual with the building manager. A second copy shall be maintained by the agency for the agency's records.

C. Routine visits must be coordinated with the Owner.

D. Send copy of monthly report to Engineer for Verification.

END OF SECTION 232513

SECTION 233113 - DUCTWORK

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Duct construction, support and accessories. Dimensions shown on the drawings are free area dimensions.

1.2 RELATED WORK

A. Division 23 Mechanical
  1. Air Devices
  2. Air Handling Units
  3. Insulation
  4. Terminal Units
  5 Fan Coil Units
  6. Fans
  7. Packaged Rooftop Air Conditioners
  8. Testing, Balancing and Adjusting (TAB) of Environmental Systems

B. Division 9 – Finishes, Painting and Color Coding

1.3 QUALITY ASSURANCE

A. The intent of ductwork specifications is to obtain superior quality workmanship resulting in an installation that is absolutely satisfactory in both function and appearance. Provide ductwork in accordance with the specifications for each type of service.

B. An approved contractor for this work under this division shall be:
  1. A specialist in this field and have the personnel, experience, training, skill, and the organization to provide a practical working system.
  2. Able to furnish evidence of having contracted for and installed not less than 5 systems of comparable size and type that have served their owners satisfactorily for not less than 5 years.

1.4 GUARANTEE

A. Guarantee ductwork for 1 year from the date of substantial completion. The guarantee covers workmanship, noise, chatter, whistling, or vibration. Ductwork shall be free from pulsation under conditions of operation.

1.5 CONTRACTOR COORDINATION

A. Erect ducts in the general locations shown, but conform to structural and finish conditions of the building. Before fabricating any ductwork, check the physical conditions at the job site and make necessary changes in cross sections, offsets, and similar items, whether they are specifically indicated or not.

B. Coordinate location of ductwork with structural members and Architectural drawings and requirements.

1.6 SHOP DRAWINGS AND SAMPLES

A. Submit shop drawings of all ductwork layouts, including enlarged plans and elevations of all air handling equipment, and summit details of duct fittings, including particulars such as gauge sizes, welds, and configurations prior to starting work.

B. Submit product data and sealing materials to be used.

C. Submit sound attenuation data.

D. Submit shop drawings in plan, elevation and sections, and three-dimensional view showing equipment in mechanical equipment areas.

PART 2 - PRODUCTS

2.1 STANDARDS AND CODES

A. Except as otherwise indicated, sheet metal ductwork material and installation shall comply with the latest edition of SMACNA HVAC Duct Construction Standards. Air distribution devices (such as dampers) included in this specification shall comply with the latest applicable SMACNA Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems and NFPA 90A.

2.2 DUCT MATERIAL AND CONSTRUCTION

A. Except for the special ducts specified below use lock forming quality prime galvanized steel sheets or coils up to 60" wide. Stencil each sheet with gauge and manufacturer's name. Stencil coils of sheet steel throughout on 10' centers with gauge and manufacturer's name. Provide certification of duct gauge and manufacturer for each size duct.

B. Rectangular low and medium pressure duct constructed of sheet metal in accordance with the latest edition of SMACNA HVAC Duct Construction Standards.

C. Medium pressure oval and round ductwork shall be spiral seam. Spiral lock-seam SMACNA Type RL-1. Fittings shall be welded construction.

1. Galvanized
2. Stainless Steel
3. Aluminum
4. Paint Grip
5. Perforated

D. Low pressure round ducts shall be shop fabricated with snap lock longitudinal seams. Ducts shall be constructed for a minimum of 2" w.g. static pressure.

E. Dishwasher Hood Exhaust System: Welded 304 Stainless steel.

F. Shower Area Exhaust Systems: Welded 304 Stainless steel.

G. Kitchen exhaust duct: Welded Black steel, minimum 16 gauge

H. Natatorium Ductwork: 304 Stainless Steel

2.3 ACOUSTICAL DUCT

A. Duct and fittings:
1. Double wall acoustically treated.
2. Annular space packed with fiberglass insulation.
3. Perforated metal liner to provide specific acoustic impedance
4. Insulation 1.0 pcf. 1 inch thick
5. United McGill Acousti-K27 spiral lockseam or approved equal
6. Material as indicated below:
    a. Paintable Galvanized Steel
    b. Stainless Steel
    c. Aluminum

B. Pressure rating and tests as specified for single wall ductwork.

2.4 DUCT SEALING OF SEAMS AND JOINTS

A. Follow seal classification as indicated in Table 1-2 of SMACNA "HVAC AIR DUCT LEAKAGE TEST MANUAL". Use seal class A for 4" w.g. static. All longitudinal and transverse joints and seams shall be sealed by use of a fireproof, non-hardening, and non-migrating elastomeric sealant. With the exception of continuously welded joints and machine made spiral lock seams, joints and seams made air tight with duct sealer.
1. Indoor applications – Foster 32-14
2. Outdoor applications – Foster 32-17

2.5 FLEXIBLE DUCT LOW PRESSURE

A. Construction:
1. Continuous galvanized spring steel wire helix, with reinforced metalized cover

a. The fabric shall be mechanically fastened to the steel helix without the use of adhesives.
2. UL 181 Class I air duct label
3. Reinforced vapor barrier jacket
4. Rated for use at system pressure (6" wc minimum)
5. Flexible duct connections from lateral taps to variable volume boxes or terminal boxes shall be rated at twice the maximum pressure rating of the medium pressure system.

B. Fire hazard classification:
1. Flame spread rating 25 maximum.
2. Smoke developed rating 50 maximum.

C. Thermal characteristics:
1. R-6 BTU/hr/sq. ft./°F (when located in a conditioned plenum)
2. R-8 BTU/HR/Sq.Ft./°F (when located in an unconditioned plenum)
3. 2" minimum wall thickness insulation with 1" overlap

D. Acceptable manufacturers:
1. Flexmaster
2. Hart & Cooley
3. Omniair
4. Peppertree Air Solutions

2.6 FLEXIBLE DUCT MEDIUM/HIGH PRESSURE

A. The duct shall be constructed of a heavy coated fiberglass cloth fabric supported by helical wound galvanized steel. The fabric shall be mechanically fastened to the steel helix without the use of adhesives.

B. The internal working pressure rating shall be at least as follows with a bursting pressure of at least two times the working pressure:
Positive: 12" w.g.
Negative: 5" w.g.

C. The duct shall be rated for a velocity of at least 5500 fpm.

D. Suitable for operating temperature range of -20°F to +250°F.

E. Factory insulate the flexible duct with fiberglass insulation.
1. R-6 BTU/hr/sq. ft./°F (when located in a conditioned plenum)
2. R-8 BTU/HR/Sq.Ft./°F (when located in an unconditioned plenum)
3. 2" minimum wall thickness insulation with 1" overlap

F. Cover the insulation with a fire retarding polyethylene vapor barrier jacket having a permeance of not greater than 0.10 perms when tested in accordance with ASTM E96, Procedure A.

G. Acceptable manufacturers:
1. Flexmaster

2. Omniair
3. Peppertree Air Solutions

2.7 DUCT BOARD

A. Construction:
1. Rigid, resin bonded fibrous glass board with damage-resistant, flame retardant, reinforced aluminum foil (FRK) facing.
   a. Pressure Sensitive Tape listed and labeled under UL 181A, Part I(P). All longitudinal and circumferential joints stapled with outward flaring 2-1/2" staples, 2" on center. Coat all joins and seams with duct closure mastic. Foster 95-90 / 95-96. Mastic shall meet UL 181A-M and UL 181B-M.
2. UL 181 Class I air duct label
3. Provide mat air stream surface to isolate glass fiber substrate from air stream and inhibit penetration by dirt, dust and other pollutants. Air stream surface shall include an EPA registered biocide to protect air stream surface from microbial growth and meet requirements of ASTM C 138, ASTM G 21 and ASTM G 22.
4. Operating static pressure to +/- 2 inches water gauge, internal air temperatures 40 degrees F to 250 degrees F and air velocities up to 6,000 feet per minute.

B. Fire Hazard classification:
1. Flame spread rating 5 maximum
2. Smoke developed rating 50 maximum

C. Thermal characteristics:
1. R-6 BTU/hr/sp. Ft./°F
2. 1-1/2" thick

D. Acceptable Manufacturers:
1. Owens Corning

2.8 FIRE DAMPERS

A. Fire dampers for required wall ratings that are 95% minimum free area. Provide Type B or Type C UL dampers for low, medium and high-pressure rectangular, square or round ducts. Dampers shall be activated by a fusible link designed to react at 165°F. Install per manufactures recommendations to provide a UL assembly. Provide sealed sleeve to meet desired leakage performance.

B. Acceptable Manufacturers:
1. Ruskin
2. Prefco Products
3. Air Balance
4. Greenheck, Inc.
5. Nailor Industries
6. Pottoroff

2.9 CEILING RADIATION DAMPERS

A. Ceiling Radiation Dampers at location shown on plans constructed and tested in accordance with the current edition of UL555C of a minimum 22 gauge (0.8) blades, hinged in the center and held open with a 165° fusible link. Maximum blade height in the open position shall be 10" overall regardless of damper area. Maximum distance between blades held in the open position shall be 1-1/4" for units not requiring blade insulation and 1/4" for units with sheetrock blade insulation. Blades requiring radiation protection insulation shall utilize sheetrock. Refractory Ceramic or Mineral Wool Fiber is not allowed in the air stream. Radiation insulation outside of the air stream shall be Mineral Wool Fiber only. Ceramic Fiber Material is not approved for use. Units shall be constructed of a minimum 20-gauge (0.9) frame welded at all seams.

B. Acceptable Manufactures
   1. Ruskin
   2. Prefco
   3. Air Balance
   4. Phillips
   5. Safe-Air
   6. Nailor Industries

2.10 WALL LOUVERS

A. Refer to schedule on drawings. Coordinate with Architectural Drawings.

B. All louver frames shall be a minimum of 0.08" extruded aluminum. All blades shall be a minimum of 0.081" extruded aluminum. Beginning point of water penetration at 0.01 oz/sq.ft. Shall be a minimum of 800 ft/min.

C. Provide all louvers with removable aluminum bird screen with 1/4" mesh.

D. Acceptable manufacturers:
   1. American Warming and Ventilation
   2. Arrow
   3. Greenheck
   4. NCA
   5. Pottorff
   6. Ruskin

2.11 FLUES FOR ATMOSPHERIC BOILERS AND WATER HEATERS

A. Type B, round or oval, double-wall vent pipe, equal to Metalbestos or Metal-Fab, including accessories such as vent caps by the same manufacturers. Use oval vent where necessary to fit in wall construction. All exterior components shall be 304 stainless steel for outdoor installations.

2.12 FLUES FOR POWER EXHAUST AND HIGH EFFICIENCY BOILERS AND WATER HEATERS

A. Double wall air insulated positive pressure chimney equal to Metalbestos, Van-Packer, Schebler or Metal-Fab. Chimney shall be rated for 550°F maximum flue gas temperature and with a UL tested pressure rating of 40 inches w.c. The interior pipe shall be constructed of AL 29-4C stainless steel and the exterior pipe shall be constructed of 304 stainless steel. Stack system shall be complete with a one inch air gap between inner liner and outer cover. Chimney shall be constructed and installed per UL-1738 and NFPA-211. All accessories shall be made by the same manufacturer and designed to be a part of a positive pressure chimney system.

2.13 FLUES FOR FAN POWERED FIRETUBE BOILERS AND WATER HEATERS

A. Double wall air insulated positive pressure chimney equal to Metalbestos, Van-Packer, Schebler or Metal-Fab. Chimney shall be rated for 1400°F continuous operation, 1800°F intermittent operation and for positive pressures up to 60 inches w.c. The interior pipe shall be constructed of 304 stainless steel and the exterior pipe shall be constructed of 304 stainless steel. Stack system shall be complete with a one-inch air gap between inner liner and outer cover. Chimney shall be constructed and installed per UL-103 and NFPA-211. All accessories shall be made by the same manufacturer and designed to be a part of a positive pressure chimney system.

2.14 FLUE CAPS

A. Stainless steel flue caps of a design so that wind action from any direction will create a vacuum in the flue. Caps as manufactured by Breidert or equal are acceptable. Refer to installation details on drawings.

2.15 DUCT LINING

A. Duct lining shall be 1" thick, 1-1/2 lb. density, flexible lining coated on the air stream side to reduce attrition. Liner shall be Schuler Lina-Coustic, Certain-Teed Ultralite, or equal meeting requirements of NFPA 90-A. Provide I.A.Q. rated liner.

2.16 CONTROL DAMPERS

A. Opposed blade dampers for 2-position and modulating control. Construct frames of 13-gauge galvanized sheet metal with provisions for duct mounting. Damper blades not exceeding 8" in width, of corrugated-type construction, fabricated from two sheets of 22-gauge galvanized sheet metal spot-welded together or a single 16-gauge sheet. Make bearings of nylon or oil-impregnated, sinthered bronze. Make shafts of 1/2" zinc-plated steel. Blades suitable for high velocity performance. Construct damper so that leakage does not exceed 1/2% based on

2000 fpm and 4" static pressure. Provide replaceable resilient seals along top, bottom and sides of frame and along blade edge. Submit leakage and flow characteristics data with shop drawings. Linkage shall be concealed out of the air stream within damper frame to reduce pressure drop and noise.

B. Acceptable Model is Ruskin Model CD60.

2.17 VOLUME DAMPERS

A. Manual balancing dampers that meet or exceed the following minimum construction standards:
   1. Frame 16-gauge
   2. Blades 16-gauge
   3. Bearings corrosion resistant
   4. Concealed linkage
   5. Opposed blade dampers

B. Acceptable manufacturer:
   1. Ruskin Model MD-35 or approved equal, by
   2. Arrow
   3. American Warming and Ventilating
   4. Nailor Industries
   5. Pottoroff

2.18 ACCESS DOORS

A. Round spin-in door of galvanized steel.
   1. Fire proof sealing gaskets and quick fastening locking devices
   2. Insulated door
   3. Conform to the requirements of the NFPA
   4. Identification and use of each access door
   5. UL label to match the construction in which it is installed
   6. Cable attached to door and outer frame
   7. Low leakage Access Door

B. Acceptable Manufacturer
   1. Flex master, Inspector Series
   2. Approved Equal

2.19 COMBINATION FIRE/SMOKE DAMPERS

A. Combination fire/smoke dampers meeting the following requirements:
   1. Each combination fire/smoke damper shall be 1-1/2 hour fire rated under UL Standard 555, 4th Edition, and shall be further classified by Underwriters Laboratories as a leakage Rated Damper for use in smoke control systems under the latest version of UL555S, and bear a UL label attesting to same. The damper manufacturer shall have tested, and qualified with UL, a complete range of damper sizes covering all dampers

required by this specification. Testing and qualifying a single damper size is not acceptable. The leakage rating under UL555S shall be Leakage Class II.

2. The damper frame shall be a minimum of 16 gauge, galvanized steel, formed into a structural hat channel shape with tabbed corners for reinforcement, as approved in testing by Underwriters Laboratories. Bearings shall be integral high surface area non-electrolytic materials construction to incorporate a friction free frame blade lap seal, or molybdenum disulfide impregnated stainless steel or bronze oilite sleeve type turning in the damper frame. The dampers shall be opposed blade type. The blades shall be constructed with a minimum of 16-gauge galvanized steel. The blade edge seal material shall be able to withstand 450°F. The jamb seals shall be flexible stainless steel compression type.
3. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (open and close) under HVAC system operation conditions, with pressures of at least 4" water gauge in the closed position, and 2,000 fpm air velocity in the open position.
4. Each combination fire/smoke damper shall be equipped with a controlled 7 to 15 second heat-actuated release device. The electric EFL shall close and lock the fire/smoke damper during test, smoke detection, power failure or fire conditions through actuator closure springs. To prevent duct and HVAC component damage, the damper shall at all times be connected to the actuator for controlled closure in not less than 7 seconds and no more than 15 seconds. Instantaneous damper closure is unacceptable. After exposure to high temperature of fire, the damper must be inspected prior to reset to ensure proper operation. Release temperature is 165°F.
5. Provide UL555S qualified electric actuator at 120 VAC.
6. Provide air-foil type blades.

B. Provide integral sleeves

C. Acceptable Manufacturers:
1. Ruskin
2. Air Balance, Inc.
3. Greenheck, Inc.
4. Nailor Industries
5. Pottoroff

2.20 SMOKE DAMPERS

A. Smoke dampers meeting the following requirements.
1. Each smoke damper shall be classified by Underwriters Laboratories as a leakage Rated Damper for use in smoke control systems under the latest version of UL555S, and bear a UL label attesting to same. The damper manufacturer shall have tested, and qualified with UL, a complete range of damper sizes covering all dampers required by this specification. Testing and qualifying a single damper size is not acceptable. The leakage rating under UL555S shall be Leakage Class II.
2. The damper frame shall be a minimum of 16 gauge, galvanized steel,

formed into a structural hat channel shape with tabbed corners for reinforcement, as approved in testing by Underwriters Laboratories. Bearings shall be integral high surface area non-electrolytic materials construction to incorporate a friction free frame blade lap seal, or molybdenum disulfide impregnated stainless steel or bronze oilite sleeve type turning in the damper frame. The dampers shall be opposed blade type. The blades shall be constructed with a minimum of 16 gauge, galvanized steel. The blade edge seal material shall be able to withstand 450°F. The jamb seals shall be flexible stainless steel compression type.

3. As part of the UL qualification, dampers shall have demonstrated a capacity to operate (open and close) under HVAC system operation conditions, with pressures of at least 4" water gauge in the closed position, and 2,000 fpm air velocity in the open position.
4. Provide UL555S qualified electric actuator at 120 VAC.
5. Provide air-foil type blades.

B. Provide integral sleeves.

C. Acceptable Manufacturers:
1. Ruskin
2. Air Balance, Inc.
3. Greenheck, Inc.
4. Nailor Industries
5. Pottoroff

2.21 DIFFUSER FITTINGS LOW PRESSURE TAPS

A. Fitting shall meet or exceed the following minimum construction standards:
1. Conical with a base diameter two inches larger than the tap diameter.
2. Construct fitting and damper of galvanized steel in accordance with ASTM A 527, G90 finish.
    a. Fitting with a 3/16-inch high stop bead approximately 2-1/2-inches from the discharge end of the fitting
    b. Provide the fitting with a butterfly damper, damper rod, end bearings and heavy duty locking quadrant.
    c. Size the length of the straight section of the fitting to match the damper blade diameter. Center the damper blade in the straight section.
3. Match the fitting body gauge to the SMACNA duct gauge, but not less than:
    a. Through 8 inches: 26 gauge; Damper blade 22 gauge
    b. 10 inches and 12 inches: 24 gauge; Damper blade 22 gauge
    c. 14 inches and 16 inches: 22 gauge; Damper blade 22 gauge
    d. 18 inches and 20 inches: 20 gauge; Damper blade 20 gauge
4. Fasten damper blade to a 3/8 X 3/8 continuous square rod with minimum (2) galvanized U-bolts.
5. Support the damper rod to the fitting with airtight nylon end bushings / bearings.
6. Provide the damper with a self-locking regulator and handle.
7. Provide a 2” sheet metal stand-off to extend the regulator.

8. Flex duct grip area – 2 inches behind retaining bead
9. Flex duct retaining bead – 1 inch from end
10. Conical length of at least 3 inches
11. Barrel length of at least 9 inches

2.22 AUXILIARY DRAIN PANS

A. Galvanized steel, same gauge and same bracing or cross breaks as a duct with same dimensions. Sides of pan turned up to 1-1/2”, all joints soldered watertight. Pan is to be large enough to complete cover drip lines of unit.

2.23 DUCTWORK SUPPORTS ON ROOF

A. Support ductwork on roof with Portable Pipe Hanger Model PHP-D fully adjustable height and width. Base material shall be high density / high impact polypropylene with UV inhibitors and anti-oxidants. Provide with hot dip galvanized framing. Nuts and washers shall be hot dip galvanized.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Use construction methods and requirements as outlined in SMACNA HVAC Duct Construction Standards as well as SMACNA Balancing and Adjusting publications, unless indicated otherwise in the specifications. Refer to details on the drawings for additional information.

B. Reinforce ducts in accordance with recommended construction practice of SMACNA. Provide additional reinforcement of large plenums as required to prevent excessive flexing and or vibration.

C. Cross break or bead sheet metal for rigidity, except ducts that are 12" or less in the longest dimension.

D. Where ducts pass through walls in exposed areas, install suitable escutcheons made of sheet metal angles as closers.

E. At locations where ductwork passes through floors, provide watertight concrete curb around penetration.

F. Support ducts where passing through floors with galvanized steel structural angles of adequate bearing surface.

G. Metal or lined ductwork exposed to view through grilles, registers, and other openings shall be painted flat black. Do not install grilles, registers, or similar items until painting is complete.

H. Fire Dampers shall be installed per manufacturer's recommendations to create a UL rated assembly.

I. Install end bearing at all location where damper shaft penetrates duct wall.

J. Clean duct to remove accumulated dust. Ducts shall be closed on ends between phases of fabrication to assure that no foreign material enters the ducts.

3.2 DUCTWORK

A. Construct rectangular ducts and round ducts in accordance with the latest SMACNA HVAC Duct Construction Standards. Use the static pressure specified on the air handling unit schedule or fan schedules as a minimum for duct construction. All ductwork between the variable volume air handling units and the terminal units shall be constructed to the medium pressure ductwork specification.

B. Provide adjustable, galvanized splitter-dampers, pivoted at the downstream end with appropriate control device at each supply duct split.

C. For branch ducts wider than 18", and when shown on drawings provide extractors with an appropriate control device at each rectangular zone or branch supply duct connection. Provide controllers for extractors. Branch ducts shall have a 45° angle in the direction of flow. Do not provide extractor at branch ducts to sidewall registers where the registers are within 10 feet of the main duct.

D. Shop manufactured curved blade scoops may be used for branch duct takeoffs up to 18" wide. Taper scoop blade to the end, to prevent any sagging that may cut into, or damage duct liner if specified during operation.
   1. Construct shop manufactured scoops and splitter blades of galvanized sheet metal 2 full gauges heavier than equivalent sheet metal gauge of branch duct (up to 16 gauge).
   2. Check extractors, scoops and splitter blades thoroughly for freedom of operation. Oil bearing points before installing.

E. Use pushrod operator with locking nut and butt hinges assembly.

F. Provide opposed-blade volume dampers with an appropriate control device in each of the following locations:
   1. Return air ductwork
   2. Outside air branch duct
   3. Exhaust branch duct
   4. Exhaust connections to hoods except kitchen grease hoods or equipment
   5. In each zone at multi-zone unit discharge installed downstream of duct mounted re-heat coils
   6. At each outside air and return air duct connection to plenum of constant volume units
   7. At discharge side of constant volume boxes
   8. Where otherwise indicated or required for balancing coordinate location of additional dampers required by TAB Contractor.

9. Provide multi-blade dampers when blade width exceeds 12". Provide end bearing where damper shaft penetrates duct wall.

G. Elbows:
1. Rectangular: Where square elbows are shown, or are required for good airflow, provide and install single-wall or airfoil turning vanes. Job-fabricated turning vanes, if used, shall be single-thickness vanes of galvanized steel sheets of the same gauge metal as the duct in which they are installed. Furnish vanes fabricated for the same angle as the duct offset. The use of radius elbows with a centerline radius of not less than 1-1/2 times the duct width may be provided in lieu of vaned elbows where space and air flow requirements permit.
2. Round Oval Duct. Provide elbows with a centerline radius of 1-1/2 times the duct diameter or duct width. For round ducts, furnish smooth elbows or 5 piece, 90° elbows and 3 piece, 45° elbows.

H. For control devices concealed by ceilings, furring, or in other inaccessible locations, furnish extension rods and appropriate recessed-type Young regulators, mounted on the surface of the ceiling or the furring, unless specified, or shown otherwise. Provide with chrome plated cover plates. Use only one mitered gear set for each control device.

I. Install streamline deflectors at any point where dividing a sheet metal duct around piping or where other such obstruction is permitted. Where such obstructions occur in insulated ducts, fill space inside streamliner and around obstructions with glass fiber insulation.

J. Insulated Flexible Duct:
1. Install in accordance with manufacturer's instructions, and the terms of its UL listing. Duct shall not exceed 6' in length. Make connections by use of sheet metal collars and stainless steel circular screw clamps. Clamps shall encircle the duct completely and be tightened with a worm gear operator to the point that will provide an airtight connection without unnecessary deformation of the duct. Provide one clamp on flexible duct and one clamp on external insulation. Vapor barrier jacket shall be tucked inside to conceal insulation material.
2. Construct bends over 45° with sheet metal elbows.

K. Duct Supports:
1. Horizontal ducts up to 40". Support horizontal ducts up to and including 40" in their greater dimension by means of #18 U.S. gauge galvanized iron strap hangers attached to the ducts by a minimum of two locations per side by means of screws, rivets or clamps, and fastened to inserts with toggle bolts, beam clamps or other approved means. Place supports on at least 8' centers. Use clamps to fasten hangers to reinforcing on sealed ducts.
2. Horizontal ducts larger than 40". Support horizontal ducts larger than 40" in their greatest dimension by means of hanger rods bolted to angle iron trapeze hangers. Place supports on at least 8' centers in accordance with SMACNA Standards.
3. Support vertical ducts where they pass through the floor lines with 1-1/2"

x 1-1/2" x 1/4" angles for ducts up to 60". Above 60", the angles shall be increased in strength and sized on an individual basis considering space requirements.
4. Supports shall be suspended from structural or by independent support. Do not support from structural bridging. Upper attachments should be selected with a safety factor of 4 or 5 times actual load conditions and subject to Engineers approval. Double wrap straps over open web of joist.

L. Branch connections for medium pressure ductwork shall be made with a conical lateral. Field installed conical branch ducts shall be minimum 20-gauge galvanized sheet metal, “Everdur” welded and coated with “Galvabar”.

3.3 PLENUMS

A. Return air plenums shall be rectangular galvanized sheet metal ductwork.

B. Fabricate plenums upstream of fan of 16-gauge material.

C. Fabricate plenums upstream of filters minimum 18-gauge material.

3.4 FLEXIBLE CONNECTIONS

A. Where ducts connect to fans or air handling units that are not internally isolated, make flexible airtight connections using "Ventglas" fabric. The fabric shall be fire-resistant, waterproof and mildew resistant with a weight of approximately 30 ounces per square yard. Provide a minimum of 1/2" slack in the connections, and a minimum of 2-1/2" distance between the edges of the ducts. Also, provide a minimum of 1" slack for each inch of static pressure on the fan system. Fasten fabric to apparatus and to adjacent ductwork by means of galvanized flats or draw bands. Where connections are made in outdoor locations, seal fabric to metal with mastic.

3.5 ACCESS DOORS

A. Install ductwork access doors as noted below, arranged for convenient access. Stencil each door for specific use. Install access doors in each of the following locations: *Some clients want doors on both sides of dampers.
1. Fire Dampers
2. Smoke Dampers
3. Smoke/fire Dampers
4. Outside Air Dampers
5. Duct Mounted Coils (up-stream)
6. Control Dampers
7. 12”x12” access door for cleaning at a maximum distance of 20’-0” from center of adjacent access door. CY-FAIR REQUIREMENT

B. Size access door 1" smaller than ductwork.
1. Available Sizes: 8”, 10”, 12”, 18”, 24”

C. Construct access door air tight, and conform to recommendations of NFPA and SMACNA.

D. Demonstrate suitability of access for the intended purpose. Install multiple access doors as required.

3.6 DUCT LINING

A. Install glass fiber acoustical lining where shown on drawings. Secure to duct surfaces with Foster 85-62 / 85-60 or Childers CP-125-1 / CP-127 adhesive and sheet metal fasteners on 12" centers. Coat exposed edges and leading edges of cross-joints with adhesive.

B. Provide metal nosing that is either channeled or "Z" profiled or are integrally-formed from the duct wall securely installed over transversely oriented liner edges facing the air stream at fan discharge and at any interval of lined duct preceded by unlined duct.

C. Refer to Insulation & Liner Detail on drawings for locations requiring liner to be installed.

D. Do not install liner in multi-zone unit ductwork.

3.7 SEALING OF SEAMS AND JOINTS

A. Seal supply, return, exhaust and outside air duct systems.

3.8 FLUES

A. Provide and install flues for all gas fired equipment.

B. Refer to plans for all related locations.

C. Contractor is responsible for coordinating stack sizing, stack drains, stack test ports, stack termination fittings and all other required fittings with the selected equipment manufacturers.

D. All fittings and accessories shall be manufactured by the flue manufacturer. The flue shall be installed per manufacturer's instruction.

E. Terminate flues at height above roof to prevent flue gas from entering the building.

3.9 DISHWASHER HOOD EXHAUST SYSTEM

A. All material and fittings shall be 304 Stainless steel, welded joints, watertight construction. Grade horizontal duct 1/4" per lineal foot to drain toward the washer.

3.10 SHOWER AREA EXHAUST SYSTEM

A. All material and fittings shall be 304 Stainless steel, welded joints, watertight construction. Grade horizontal duct 1/4" per lineal foot slope down to grille connection. Install in accordance with Fig. 2-21 of SMACNA HVAC Duct Construction Standards.

3.11 KITCHEN EXHAUST DUCT

A. All material and fittings shall be minimum 16 gauge, coated black steel to prevent rusting. All seams and joints in the kitchen exhaust duct, and penetrations of the hood enclosure to its lower outermost perimeter that directs and captures grease-laden vapors and exhaust gases shall have a liquid tight continuous external weld. All ducts shall be installed without forming dips or traps that might collect residues. Provide 18" x 18" or equal area at each elbow and as required for cleaning access, in direction of air flow. UL Listed access panel shall be located on the vertical wall of the duct 1-1/2" from the bottom of duct and shall be fitted with two handles, grease and air tight fitting access door and latch. All interior surfaces of ducts shall be accessible for cleaning and inspection purposes. Duct shall maintain minimum 1/4" per lineal foot slope to the exhaust hood. Provide duct over lay at the roof curb for a complete seal. Install kitchen exhaust system per local authority. In the absence of a local authority, the requirements of the Uniform Mechanical Code and NFPA 96 shall govern.

3.12 FUME HOOD EXHAUST SYSTEM

A. All material and fittings shall be 304 stainless steel construction.

3.13 ACOUSTICAL DUCT

A. Install in the following locations:
   1. Gymnasiums
   2. Auditorium
   3. And/or where indicated on the drawings

3.14 SCREENS

A. Furnish and install screens on all duct, fan, etc., openings furnished by the Contractor that lead to, or are, outdoors; screens shall be No. 16 gauge, one-half inch (1/2”) mesh in removable galvanized steel frame. Provide safety screens meeting OSHA requirements for protection of maintenance personnel on all fan inlets and fan outlets to which no ductwork is connected.

3.15 CONNECTIONS TO LOUVERS

A. Make watertight connections to all louvers. Ductwork behind louver shall have watertight soldered joints for a minimum of three feet and be sloped to bottom of louver. Lap duct to be over bottom louver blade where possible.

B. Where plenums are installed on inside of louver, construct such that bottom of plenum will lap over bottom blade of louver to drain any water that may enter.

3.16 PLENUMS

A. Construct plenums with galvanized steel framing members and galvanized sheet steel, cross broken and rigidly braced with galvanized angles. Gauges and bracing shall conform to SMACNA recommendations for ductwork of like sizes. Openings for fans, access doors, etc., shall be framed with galvanized steel angles.

B. Provide access doors.

3.17 AUXILIARY DRAIN PANS

A. Where coils that have a condensate drain are located above ceiling.

3.18 TESTING OF LOW PRESSURE DUCTWORK

A. Test ductwork for leaks before concealing. Maximum allowable leakage is 5% of total airflow.

B. Provide equipment necessary for performing tests, including rotary blower large enough to provide required static pressure at allowed CFM quantity, certified orifice section with proper papers, traceable serial numbers and pressure vs CFM leakage rate scale, U-tube gauge board complete with cocks, tubing, and inclined manometer for leakage rates.

C. Mains: Test mains after risers and branches are tied in and all equipment set. Close runout connections and place fan in operation. Provide pressure in mains at 1-1/2 times design pressure. Visually inspect joints. Repair leaks detected by sound or touch. Release mains for completion after joints are tight.

D. Ductwork down stream of terminal boxes, return, exhaust, and outside air ducts are to be visually inspected.

3.19 TESTING OF MEDIUM AND HIGH PRESSURE DUCT

A. As the project progresses, test the ductwork in sections.

B. Provide equipment necessary for performing tests, including rotary blower large enough to provide required static pressure at allowed CFM quantity, certified orifice section with proper papers, traceable serial numbers, and pressure vs. CFM leakage rate scale, U-tube gauge board complete with cocks, tubing, and inclined manometer for leakage rates.

C. Finally as a complete system, test ductwork at a minimum of 2.5” with a maximum allowable leakage of 1% of the total design supply airflow.

D. Test method as set forth in SMACNA "HVAC Duct Construction Standards".

END OF SECTION 233113

SECTION 233416 - FANS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install fans, including centrifugal, axial and propeller types, with supplemental equipment.

1.2 RELATED WORK

A. Division 23 Mechanical:
   1. Ductwork
   2. Vibration Isolation
   3. Air Balance
   4. Electrical Provisions of Mechanical Work

1.3 PERFORMANCE

A. Provide fan type, arrangement, rotation, capacity, size, motor horsepower, and motor voltage as shown. Fan capacities and characteristics are scheduled on the drawings. Provide fans capable of accommodating static pressure variations of +10% of scheduled design at the design air flow.

B. Rate fans according to appropriate Air Moving and Conditioning Association, Inc. (AMCA), approved test codes and procedures. Supply fans with sound ratings below the maximums permitted by AMCA Standards. All fans provided must be licensed to bear the Certified Ratings Seal.

C. Statically and dynamically balance all fans.

D. Motors shall be sized so that they do not operate within the motor service factor.

E. Fans shall be capable of 120% of the scheduled air capacities.

F. All static pressures shown on schedules are external to fans. Manufacturer shall add damper and accessory losses to scheduled value before selecting fan.

1.4 SUBMITTALS

A. Submit fan performance curves with system operating point plotted on curves.

B. Submit manufacturer’s printed installation instructions.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Cook

B. Greenheck

C. Penn Barry Ventilator

D. Twin City Fans

2.2 PROTECTIVE COATINGS

A. Manufacturer's Standard. Apply to fans, motors and accessories, the manufacturer's standard prime coat and finish, except on aluminum surfaces or where special coatings are required.

B. Galvanizing. After fabrication of the parts, hot-dip coat surfaces that require galvanizing. Where galvanizing is specified, a zinc coating may be used. After fabrication, apply the zinc coating and air-dry the coating to 95% pure zinc. Acceptable zinc coatings include Zincilate, Sealube, Amercoat, Diametcoat, or an approved equal.

2.3 SUPPLEMENTAL EQUIPMENT

A. Motor Covers. Provide weatherproof motor covers for installations out of doors. Apply the same finish as used on the fan.

B. Belt Drives:
   1. Unless otherwise specified for belt-driven fans, equip the fan motors with variable pitch sheaves. Select the sheave size for the approximate midpoint of adjustment and to provide not less than 20% speed variation from full open to full closed. Size drives for 150% of rated horsepower. Key the fan sheave to the fan shaft.
   2. Nonadjustable motor sheaves may be used for motor sizes over 15 horsepower, at the Contractor's option. However, if changing a nonadjustable sheave becomes necessary to produce the specified capacity, the change must be made at no additional cost.
   3. Provide belt guards and apply the same finish as used on the fan.
   4. Oil and heat resistant, nonstatic type belts.
   5. Bearings shall be designed and individually tested specifically for use in air handling applications. Construction shall be heavy duty, regreasable, ball type, in a pillow block, cast iron housing, selected for a minimum L50 life in excess of 200,000 hours at maximum catalog operating speed.

C. Safety Disconnect Switch: Provide a factory-wired to motor, safety disconnect switch on each unit.

D. Relief Vents and Air Inlets: Provide vents and inlets with aluminum frames and 1/2" mesh, galvanized bird screens. Include dampers where shown.

E. Prefabricated Roof Curbs: Furnish prefabricated roof curbs as detailed. The minimum height is 14". Include a resilient pad on each roof curb so the equipment can be mounted on the top flange for proper seal. Coordinate roof slope and curb to ensure equipment is installed in level position. Provide double shell to protect insulation from damage.

F. Dampers. Where automatic backdraft damper is scheduled:
1. Multi-bladed.
2. Heavy duty.
3. Roll formed aluminum blades.
4. Nylon bearings.
5. Neoprene weather strip on blade edge.

G. Where motorized damper is scheduled:
1. The motor and damper are specified in the Building Management and Control System Specification.

H. All fans are to be provided with a durable, deep etched, .025" thick, factory installed aluminum identification plate with the following information. Plates are to be furnished with four mounting holes.
1. Fan mark as indicated on the Contract Drawings.
2. Serial number
3. Model number
4. Capacity (CFM) and static pressure.
5. Motor HP
6. Motor Amps
7. Manufacturer
8. Motor phase
9. Number of Belts/Make/Size
10. Motor volts

2.4 VENTILATION AND EXHAUST FANS

A. Provide the ventilation and exhaust fans shown on the drawings.

B. Provide each motor with internal overload protection.

C. Provide each belt driven fan with approved, totally enclosed belt guard.

D. Provide approved safety screen where inlet or outlet is exposed.

E. Provide duct flanges where required for connections.

F. Furnish kitchen hood exhaust fans with vented curb extension that meets NFPA 96, cleanout port, grease tap, curb seal, drain connection and hinge kit.

G. Furnish supply fans with 1” aluminum, washable filter section.

2.5 ROOFTOP VENTILATION AND EXHAUST SYSTEMS

A. Provide the rooftop ventilation and exhaust systems shown on the drawings.

B. Provide each motor with internal overload protection.

C. Components:
   1. Aluminum, stainless steel or plastic coated bird guard.
   2. Screws and fasteners of stainless steel or nonferrous material.
   3. All aluminum construction unless indicated otherwise on fan schedule.

D. Welded construction, corrosion resistant fasteners, minimum 16 gauge marine allow aluminum.

E. Aluminum base shall be continuously welded curb cap corners.

2.6 GRAVITY ROOF-TOP INTAKE AND RELIEF VENTS

A. Provide the rooftop intake and relief vent systems shown on the drawings.

B. Provide with aluminum, stainless steel or plastic coated bird guard.
   1. Screws and fasteners of stainless steel or nonferrous material
   2. All aluminum construction

C. Welded construction, corrosion resistant fasteners, minimum 16-gauge marine alloy aluminum.

D. Aluminum base shall be continuously welded curb cap corners.

2.7 OSCILLATING AIR CIRCULATOR FAN

A. Three speed CFM Low 1657 – CFM Medium 2060 – CFM High 3100

B. Totally enclosed motor voltage – 120 Voltage – 60 Hz

C. Cast Aluminum 20-inch diameter, three blade fan with OSHA Guard

D. Wall Mounted

E. Factory wired 10’, 3 conductor with ground molded plug

F. Acceptable Manufacturer: Dayton 4PRV7 or approved equal

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fans according to the manufacturer's instructions and in the locations shown on the drawings. Ensure fan location is installed at minimum distance from roof edge to meet code requirements.

B. Do not operate fans or fan powered devices for any purpose until ductwork is clean, filters in place, bearings lubricated and the fan has been run under observation.

C. Roof mounted fans and gravity roof-top intake and relief vents shall be secured to the curb with stainless steel lag screws at a minimum of 6-inches on center. Follow manufacturer’s installation instructions if they are more stringent. Install roof mounted equipment in a level position. Units shall be seated on properly sized curb. Gap between base of the fan and top of the curb shall be sealed with neoprene 1” x ¼” gasket. Gasket shall be glued or attached with pressure sensitive adhesive.

D. Install curbs and equipment in level position.

E. Ceiling mounted in-line centrifugal blowers
   1. Shall be suspended from structure with 1/2-inch zinc plated all-thread rods secured to structure.
   2. Provide sub-structure where required.
   3. Mount bottom of fan no more than 18-inches above the finished ceiling height.

3.2 EXTRA MATERIALS

A. Provide two sets of belts for each fan, not including the set installed on the fans. Tag set to identify fan.

END OF SECTION 233416

SECTION 233713 - AIR DEVICES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install air distribution devices, including grilles, diffusers, registers, dampers, and extractors.

1.2 RELATED WORK

A. Division 23 Mechanical.
   1. Ductwork.
   2. Air Balance.
   3. Electrical Requirements for Mechanical Work.

1.3 COOPERATION WITH OTHER TRADES

A. Coordinate this work with work under Division 26 Electrical, to ensure that intended functions of lighting and air systems are achieved.

1.4 SUBMITTALS

A. Submit product data for outlets, grilles, registers, control devices, and similar equipment for review prior to placement of purchase order.

B. Submittal shall include performance sheet for each air device type. Performance sheet shall include NC levels, throw, and total pressure loss at various air flows.

1.5 FINISHES

A. Paint exposed devices with factory standard prime coat, or factory finish coat, as specified.

PART 2 - PRODUCTS

2.1 DIFFUSERS, GRILLES AND REGISTERS - Refer to Drawing Schedule.

2.2 ACCEPTABLE MANUFACTURERS

A. Titus.

B. Krueger.

C. Nailor Industries.

D. Price

E. Metal-Aire

2.3 ACCESSORIES

A. Supply Grille Extractors. Provide supply grilles with an air control device capable of positively regulating the volume of air extracted from the supply duct.

Select extractors similar to Titus Model AG25, tight-closing in the minimum position. Include a key-operated or worm-gear adjusting mechanism to facilitate positioning from the grille opening. Where adjustment is not accessible at the grille opening, provide a square control rod equipped with a locking quadrant.

B. Mounting Frames. Provide each grille or register not equipped with a removable core with a companion, all-purpose mounting frame constructed like grille frame to facilitate installation and removal of the grille or register without marring adjacent mounting surfaces.
   1. Furnish frames with 1/2" thick sponge rubber gasket to prevent air leakage.
   2. Provide a frame that neatly fits the grille. Mounting frames will not be required for grilles or registers mounted directly on exposed ductwork.

PART 3 - EXECUTION

3.1 INSPECTION

A. Do not install ceilings adjacent to fixtures until installation of fixtures, air supply assemblies, return-air blank-off strips and flexible duct have been approved. Remove and reinstall any part of the installation found incorrect.

3.2 INSTALLATION

A. Louvered diffuser outlets mount tight against the ceiling. Fasten outlets to ductwork with sheet metal screws. For perforated diffusers, attach the frame assembly by a concealed hinge assembly to an outer frame compatible with the type of ceiling on which the diffuser is installed.

END OF SECTION 233713

SECTION 234100 - AIR FILTRATION

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install air filters and air filter gauges.

1.2 RELATED WORK

A. Division 23 Mechanical.

1.3 SUBMITTALS

A. Submit manufacturer's product data sheets and capacity information as specified.

B. Submit recommended Dirty Filter pressure drop.

PART 2 - PRODUCTS

2.1 AIR FILTER GAUGES

A. Install an air filter gauge as specified for each air handling unit and heat pump indoor fan/coil unit. (Not perimeter heating fan/coil units.)
   1. Mount to take pressure differential across each filter bank.
   2. Locate to be easily read from 5'-6" eye level.

B. Install filter gauges on:
   1. Each constant volume air handling unit.
   2. Each heating/cooling fan/coil unit.
   3. Two selected plenum heater fan/coil units.

C. Provide with range appropriate to the filter manufacturer's recommendation for maximum pressure drop across the filter.

D. Filter gauge shall be Dwyer Series 3000 Photohelic.
   1. Static pressure tips.
   2. Sensing tubing.
   3. Adjustable alarm signal flag.
   4. Auxiliary contacts for remote monitoring.

E. Filter gauge shall be Dwyer Series 2000 Magnahelic:
   1. Static pressure tips.

2. Sensing tubing.
3. Adjustable alarm signal flag.

F. Set alarm signal flag and auxiliary contacts as recommended for maximum pressure drop Dirty Filter across the filter bank.

G. Mount the filter gauge on a rigid structural bracket on the unit.

2.2 AIR FILTERS

A. The filter cells:
1. Permanent frame with renewable media.
2. 18-gauge galvanized steel holding frame.
3. 11-gauge galvanized steel wire grids to support the media.
4. Front grid hinged and secured with a latch.

B. The renewable viscous coated glass fiber media:
1. Graduated density from front to back.
2. Initial resistance not to exceed 0.17" WG at 500 fpm velocity.
3. UL listed Class II.

C. Acceptable manufacturers:
1. Cam-Farr.
2. AAF.

D. Spare filter:
1. Provide the following material to the Owner for use during the warranty period.
2. Sufficient media of each thickness, in original cartons, for a complete change.

2.3 AIR FILTERS

A. Filter cells:
1. Permanent, impingement, washable.
2. Metal, panel type.
3. Electro galvanized 14 mesh steel screen media arranged in alternate layers of flat and herringbone-crimp screens, 4 layers of each per inch.
4. 1/8" rod reinforced.
5. Enclosed 16 gauge galvanized steel frames.
6. Coated with high flash point adhesive.

B. Resistance to air flow of clean filter not to exceed 0.10" WG at 500 fpm.
1. Maximum face velocity 500 fpm.

C. Provide one complete set of spare filters for each unit.

2.4 AIR FILTERS

A. The filter cells:
   1. Disposal media and frame.
   2. Coated with high flash point adhesive.

B. Resistance to air flow of a clean filter not to exceed 0.12" WG at 300 fpm.

C. UL listed Class II rated.

2.5 MEDIUM EFFICIENCY AIR FILTERS

A. The filter cells:
   1. Pleated media.
   2. Disposable type.
   3. Contain not less than 4.6 sq. ft. of filtering media per square foot of face area.
   4. 16 pleats per linear foot of filter.
   5. 2" thick.

B. Media of reinforced nonwoven cotton fabric treated with adhesive and continuously laminated to a supporting steel wire grid conforming to the configuration of the pleats.
   1. Seal the media pack in a chipboard frame.

C. Rated average dust spot efficiency of not less than 36%.
   1. Average synthetic arrestance in excess of 93% when tested in accordance with the ASHRAE 52-68 test standard.

D. Filter capable of operating with variable face velocities up to 500 fpm without impairing efficiency.

E. Initial resistance to air flow:
   1. 300 fpm - 0.12" WG.
   2. 500 fpm - 0.28" WG.

F. UL listed with Class II rating.

G. Provide one spare set for a complete change, in original cartons, for Owner's use during the warranty period.

2.6 HIGH EFFICIENCY AIR FILTERS AND HOUSING

A. Air filter module:
   1. Dry type.
   2. With a permanent galvanized steel holding frame.
   3. Replaceable filter cartridge.
   4. Pre-filter cell.

B. Filter efficiency shall be rated on atmospheric dust by the dust spot test method in accordance with ASHRAE Standard 52-76.
   1. The average efficiency of the filter shall be as scheduled.

C. Filter housing:
   1. Factory assembled of 16-gauge galvanized steel with turned down flanges to provide a flush exterior.
   2. Integral pre-filter section.
   3. Furnished with a door at each end.
   4. Access to only one side shall be required for filter servicing.
   5. Doors shall utilize:
      a. Perimeter gaskets of neoprene rubber.
      b. Quick acting, spring-loaded and non-corrosive latches.
      c. Plated hinges.
   6. Filter mounting tracks shall be of extruded aluminum with factory-installed gaskets of molded PVC.
      a. Sealing pressure applied with a toggle and cam mechanism.
      b. Integral pre-filter track for 2" pre-filters.
   7. American Air Filter "Serviside" with lever lock seal.

D. The filter cartridge shall consist of filter media attached to a rigid, rust inhibiting steel header.

E. Filter media and header shall be factory sealed against leakage by cementing the media to the header.
   1. Cartridges shall be collapsible.
   2. Fireproof media UL listed Class II.
   3. American Filter "Dri-Pak".

F. Pre-filter cells:
   1. Renewable media type.
   2. 18-gauge galvanized steel holding frame.
   3. 11-gauge galvanized steel wire grids to support the media.
   4. Front grid hinged and secured with a latch.
   5. Filter media:
      a. Viscous coated glass fiber.
      b. 2" thick.
      c. Graduated density from front to back.
      d. Flame proof UL listed Class II.
   6. American Air Filter "Renu".

G. Pre-filter cells:
   1. Disposal media and frame.
   2. Coated with high flash point adhesive.
   3. UL listed Class II rated.
   4. American Air Filter 5700 Industrial.

2.7 ACTIVATED CARBON AIR PURIFICATION FILTER

A. Air purification filters module:
   1. Perforated, activated carbon filled, multiple-element, gas and odor absorption cells.
   2. Uniform carbon bed thickness throughout.
   3. Cell elements arranged so that air to be purified will pass uniformly through the carbon.
   4. With a permanent galvanized steel holding frame.
   5. Replaceable carbon trays.
   6. Pre-filter cell.

B. Filter housing:
   1. Factory assembled of 16 gauge galvanized steel with turned down flanges to provide a flush exterior.
   2. Integral pre-filter section.
   3. Furnished with a door at each end.
   4. Access to only one side shall be required for tray removal.
   5. Doors shall utilize:
      a. Perimeter gasket of neoprene rubber.
      b. Quick acting, spring loaded and non-corrosive latches.
      c. Plated hinges.

C. Pre-filter
   1. 2" thick.
   2. Disposable media and frame as specified.

D. The filter shall contain approximately 45 lbs. of activated carbon per 1,000 cfm.

E. Provide a detachable test element.
   1. When returned to the manufacturer after a specified period of operation, will indicate the service life remaining.

F. Provide a charcoal filter management and service program for a period of one year from substantial completion of the system to include the following:
   1. Send the test element to the filter manufacturer for evaluation of service life remaining.
   2. Provide review of report and evaluation on testing.
   3. Establish the recommended schedule for analysis and evaluation of the future test element program.
   4. Provide for training of operating personnel.
   5. Insert all information in the Owner's operating manuals.

G. Capacity as scheduled on the drawings.

H. Provide one complete set of spare trays loaded with fresh carbon for the Owner's use after the warranty period.

2.8 OUTSIDE AIR PURIFICATION SYSTEM

A. Filter and fan section cabinet construction:
   1. All stainless steel construction including screws.
   2. Gasketed, hinged side access doors with 1/4 turn cam handle latches.
   3. Weatherproof construction suitable for outdoor installation.

B. Staged filtration shall consist of a 30% efficient pre-filter, (2) pass chemical filter and a 90% efficient after filter.

C. Fan shall be sized for 1,245 CFM and 3-1/2" W.C. total static pressure.
   1. Belt drive with adjustable sheave.
   2. 3.0 HP
   3. 480-3-60 current characteristics.

D. Purafil Model #304-892P12M12M-5F-BLR with (2) 300lb Purafil II Chemisorbant media banks.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install the filters and filter gauges in accordance with the manufacturer's instructions.

END OF SECTION 234100

SECTION 234300 - AIR PURIFICATION SYSTEM

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install an air purification system intended for the use as a part of another manufacturer’s air handling unit as shown on the drawings, details and equipment schedules.

1.2 RELATED WORK

A. Division 23 Mechanical.
   1. Ductwork.
   2. Air Balance.
   3. Electrical Requirements for Mechanical Work.
   4. Building Management and Control System.
   5. Ductwork.

1.3 REFERENCES

A. ASHRAE Standard 62.1 – Ventilation for Acceptable Indoor Air Quality

B. ASHRAE Standard 52.2 – Method of Testing General Air Cleaning Devices for Removal

C. Efficiency by Particle Size

D. NFPA 70 – National Electrical Code

E. U.L. 867 – Electrostatic Air Cleaners

F. U.L. 2998 - Environmental Claim Validation Procedure (ECVP)

1.4 SUBMITTALS

A. Submit manufacturer's documentation in accordance with specification requirements.

B. Submit the following information:
   1. Manufacturer's installation instructions.
   2. Minimum Circuit Ampacity.
   3. Maximum Overcurrent Protection size.
   4. Electrical interlocks.

C. Submit recommended clearance dimensions for air flow and service.

D. Submit a schedule, at the front of the submittal, of equipment indicating:
   1. Unit designation
   2. Model number
   3. Electrical characteristics

E. Submit Copy of U.L. 2998 and U.L. 867 certificates for each product being submitted.

F. Mark-up a copy of the specifications, indicating in the margin of each paragraph, the following: COMPLY, DO NOT COMPLY, NOT APPLICABLE.

1.5 QUALITY ASSURANCE.

A. A qualified representative from the manufacturer shall be available to inspect the installation of the air purification system to ensure installation in accordance with manufacturer's recommendation.

B. Manufacturers shall have their product tested to UL 2998 Environmental Standard for confirmation of no ozone with certificate available. The final report shall indicate the ozone levels and high voltage output the device's electrode(s) were operating during the test. Reports that do not include high voltage output during the UL 2998 testing shall not be acceptable.

1.6 DELIEVERY, STORAGE AND HANDLING

A. Deliver in factory fabricated shipping containers. Identify on outside of container type of product and location to be installed. Avoid crushing or bending.

B. Store in original cartons and protect from weather and construction work traffic.

C. Store indoors and in accordance with the manufacturers' recommendation for storage.

1.7 WARRANTY

A. The manufacturer shall provide a parts warranty for a period of one (1) year from substantial completion.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Global Plasma Solutions

B. Plasma Air

C. Engineer Approved Equal. Must submit prior approval request to engineer as described in specifications.

2.2 DESIGN AND PERFORMANCE CRITERIA

A. Each piece of air handling equipment (Air Handling Units, Outside Air Handling Units, Fan Coil Units, and Packaged Rooftop Air Conditioners), as designated on the plans, details, equipment schedules and/or specifications shall contain a Plasma Generator with Bi-polar Ionization output as described here within.

B. The Bi-polar Ionization system shall be capable of:
   1. Effectively killing microorganisms downstream of the bi-polar ionization equipment (mold, bacteria, virus, etc.).
   2. Controlling gas phase contaminants generated from human occupants, building structure, furnishings and outside air contaminants.
   3. Capable of reducing static space charges.
   4. Effectively reducing space particle counts.
   5. When mounted to the air entering side of a cooling coil, keep the cooling coil free from pathogen and mold growth. A non-contact voltage detector can confirm the entire coil is covered with airflow turned off. Devices that do not clean the entire coil are not acceptable.
   6. All manufacturers shall provide documentation by an independent NELEC accredited laboratory that proves the product has minimum kill rates for the following pathogens given the allotted time and in a space condition:
      a. MRSA - >96% in 30 minutes or less
      b. E.coli - > 99% in 15 minutes or less
      c. TB - > 69% in 60 minutes or less
      d. C. diff - >86% in 30 minutes or less
      e. Noro Virus -> 93.5% in 30 minutes or less
      f. Legionella -> 99.7% in 30 minutes or less
      g. SARS-COV2 -> 99.4% in 30 minutes or less

   7. Capable of modular field assembly in six-inch (150mm) sections.

C. The bi-polar ionization system shall operate in a manner such that equal amounts of positive and negative ions are produced. Ionizers with positive and negative output (DC type) shall be self-cleaning. Ionizers provided on AHUs shall be AC type ionizers with each electrode pulsing between positive and negative and the electrode shall be modular. Ionizers on RTUs shall be self-cleaning DC type ionization. All ionization systems shall use carbon fiber brushes
   1. Air exchange rates may vary through the full operating range of a constant volume or VAV system. The quantity of air exchange shall not be increased due to requirements of the air purification system.
   2. Velocity Profile: The air purification device shall not have maximum velocity profile.

D. Humidity: Plasma Generators shall not require preheat protection when the relative humidity of the entering air exceeds 85%. Relative humidity from 0 - 100%, condensing, shall not cause damage, deterioration or dangerous conditions within the air purification system. Air purification system shall be capable of wash down duty.

E. Equipment Requirements for Air Handling Units and Packaged Rooftop Air Conditioners:
1. Electrode Specifications (Bi-polar Ionization):
a. Each alternating current (AC) Ionization Bar with Bi-polar Ionization output shall include a minimum of eighteen carbon fiber cluster ion needles per foot of coil face width shall be provided. The entire cooling coil width shall have equal distribution of ionization across the face. Systems without ion needles at least 0.50" (12.5mm) apart shall not be acceptable. The plasma electrode shall require no more than 1.0" (25mm) in the direction of airflow for mounting. AC ionization bars using any electrode material other than carbon fiber brushes, shall not be acceptable. All hardware required for mounting shall be provided by the air purification manufacturer except self-tapping screws for the power supply. Bi-polar ionization tubes manufactured of glass and steel mesh shall not be acceptable due to replacement requirements, maintenance, and performance output reduction over time, ozone production and corrosion.
b. Electrodes shall be provided in 6.0" (150mm) increments, epoxy filled for an IP55 rating and utilizing brass connection hardware that is recessed into the connection joint once fully engaged and assembled.
c. Electrodes shall be energized when the main unit disconnect is turned on.
d. The ionization output shall be a minimum of 140M ions/cc per inch of cooling coil width as measured 1 inch from the cold plasma needles. Provide multiple rows of bars to achieve equivalent output per inch listed above.
e. Ionization bars shall be provided with magnet mounting kits to prevent penetration into cooling coils.
f. Ionization bars shall be constructed of UL 94VO and UL746C composite material.
g. Device shall be OSPD certified.

F. Equipment Requirements for Ductless Units, Fan Coils and Wall Mount Units:
1. Electrode Specifications (Bi-polar Ionization):
a. The mechanical contractor shall mount the Plasma Generator and wire it to the unit control power (24VAC) as instructed by the Air Purification Manufacturer's instructions or line voltage subject to power available. Each unit shall be designed with a molded casing, programmable self-cleaning system, self-cleaning test button, power status LED and dry contacts to prove ion output is operating properly. The dry contacts shall close to prove the ion generator is working properly and may be daisy chained in series such that only one dry contact per air handler is required to interface to the BAS or

the optional DDC controller where airflow capacity requires more than one unit. Dry contacts proving power has been applied in lieu of the ion output is actually operating, are not acceptable. Manufacturers providing multiple ion modules that have alarm status wired in parallel, and not in series, shall not be acceptable.

b. Ionization output from self-cleaning units shall be a minimum of 200M ions/cc for units < 1200CFM and a minimum of 400M ions.cc for units > 1200CFM.

c. Carbon fiber brushes shall be replaceable.

d. Voltage input shall be universal acceptance from 24VAC to 240VAC or DC without the use of an external transformer.

G. Electrical Requirements:

1. Wiring, conduit and junction boxes shall be installed within housing plenums in accordance with NEC NFPA 70. Plasma Generator shall accept an electrical service of 24VAC, 115 VAC or 208-230VAC, 1 phase, 50/60 Hz. The contractor shall coordinate electrical requirements with air purification manufacturer during submittals.
2. All Plasma Generators shall have internal short circuit protection, overload protection, and automatic fault reset. Systems requiring fuses shall not be acceptable.
3. The Plasma Generator power supply shall have internal circuitry to sense the ionization output and provide dry contact alarm status to the BMS as well as a local “Plasma On” indication light.
4. The installing contractor shall mount and wire the Plasma device within the air handling unit specified or as shown or the plans. The contractor shall follow all manufacturer IOM instructions during installation.

PART 3 – EXECUTION

3.1 GENERAL

A. The Contractor shall be responsible for maintaining all air systems until the substantial completion.

3.2 ASSEMBLY & ERECTION: PLASMA GENERATOR

B. All equipment shall be assembled and installed in a workman like manner to the satisfaction of the owner, architect, and engineer.

C. Any material damaged by handling, water or moisture shall be replaced, by the mechanical contractor, at no cost to the owner.

D. All equipment shall be protected from dust and damage on a daily basis throughout construction.

3.3 TESTING

A. Provide the manufacturers recommended electrical tests.

3.4 COMMISSIONING & TRAINING

A. A manufacturer's authorized representative shall provide start-up supervision and training of owner's personnel in the proper operation and maintenance of all equipment.

END OF SECTION 234300

SECTION 235235 - GAS-FIRED MODULATING HOT WATER BOILER (Condensing)

PART 1 – GENERAL

1.1 WORK INCLUDED

A. This section specifies a packaged gas-fired stainless-steel condensing firetube boiler complete with all controls and trim for indoor installation.

B. Each boiler shall be provided with all components, accessories and appurtenances necessary for a complete and operable boiler, as hereinafter specified, in one complete package. Each unit shall be furnished factory assembled with required wiring and piping as a self-contained unit. Each unit shall be readily transported and ready for installation.

C. Each factory packaged boiler, including pressure vessel, trim, valve trains, burner, control system, and all related components, accessories and appurtenances as herein specified shall all be assembled and furnished by the boiler manufacturer. The boiler manufacturer shall provide unit responsibility for the engineering, coordination, workmanship, performance, warranties, and all field services for each factory boiler as specified herein. The boiler manufacturer shall be fully responsible for all components assembled and furnished by him whether or not they are of his own manufacture.

1.2 RELATED WORK

A. Division 23- Mechanical
   1. Hot Water Piping
   2. Gas Piping
   3. Ductwork

1.3 PERFORMANCE

A. Provide performance as scheduled on drawings. Boilers shall be certified for up to 98% efficiency.

1.4 WARRANTIES

A. The boiler manufacturer shall warrant each boiler, including boiler, trim, boiler control system, and all related components, accessories, and appurtenances against defects in workmanship and material for a period of eighteen (18) months from date of substantial completion. Heat exchanger and fuel burner shall be warranted for a period of five (5) years from date of substantial completion.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Fulton

B. Aerco

C. Lochinvar

D. Camus

2.2 PERFORMANCE CRITERIA

A. Each boiler shall be capable of operating continuously at rated capacity while maintaining a CSA certified efficiency of not less than 92 % on 500 MBH input boilers and less and not less than 95% on larger than 500 MBH input boilers. Each boiler shall be capable of operating with a minimum outlet water temperature of 68º F.

B. Boiler shall comply with ASME Section IV for 80 psig, max 200º F (100 psig on 1500 MBH and larger units).

C. Fuel shall be natural gas with an assumed higher heating value of 1,030 Btu/Cu Ft and an assumed specific gravity of 0.60 (relative to air). Natural gas shall be supplied at a pressure of no less than 3.5 inch WC to the inlet gas valve. Maximum inlet gas pressure shall not exceed 14 inch WC.

D. Boilers shall be certified for low NOx by the TCEQ. NOx emissions shall not exceed 30 PPM when referenced at 3% O2 at all firing rates.

E. The burner, gas train and controls shall conform to the requirements of G.E. Global Asset Protection (GAP) Services.

2.3 BOILER DESIGN

A. Each hot water boiler shall consist of a vertical stainless-steel firetube heat exchanger complete with trim, valve trains, burner, and boiler control system. The boiler manufacturer shall fully coordinate the boiler as to the interaction of its elements with the burner and the boiler control system such that the required capacities, efficiencies, and performance is provided as specified/scheduled.

B. All boiler pressure parts shall be constructed in accordance with the latest revision of the ASME Boiler and Pressure Vessel Code, Section IV, and shall be so stamped.

C. Boiler shall be enclosed with a single wall outer casing. It shall be fabricated from minimum 16 gauge carbon steel. The complete outer casing shall be finished, inside and out, with a powder coat finish. The composite structure of the boiler combustion chamber, insulating air gap and outer casing shall be of such thickness and materials to assure an outer casing temperature of not more than 50^{o}F above ambient temperature when the boiler is operated at full rated load.

D. Boiler shall have a single condensing heat exchanger. A boiler that utilizes a secondary condensing heat exchanger is unacceptable.

E. An observation port shall be located on the boiler to allow for observation of the burner flame.

F. Boiler heat exchanger headers shall be fabricated steel and be completely removable for inspection. Seals shall be EPDM, rated for 400 deg F service. Push nipples or gaskets between the sections are not permitted.

2.4 BOILER TRIM

A. Each boiler shall be provided with all necessary trim. Boiler trim shall be as follows:
1. Safety relief valve shall be provided in compliance with the ASME code. Contractor is to pipe to acceptable drain.
2. Water pressure temperature gauge.
3. Primary low water flow fuel cutoff (probe type with manual reset).
4. Manual reset high limit water temperature controller.
5. Operating temperature control to control the sequential operation of the burner.
6. Separate inlet and outlet water temperature sensors capable of monitoring flow
7. Exhaust temperature sensor
8. Provide condensate neutralization kit (shipped loose).

2.5 BOILER FUEL BURNING SYSTEM

A. The boiler manufacturer shall furnish each boiler with an integral, power type, straight gas, fully automatic modulating fuel burner. The fuel burner shall be an assembly of gas burner, combustion air blower, valve train, and ignition system. The burner manufacturer shall fully coordinate the burner as to the interaction of its elements with the boiler heat exchanger and the boiler control system to provide the required capacities, efficiencies, and performance as specified/scheduled.

B. Each burner shall provide adequate turbulence and mixing to achieve proper combustion without producing smoke or producing combustibles in the flue gases.

C. Each burner shall be radial-fire type with metal fiber mesh. All burner material exposed to the combustion zone shall be of stainless steel construction.

D. Each boiler shall be provided with an integral variable speed power blower to premix combustion air and fuel within the blower. The combustion air blower shall have sufficient capacity at the rated firing rate to provide air for stoichiometric combustion plus the necessary excess air. Static and total pressure capability shall comply with the requirements of the boiler. The blower shall operate at 6000 RPM maximum without undue vibration and noise and shall be designed and constructed for exposure to temperatures normal to its location on the boiler. The operating fan speed will be tachometer sensed and be capable of being displayed at the text based display.

E. Each boiler shall be provided with a “Full Modulating” firing control system whereby the firing rate is infinitely proportional at any firing rate between 20% and 100%

2.6 IGNITION SYSTEM

A. Each boiler shall be equipped for direct spark ignition.

2.7 BOILER CONTROL SYSTEM

A. The boiler control system shall have the following capabilities at a minimum:
1. Maintain single set point
2. Reset the set point based on outdoor air temperature
3. Boiler shutdown based on outdoor air temperature
4. Internal dual set point program with an external switchover. (e.g. - night setback w/external clock, supplied by others)
5. Alarm relay for any for any manual reset alarm function.
6. Programmable Low Fire Delay to prevent short cycling based on a time and temperature factor for release to modulation.
7. Local Manual Operation.
8. Remote Control System (Building Management / Sequencer Control) - The boiler control shall be capable of integrating to a BMS
9. Computer (PC) interface for programming and monitoring all functions

B. Each boiler shall be provided with an integral combustion air control system. The combustion air system shall be factory assembled. Each combustion air control system shall include at least the following:
1. The primary control shall vary the speed of the blower based on load demand. The blower shall apply a varying negative pressure on the gas valve which will open or close to maintain zero pressure at the valve orifice, thereby increasing or decreasing the firing rate. Both the air and gas shall be premixed in the blower.
2. One (1) low airflow differential pressure switch to insure that combustion air is supplied.
3. High exhaust back pressure switch

C. Each boiler shall be provided with an integral burner control system. The burner control system shall be factory assembled and shall include the following:
1. The control system shall be supplied with a 24 VAC transformer (120 VAC, single phase, 60 hertz primary). The 120/1/60 power supply to each

boiler shall be protected by a circuit breaker sized per the manufacturers recommendations (supplied by contractor).
2. The boiler shall include an electric spark ignition system. Main flame shall be monitored and controlled by flame rod (rectification) system.
3. Each boiler shall be provided with all necessary controls, all necessary programming sequences, and all safety interlocks. Each boiler control system shall be properly interlocked with all safeties.
4. Each boiler control system shall provide timed sequence pre-ignition air purge of boiler combustion chamber. The combustion airflow sensor shall monitor and prove the airflow purge.

D. The boiler manufacturer shall provide each boiler with an integral factory prewired control panel. The control panel shall contain at least the following components, all prewired to a numbered terminal strip:
1. One (1) burner "on-off" switch.
2. One (1) electronic combination temperature control, flame safeguard and system control.
3. All necessary control switches, pushbuttons, relays, timers, terminal strips, etc.
4. Text Based Display Panel to adjust set points and control operating parameters. Text Based Display is to indicate burner sequence, all service messages, fan speed, boiler set point, and sensor values such as inlet temperature, outlet temperature, flue gas and outdoor air temperature

2.8 FACTORY TESTING - HYDROSTATIC

A. Each factory "packaged" boiler shall be hydrostatically tested and bear the ASME “H” stamp.

2.9 SEQUENCE CONTROLLER

A. Boiler shall be provided with a boiler sequence controller that is capable of controlling
1. One or multiple boilers
2. All condensing or all non-condensing boiler
3. Combination of condensing and non-condensing boilers (hybrid system).

B. When controlling hybrid systems, sequence controller shall sequence the lead boiler based on its condensing capabilities to provide the most efficient operation.
1. Controller shall be capable of communicating via MODBUS protocol.
2. Controller shall allow boiler or boilers to operate via a remote header sensor (header sensor provided by boiler manufacturer, installed by contractor).
3. Controller shall be capable of allowing boiler or boilers to operate based on outdoor reset. This shall be achieved by either:
   a. Programming the controller with an outdoor air reset curve in conjunction with a separate outdoor air sensor (outdoor sensor shall be provided by boiler manufacturer, installed by contractor),

b. Setpoint control via 0-10 VDC analog communication with building automation system,
c. Setpoint control via MODBUS communication.
4. Controller shall visually display relay status, firing rate of each boiler, header temperature, outdoor air temperature. Coordinate wiring of this controller with mechanical and control's contractor.

2.10 CARBON MONOXIDE MONITORING SYSTEM

A. Provide and install a manual reset Carbon Monoxide Detector located within the boiler room when combustion air is ducted to boilers. The Carbon Monoxide Detector and the boilers shall be interlocked so that the burners will not operate when the level of CO in the room rises above 100ppm. The Carbon Monoxide detector shall disable the boiler's burner upon loss of power to the detector.

B. Carbon Monoxide Sensor with two year warranty by U.S. Draft Co. Model CGM-505 with model XB expansion module.
1. Provided with pre-programmed dry contacts to shut down equipment during unsafe operation.
2. NEMA 1 Enclosure
3. Additional features shall include 0-10 VDC control signal out, visual alarm and audible alarm.

C. Provide expansion board for additional equipment interlocks.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install isolation valves and unions on supply and return water lines to boiler.

B. Install strainer, drain with valve, pressure and temperature gauge on return water line to boiler.

C. Install main gas cock, drip leg and union close to boiler.

D. Install on 4" concrete pad and place into operation in accordance with manufacturer's instructions. Pipe as detailed on drawings.

E. Provide Category IV vent stack material. Mechanical contractor shall coordinate draft requirements and other venting requirements between stack supplier and boiler supplier.

F. Install boilers, piping and accessories in accordance with the manufacturer's installation instructions and state boiler code.

G. Pipe each gas relief vent to the outdoors, in accordance with the manufacturer's recommendations and the local codes.

H. Contractor to route condensate connection off of boiler and stack to acid neutralization kit and then to appropriate drain. Trap as required by boiler manufacturer.

3.2 BOILER MANUFACTURER STARTUP SERVICE

A. Provide factory authorized startup services to assure its proper operation.

B. Set the boiler operating and safety controls.

C. Perform a flue gas analysis at the boiler outlet. Record the following results of the analysis:
1. Carbon dioxide percent volume.
2. Oxygen percent volume.
3. Stack temperature.
4. Calculated combustion efficiency.

D. Do not operate the boiler for any reason until the factory startup service has been completed.

E. Startup procedure shall include a functional test of Carbon Monoxide Detector. Simulate an alarm condition and demonstrate the functionality of the detector shutting down the appliances. Owner/Engineer shall be present to witness test.

END OF SECTION 235235

SECTION 236426 - WATER-COOLED ROTARY SCREW CHILLER

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install a packaged, electric-driven, water-cooled, water chilling unit, with screw compressor.

B. Section includes design, performance criteria, refrigerants, controls, and installation requirements for water-cooled screw chillers.

1.2 RELATED WORK

A. Division 23 Mechanical
  1. Chilled Water Piping
  2. Condenser Water Piping
  3. Vibration Isolation
  4. Building Management Control System
  5. Electrical Provisions of Mechanical Work

B. Comply with applicable Standard/Codes of ARI 550/590, ANSI/ASHRAE 15, ANSI B31.5, ASME Section VIII, ASTM, NEMA, NEC, UL984, and OSHA as adopted by the State.

1.3 PERFORMANCE

A. Furnish a unit with minimum capacity and characteristics as scheduled, allowing for 0.0001 fouling factor in the cooler and 0.00025 fouling factor in the condenser.

1.4 SUBMITTALS

A. Submit manufacturer's certified computer generated performance and capacity data in accordance with specification requirements.

B. Submit the following information:
  1. Manufacturer's installation instructions.
  2. Minimum Circuit Ampacity.
  3. Maximum Overcurrent Protection.
  4. Maximum conductor / Terminal Lug size.
  5. Minimum flow thru evaporator.
  6. Electrical interlocks.

C. Submit recommended service clearance dimensions.

D. Submit internal wiring diagram of Control Center.

E. Submit AHRI certified performance data and energy consumption at design conditions and partial load operation of 25, 50, 75, and 100% loads with constant entering condenser water temperature at design conditions as specified.

F. Submit shop drawings showing the placement of the water box connection after visiting the project. Match existing piping connections.

G. Mark-up a copy of the specifications, indicating in the margin of each paragraph, the following: COMPLY, DO NOT COMPLY, NOT APPLICABLE.

1.5 DELIVERY/STORAGE/HANDLING

A. Ship machine without initial charge of refrigerant and lubricating oil. The initial charge shall be supplied, shipped in containers and cylinders for field installation by the Manufacturer's service technician.

B. All equipment and accessories shall be suitably boxed, crated, covered with a tarp, and protected internally and externally to prevent shipping damage and damage from the weather.

1.6 WARRANTY

A. The Chiller manufacturer shall provide a full machine parts, labor, and refrigerant warranty for a period of five (5) years from substantial completion.
   1. The warranty shall include, but not be limited to the compressor assemblies including motor, condensers, fans, variable frequency drives, controls, evaporator, condenser, refrigeration system and all other auxiliary components and accessories as well as refrigerant and oils in systems.
   2. In the event of failure, provide new or factory authorized rebuilt parts. Shop or job site rebuilt parts are not acceptable.
   3. On all manufacturers warranties the chiller manufacturer shall provide a factory certificate listing as a minimum chiller model, serial, and warranty information as specified above. Each chiller tag shall be provided with an individual and unique warranty certificate. Manufacturer's representative warranty letters are not acceptable as an alternative to the original manufacturer's certificates.
   4. The chiller manufacturer authorized service agency is required to perform any and all warranty service. Contractor warranty service is not authorized. Warranty work shall be performed with District Representative present.

B. The Chiller manufacturer shall provide a compressor and motor parts only extended warranty for a total of 10 years.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Carrier

B. Trane

C. York

D. Daikin

2.2 COMPRESSOR AND MOTORS

A. Supply rotary screw, open drive or semi-hermetic compressor with a forced-feed lubrication system. Full load power factor shall be a minimum of 0.92. Equip with the following:
   1. Crankcase oil sight glass.
   2. Oil filter.
   3. Crankcase oil heater.
   4. Electrically actuated capacity control utilizing slide valve.
   5. Suction and discharge stop valves, seal cap type with back seating.
   6. Rubber isolation pads.
   7. Oil sight glass.
   8. Discharge oil separator.
   9. Load and unload with slide valve.

B. Supply motors with the following characteristics:
   1. Operating at 3570 revolutions per minute.
   2. Air or refrigerant cooled.
   3. Having inherent, 3-phase overload protection.

C. Acoustics. System shall consist of removable blanket insulation, constructed of a composite of barriers and absorbers with Velcro flaps. The removable blanket insulation shall cover as necessary, compressors & extended components (compressors, discharge & suction piping, oil separators etc.) for the specified chiller. The covers shall be connected by means of cloth straps with “D” rings and Velcro fasteners. System shall be manufactured by BRD Noise and Vibration Control, Inc.

2.3 EVAPORATOR

A. Components
   1. Shell-and-tube heat exchanger.
   2. Cleanable copper tubes with continuous 0.028-inch thickness from tube

root to root.
3. Removable heads.
4. Nonferrous tubes and baffles for maximum corrosion resistance.
5. Tested for 225 psig with a 150 psig working pressure water side construction.
6. Tested for 450 psig with a 300 psig working pressure refrigerant side construction.
7. Refrigerant side shall be designed, tested and stamped in accordance with ASME Boiler and Pressure Vessel Code, Section VIII - Division 1.
8. Provide a distributor to ensure uniform distribution of refrigerant over the entire shell length.

B. Select the cooler with the fouling factor shown in the schedule.

C. Provide grooved connections for water boxes. Vent and drain connections with plugs shall be provided on each water box.

D. Include pressure relief devices sized to meet the requirements of ASHRAE 15.

E. The tubes shall be individually replaceable and secured to the intermediate supports without rolling or expanding to facilitate replacement if required.

F. An electronic expansion valve shall control refrigerant flow to the evaporator.

G. Provide liquid level sight glasses. Proven refrigerant charging valve.

2.4 CONDENSER

A. Components
1. Shell-and-tube heat exchanger.
2. Cleanable copper tubes with continuous 0.028-inch thickness from tube root to root.
3. Removable heads.
4. Nonferrous tubes and baffles for maximum corrosion resistance.
5. Tested for 225 psig with a 150 psig working pressure water side construction.
6. Tested for 450 psig with a 300 psig working pressure refrigerant side construction.
7. Refrigerant side shall be designed, tested and stamped in accordance with ASME Boiler and Pressure Vessel Code, Section VIII - Division 1.
8. Provide a distributor to ensure uniform distribution of refrigerant over the entire shell length.

B. Select the condenser with the fouling factor shown in the schedule.

C. Provide grooved connections for water boxes. Vent and drain connections with plugs shall be provided on each water box.

D. Include pressure relief devices sized to meet the requirements of ASHRAE 15.

E. The tubes shall be individually replaceable and secured to the intermediate supports without rolling or expanding to facilitate replacement if required.

F. Provide a discharge gas baffle to prevent direct high velocity impingement on the tubes.

G. Provide liquid level sight glasses. Proven refrigerant charging valve.

2.5 INSULATION

A. Field applied after installation prior to start-up.

B. Flexible closed cell plastic. Two 3/4" layers, overlapping seams of the first layer.

C. Applied with vapor proof cement to:
1. Cooler shell.
2. Float chamber.
3. End sheets.
4. Suction connection.
5. Motor cooling connection (hermetic machines).
6. Necessary auxiliary tubing.
7. Other components subject to surface condensation.

D. Resistant Coating
1. WB Armaflex Finish
2. Apply weather protective finish on elastomeric insulation. Provide a minimum of three coats.
3. Color to match chiller manufacturer’s equipment.

2.6 REFRIGERANT ISOLATION

A. Provide unit with manually operated isolation valves located at the inlet and outlet of the condenser. Condenser shall be able to store the entire system refrigerant charge during servicing. Provide service valves to facilitate removal of the refrigerant from the system. If isolation valves cannot be provided, the chiller manufacturer shall provide a separate refrigerant transfer/storage unit to hold the full refrigerant charge of one chiller when 90% full.

2.7 BASE

A. Construct the unit base of welded steel, with each compressor mounted on sound attenuation vibration isolators.

2.8 CONTROLS AND INSTRUMENT PANEL

A. Operation. For constant flow applications, automatically modulate the compressor through controls actuated by changes in the temperature of water leaving the chiller. For variable flow applications, modulate each compressor through changes in the temperature of water leaving the chiller. Start the compressors unloaded.

B. Furnish a complete Microcomputer Control Center installed in a NEMA 1 lockable enclosure, factory mounted, wired, and tested. The enclosure shall have a barrier panel to segregate line voltage components. The control Center shall include a tactile keypad mounted on the front of the Control Center, that allows the operator to display system operating parameters on a Multi-character alphanumeric display that is part of the keypad. These operation parameters include:
1. Chilled water temperatures - supply and return.
2. Condenser water temperatures - supply and return.
3. Refrigerant pressures - evaporator and condenser.
4. Differential oil pressure at oil filter.
5. Motor current in % full load amps.
6. Saturation temperatures - evaporator and condenser.
7. Water flow indication.
8. Oil temperature.
9. Percent slide valve position.
10. Three phase volts and three phase amps.
11. Elapsed time meter and number of compressor starts.
12. Oil pressure at compressor.
13. Alarm and failure messages.
14. Diagnostics Service Log
15. Chiller Run and alarm status relay cards.

C. Setpoints shall be operator entered on the front of the control center keypad. Setpoints shall be displayed on the multi-character alphanumeric display. The system set points shall include as a minimum:
1. Chilled water supply temperature.
2. Current limit.
3. Pull down demand limit.
4. Remote reset temperature range.
5. Remote alarm contact.

Any input that potentially harms the machine shall be rejected and the operator shall be advised via display message. All system shutdowns (safety or cycling) shall be preserved (until the system is reset with pass-word or restarted) in the microcomputer's memory for subsequent viewing on the alphanumeric display. The operator shall be continuously advised of system operating conditions by various background and warning messages. The keypad shall contain special service passwords for use by service technicians when performing system troubleshooting.

D. Safety controls shall be annunciated through the alphanumeric display consisting of day, time of shutdown, cause of shutdown, and type of restart required. Safety controls with automatic unit shutdown shall be provided for:

1. Sensor malfunction.
2. High and low compressor oil pressure.
3. High and low refrigerant pressure.
4. High compressor discharge temperature.
5. Low evaporator pressure or high condenser pressure.
6. Low chilled water temperature.
7. High oil temperature.
8. Starter fault.
9. Unit shall not start without minimum flow through the evaporator or the condenser.
10. Clogged oil filter.
11. Low oil level.
12. Freeze protection.
13. High discharge and low evaporator pressure cutout.
14. Chilled water freeze protection.
15. Loss of evaporator or condenser water flow.
16. Phase loss, phase reversal, phase imbalance, and under or over voltage protection.
17. Motor current overload

E. Battery backup shall be provided to keep all Setpoints in memory for minimum of one month in case of power failure. Control Center shall provide for an automatic restart of chiller after a momentary power failure.

F. Chilled water and condenser water flow detection devices shall be provided to shut down unit when flow drops below minimum through evaporator or condenser.

G. Security access shall be provided to prevent unauthorized change of Setpoints, reset failures and to allow local or remote control of the chiller.

H. The Microcomputer Control Center shall provide interface that includes as a minimum:
1. Remote start.
2. Remote stop.
3. Remote leaving chilled water temperature setpoint and reset.
4. Remote current limit setpoint.
5. Ready to start status contact.
6. Safety shutdown status contacts.
7. Cycling shutdown status contacts.
8. Run contacts.
9. Common alarm contact.

I. Solid State Starter or Wye-Delta / Disconnect: Sized to match the screw chiller package requirements. Conform to latest published NEMA standards.
1. Solid-State with stepless compressor motor acceleration to limit motor inrush current.
2. Circuit breakers shall be adjustable, instantaneous trip breakers, specifically designed for motor circuit protection.
3. Provide motor overload protection in each phase leg.

4. Low voltage control panel:
   a. Fused low-voltage control circuit.
   b. Current transformer for a signal to the control center current limiting device.
   c. Control relays or timers as required, wired to terminal blocks.
   d. Other features which may be required by the control system.
5. Unit Mounted Starters. Furnish solid-state or Wye-Delta starter shall be supplied. The compressor motor starter shall be factory mounted, wired and tested prior to shipment by the chiller manufacturer. Sized in accordance with NEMA standards for reduced voltage starting. Electrical connection for compressor motor power shall be limited to main starter power connection only. The following protective and monitoring devices shall be provided with the starter.
   a. Motor Overload Protection.
   b. Phase protection and loss.
   c. Power fault.
   d. Under voltage safety.
   e. Non - fused disconnect.
   f. Ground fault.
   g. Phase unbalance.
   h. Phase reversal.
   i. Trip values and motor data; field input and adjustable.
   j. Shorted SCR
6. Door mounted additional equipment:
   a. Three phase thermal overload relays external hand reset.
   b. Digital Meter with keypad to select line current in amperes / volts for each phase. Meter shall have an accuracy of 1% of full scale.
7. The combination starter shall be factory wired to the compressor motor. Factory assembly shall include:
   a. Control circuit wiring.
   b. Internal auxiliary systems control and power wiring.
   c. Power wiring between the starter and the motor.
   d. Mounted on machine.
8. 2 KVA Control/Oil heater transformer minimum.
9. Branch circuit breaker for control power and oil heater and oil pump.
10. Provide a single point power connection with unit factory installed unit mounted disconnect / circuit breaker.
11. Provide in a NEMA 1 enclosure.

J. Provide a single point power connection with unit factory installed unit mounted disconnect / circuit breaker.

K. Provide a relay control to signal the chilled and condenser water pumps and cooling tower. Provide a 30 second time delay between sequential ancillary equipment starts.

L. Provide an AUTO RESTART AFTER POWER FAILURE control with manual reset for oil temperature low limit control.

M. Provide valves & controls to enable chiller to operate with 40 degree entering condenser water temperature.

N. Chiller shall include a relay board with dry contacts for alarms to notify a Building Automation System of certain events or states of the chiller.

O. Chiller shall include input for leaving chilled water temperature setpoint based upon a 2-10VDC or 4-20mA signal from a Building Automation System.

P. Chiller shall include input for chiller current limit setpoint based upon a 2-10VDC or 4-20mA signal from a Building Automation System.

PART 3 - EXECUTION

3.1 HANDLING & INSTALLATION

A. Install system in accordance with manufacturer's instructions.

B. Install new chiller and align new chiller on concrete foundations, sole plates and sub-bases. Adjust and level chiller in alignment on supports and grout in place.

C. Arrange piping for easy dismantling to permit tube cleaning and service.

D. Coordinate electrical installation with the electrical contractor.

E. Coordinate controls with the control contractor.

F. Provide all appurtenances required to ensure a fully operational and functional chiller.

G. Install flow detection/measuring devices in a horizontal section of pipe where there is a straight section of at least 3 pipe diameters on each side of the flow detection / measuring device.

H. Do not operate the equipment for any reason until the factory start-up service has been completed.

I. Do not operate the equipment for any reason until the complete circulating condenser water chemical treatment system is operational as specified.

J. Do not operate the equipment for any reason until the complete circulating condenser water temperature controls are operational.

K. Do not install paddle flow switches. Wet DP switches only. DP switches shall be installed per manufacturers recommendations.

L. All electrical conduits shall be connected to chiller in the bottom of electrical cabinet. Top and side connections are not acceptable.

3.2 CHILLER MANUFACTURER START-UP SERVICE

A. Provide the services of a factory trained service technician employed full time by the chiller manufacturer to start-up the system. Technicians, as required, shall be trained and experienced in the work they perform. (Contractor startup is unacceptable.)

B. The technician shall utilize comprehensive report forms to document results. Sample forms shall be submitted for review prior to commencing work.

C. Upon completion of the work, the report forms shall be signed by the technician and included in the final report and Owner's manual.

D. Submit four copies of the final report to the Architect/Engineer within 10 working days of start-up.

E. Follow the manufacturer's start-up procedures.
   1. Verify interlocks.
   2. Test and verify operation of safety controls.
   3. Calibrate controls.
   4. Verify microprocessor based control operation.
   5. Test, calibrate, and set the chilled water temperature controls.
   6. Verify chilled water temperature reset sequence.
   7. Verify operation of the integrated control panel.
   8. Verify correct interface between Building Management Control System and chiller control panel.

F. Measure and record the following data:
   1. Chilled and condenser water entering/leaving temperature.
   2. Chilled and condenser water flow through the chiller.
   3. Suction pressure/condensing pressure.
   4. Suction pressure/unloading steps.
   5. Air entering/leaving cooling tower wet / dry bulb temperature.
   6. Outdoor ambient; wet / dry bulb.
   7. Motor nameplate voltage; phase and full load amperes.
   8. Heater coil in starter (as applicable)
      a. Rating in amperes.
      b. Manufacturer's recommendation.
   9. Power reading (voltage and amperes of legs at motor terminals).

G. Test and calibrate the operation of the electronic ground current sensing devices.

H. If the system has been shipped with a holding charge:
   1. Leak test.
   2. Refrigerant pressure test.
   3. Evacuate, dehydrate and charge.

I. Verify that accessories are installed and performing the specified functions. Insert certification in Owner's manual.

J. Instruct the Owner's operating personnel. Provide Owner with 8 hours of training prior to substantial completion after a complete startup procedure.

K. Do not operate the equipment for any reason until the factory start-up service has been completed.

L. Provide a printout from the unit microcomputer control system showing the correct operation of all system controls and components.

M. Do not operate the equipment for any reason until the complete circulating condenser water chemical treatment system is operational as specified.

N. Do not operate the equipment for any reason until the complete circulating condenser water temperature controls are operational under Section 23 09 33 as specified.

3.3 TRAINING

A. The manufacturer shall provide, as part of their proposal, training two Owner representatives for a two-day training session.

B. Training shall include hands on and classroom type training which pertains to the purchased equipment. The training shall give the trainees the ability to completely tear down and overhaul the purchased equipment. Any and all literature, manual or information shall be given to the trainees.

3.4 ADDITIONAL REQUIREMENTS

A. The manufacturer shall provide and deliver to the owner the following spare equipment and parts prior to acceptance of the liquid chillers. Four oil filter cartridges.

B. The manufacturer is to supply two complete sets of maintenance manuals for the chiller. The manual should be a complete overhaul and maintenance manual. Detailed drawings of all internal parts and complete parts list shall be provided with the chillers.

3.5 FACTORY CHILLER CAPACITY TEST

A. Test each chiller at a test facility certified by AHRI.

B. Perform tests in accordance with the current edition of ARI Standard 550-590.

C. The centrifugal chiller shall deliver:
   1. At least the specified cooling capacity.
   2. Maximum kilowatt per ton input not to exceed 105% of the specified

value.

3. Provide demonstration point at 10% load and design condenser water temperature/flow without the use of hot gas bypass.

D. Make computations for adjusted test results to reflect the fouling factors as shown in the schedule.

E. Submit 6 copies of the completed test results for the chiller, certifying:
   1. Capacity.
   2. Maximum kilowatt/ton.
   3. Demonstration of unloading point.

F. The test results shall be certified by an Officer of the Manufacturer.

G. If the chiller fails to meet the scheduled capacity, the manufacturer shall make revisions to the equipment to achieve the scheduled capacity requirements. Conduct a second test and submit AHRI certified test results after revisions to the equipment are made.

END OF SECTION 236526

SECTION 236541 - PACKAGED STEEL COOLING TOWER

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install a packaged stainless steel cooling tower as shown on the drawings with the following characteristics.
   1. Single or two-cell as indicated
   2. Induced draft
   3. Vertical discharge
   4. Cross flow or counter flow

1.2 RELATED WORK

A. Division 23 Mechanical
   1. Condenser water piping
   2. Building Management Control System
   3. Chemical treatment
   4. Electrical Provisions for Mechanical Work
   5. Valves

1.3 PERFORMANCE

A. Certify in accordance with the standards of the cooling tower institute. Provide performance as specified on Drawings and below.
   1. 95°F entering water temperature.
   2. 85°F leaving water temperature.
   3. 1200 GPM.
   4. 79°F ambient wet bulb temperature.
   5. 10 HP fan per cell.
   6. 480v/3ph.
   7. VFD.
   8. BAC Series 3000, Evapco AT, or Marley approved equal.

B. Sound levels and safety features shall be in compliance with latest OSHA requirements.
   1. Sound levels shall not exceed 85dB

1.4 SUBMITTAL

A. Shop drawing submittal includes, but is not limited to the following:
   1. Manufacturer's certified capacity curve with selections plotted
   2. Shop drawings and product data
   3. Foundation requirements and operating weights

4. Manufacturer's installation, start-up and service instructions
5. Submit a chart of specific sound power level at each octave band center frequency.
6. Coordinate new tower unit inlet/outlet piping connections to match existing system on site.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Baltimore Aircoil

B. Marley

C. Evapco

2.2 UNIT HOUSING

A. Construct the unit housing of no less than 14 gauge Type 304 stainless steel.

B. Cold water basin shall be bolted Type 304 stainless steel.

C. Inlet louvers shall be wave formed, fiberglass-reinforced polyester (FRP) spaced to minimize air resistance and prevent water splash-out.

D. Capable of withstanding wind velocity of 100 mph without damage.

2.3 FAN MOTOR

A. Select the motor so the brake horsepower required to deliver the design air quantity at the tower static pressure will not exceed the motor nameplate rating.
   1. Single speed, variable or 2-speed single winding 1800/900 rpm as scheduled
   2. Permanently lubricated, and ball bearing type
   3. 1.15 service factor
   4. Premium Efficiency TEFC
   5. Inverter compatible for variable speed applications
   6. Cast iron material
   7. Will not exceed the motor nameplate rating
   8. Motor shall be out of the air stream

2.4 FAN

A. Blades shall be slow speed, aerodynamically designed propeller type.

B. Coat fan blades and hub with corrosion resistant material.

C. Fabricate fan Venturi to provide eased inlet contour.
   1. Galvanized wire ring type fan guard

D. Belt Drive is not acceptable

E. Gear drive only; belt drive is not acceptable

F. Provide variable frequency drive.

G. Provide five-year parts and labor warranty for gear drives.

2.5 FAN BEARING

A. Grease lubricated and self-aligning

2.6 FILL

A. Fill and eliminator shall be non-corrosive and non-ferrous.
   1. Polyvinyl chloride plastic material

B. The material shall be fire resistant and meet the provisions of ASTM E84 with a maximum flame spread rate of 25.
   1. Meet the provisions of ASTM E 84 with a maximum flame spread rate of 25.

C. Drift loss shall be less than 0.2% of flow rate.

2.7 HOT WATER DISTRIBUTION SYSTEM

A. Hot water distribution basin shall be the open basin gravity feed type.
   1. Plastic diffuser metering orifices.

B. Provide removable hot water basin covers.

2.8 BASIN ACCESSORIES

A. Side or bottom outlet as shown on the drawings with flange or grooved connections.

B. Adjustable brass make-up float valve assembly.

C. Drain outlet fitting with grooved connection.

D. Overflow outlet fittings with grooved connection.

E. Stainless steel strainer with antivortexing plate.

F. Quick fill connection.

G. Equalizer piping connection.

H. Bypass inlet fitting with grooved connection.

2.9 VIBRATION SWITCH

A. Electromechanical Design

B. NEMA 4X weatherproof enclosure.

C. Remote Reset

D. Detect shock/vibration in three planes of motion.

E. Sensitivity adjustment.

F. Two SPDT snap switches.

G. Time delay.

H. Acceptable Manufacturers
   1. Frank W. Murphy
   2. Metrix Instrument Co.

2.10 OIL LEVEL SWITCH

A. Explosion proof case.

B. External site indication gauge.

C. 304 stainless steel float.

D. DPDT contacts.

E. Acceptable Manufacturers
   1. Frank W. Murphy

2.11 SERVICE ACCESS (Per Cell)

A. Provide an external service platform with ladder and supports to provide access inside tower.
   1. Provide a plenum walkway inside of tower.

B. Provide an external service platform with ladder and supports to provide access to service motor.

C. Provide an external ladder and perimeter handrails for access to top of tower.
   1. Provide OSHA approved safety cage and ladder.

D. All ladders shall have extensions to ground level.

2.12 ADDITIONAL ACCESSORIES

A. Provide (1) davit for each cell to assist in removal of gear drive and motors.

B. Provide an external ladder and perimeter handrails for access to top of tower.

C. Provide OSHA approved safety cage and ladder.

D. Plenum walkway

E. All ladders shall have extensions to ground level.

PART 3 - EXECUTION

3.1 MANUFACTURER INSTALLATION REQUIREMENTS

A. Install all field accessories including but not limited to the following items not installed at factory:
   1. Upper fan cylinder
   2. Fan guard
   3. Distribution flume baffles
   4. Motor supports
   5. Motor and shaft
   6. Vibration & oil level switch
   7. Handrails
   8. Ladder and extension
   9. Safety Cage
   10. Service access platform
   11. Plenum walkway
   12. Davit
   13. Perimeter handrail, knee rail and toe board

B. Provide a factory-trained technician to supervise the installation of the cooling tower.

C. Built-in-place cooling tower erection on the structural foundation is by the manufacturer.

D. Tower support design is based upon the scheduled tower. Coordinate revised support requirements if an alternate tower is furnished.

3.2 MANUFACTURER START-UP SERVICE AND ALIGNMENT

A. Start-up the system in accordance with the manufacturer's installation, start-up and service instructions.

B. Technician shall be responsible for final checkout, adjustment and initial start-up of the tower.
   1. Correct operation of make-up water float valves.
   2. Correct setting of vibration cutout switches.
   3. Correct setting of oil level switches.
   4. Alignment of drive shaft.
   5. Fill basin with water and adjust operating level with pumps and towers energized.
   6. Clean hot and cold water basins.

C. Provide a written start-up report for inclusion in the Owner’s Operating and Maintenance Manual.

3.3 CAPACITY TEST

A. Test the capacity of the cooling tower upon completion and when load available is adequate for test. The test shall be in accordance with the latest version of the Cooling Tower Institute’s Acceptance Test Procedure. Test in the presence of a CTI test observer. The tower manufacturer shall pay for the test.

B. If the capacity test indicates a deficiency, the cooling tower manufacturer will alter the tower to overcome the deficiency. If the deficiency cannot be corrected, the tower manufacturer shall compensate the purchaser with the addition of cooling tower capacity or a refund of percentage of the contract price proportional to the deficiency. Owner shall choose the compensation.

END OF SECTION 236541

SECTION 237313 - AIR HANDLING UNITS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install air handling units with casing, fans, coils, filters and special items.

1.2 RELATED WORK

A. Division 23 Mechanical
1. Air Balance
2. Ductwork
3. Controls
4. Electrical Provisions of Mechanical Work
5. Air Filtration
6. Heating and Cooling Coils
7. Other applicable sections

1.3 PERFORMANCE

A. Unit capacities and characteristics as indicated.
1. Units must be certified in accordance with ARI Standard 430-66.
2. UL 1995 certification for safety including electric heat.
3. ARI 430 listed and meet NFPA 90A requirements.

1.4 SHOP DRAWINGS

A. Indicate assembly, unit dimensions, weight loading required clearances, construction details, field connection details, and electrical characteristics and connection requirements.

B. Submit fan performance curve for each unit:
1. Plot fan volume against static pressure, horsepower and efficiency.
2. Show point of rating based on static requirements of the system.
3. Chart of specific sound power level at each octave band center frequency.
4. For variable volume units, plot fan volume over entire range.

C. Submit for review a unit internal static pressure loss calculation.
1. Provide an itemized list of static pressure loss at the scheduled CFM for each unit component including and not limited to:
a. Coils

b. Dirty filters
c. Fan and unit system effect
d. Cabinet and cabinet inlet and outlet
e. Unit mounted dampers

2. If a unit mounted outside air pretreatment section without supply fan, “piggyback” is specified:
   a. Provide an itemized static pressure loss as indicated above.
   b. Determine losses for unit configuration, i.e. parallel or series.
   c. Include losses in the primary unit internal static pressure required by configuration.
3. The air handling unit schedule indicates static pressure external to the unit and does not include any losses associated with the air handling equipment.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units until ductwork is clean, filters are in place, bearings lubricated, condensate properly tapped, piping connections verified and leak tested, belts aligned and tensioned, all shipping braces have been removed, and fan has been tested under observation.

1.6 DELIVERY, STORAGE AND HANDLING

A. Inspect for transportation damage and store in a clean, dry location. Protect from weather and construction traffic.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Carrier

B. Trane

C. York

D. Daikin

2.2 MISCELLANEOUS REQUIREMENTS

A. Provide factory assembled units. Large units may be shipped in sections, at contractor's option, to enable entrance to building, or for oversize shipping reasons only.

B. Furnish units with sealing and fastening hardware supplied by the manufacturer.

Include written instructions needed to complete field assembly of the components.

C. Provide units designed and constructed so that coils, panels, fan housing and fans can be removed without affecting the structural integrity of the unit.

D. Unit casing panels shall be a minimum of 2” double wall construction with solid galvanized exterior and solid galvanized interior. Panels shall have a minimum thermal resistance of R-13. The casing shall not exceed 0.0042 inch deflection per inch of panel span at 1.5 times the design static pressure up to a maximum of +8 inches in all positive pressure sections and -8 inches in all negative pressure sections.

E. Provide full perimeter base rail channel under units constructed of heavy gauge galvanized steel (minimum 10 gauge) and intermediate cross members to assure unit integrity. Provide minimum size base rail to ensure proper trapping and slope of condensate drain (minimum 6 inch from bottom of drain opening).

F. Fan assembly shall be provided with 1" deflection internally mounted spring vibration isolation under the fan and motor base on units with coils less than 8 sq. ft. and 2" deflection internally mounted spring vibration isolation under the fan and motor base with coils greater than 8 sq. Ft. Units with coils over 35 sq. ft. shall have spring thrust restraints securing the fan housing to the discharge opening panel on units. Fan motor shall be internally mounted. Provide internal flex connection of fan discharge. Maximum acceptable RPM of fan shall not exceed 1000.

G. Provide factory installed removable hinged access doors in the following locations:
1. Entering side of all coils to allow for cleaning of coils on both sides of unit.
2. Each side of filter compartment to allow changing of filters from either side.
3. Each side of motor compartment to allow motor and isolation access.
4. Each side of condensate drain pan to allow for cleaning and inspection.
5. Swing the doors against the casing static pressure.

H. Provide all coil modules, including heating coil modules, with stainless steel drain pans to facilitate cleaning and maintenance of the coils. Drain pan to extend 10” minimum downstream of cooling coil.

I. Provide coils with stainless steel casings, end plates, tube supports and top & bottom plates.

J. Units shall meet ASHRAE III Class 6 Low Leakage Standard. Casing shall have less than a 1% leakage rate at plus or minus 8 inches W.G.

K. Provide units with a low velocity angled filter section unless otherwise specified.

2.3 DRAW THROUGH AIR HANDLING UNITS – CONSTANT VOLUME (BELT DRIVEN

FORWARD CURVE).

A. Provided with:
   1. V-belt drive assembly and motor with totally enclosed belt guard.
   2. Insulated sheet metal cabinet with removable panels for access to the interior.
   3. Full hinged double wall doors with two-step safety handles.

B. Drive assembly:
   1. Size for 50% overload.
   2. Matched belts.
   3. Minimum two belt drive.
   4. Provide adjustable pitch motor pulley for motors.
   5. Provide motor and fan pulley of cast iron keyed to the shaft.

C. Select the motor so that the brake horsepower required to deliver the design air quantity at the system static pressure will not exceed the motor nameplate rating.
   1. Totally enclosed, fan cooled, 1750 rpm.
   2. Minimum 90% nominal efficiency at loads of 70% to 100%.
   3. Premium efficiency
   4. Cast iron frame and end plate
   5. Forged steel lifting eye
   6. Oversized conduit box with ground lug
   7. Provide with factory installed shaft grounding ring by Aegis on units which utilize a variable frequency drive.

D. Supply Fans:
   1. Double width, double inlet, forward curve blades.
   2. Statically and dynamically balanced.
   3. Tested after being installed in the fan sections.
   4. Selected for the design air quantities and pressure of the system.
   5. Mounted on a common shaft if multiple wheels.

E. Select fan to operate at or near its maximum efficiency point when handling the required air quantity and static pressure.

F. Stainless steel condensate pan with positive slope in all directions to outlet. Line the condensate drain pan with minimum 1-1/2" waterproof insulation.

G. Fan bearings:
   1. Remote grease fittings grouped on the motor access side of the unit.
   2. Self-aligning.
   3. Select for an average life of 200,000 hours.

H. Insulation, vapor barriers, facings and adhesives shall have:
   1. Flame spread not higher than 25.
   2. Smoke developed rating not higher than 50.

I. Double wall casing construction. Construct interior casing panels with 3 lb. minimum density insulation for acoustical and condensation control.
   1. Condensation on the exterior of the air handling units is not acceptable.

J. Filter section:
   1. Constructed with substantial hinges.
   2. Neoprene gasketing.
   3. Permanent quick release latching devices.
   4. Arranged to accommodate the 2" thick filters as specified.
   5. Low velocity angled filter section unless otherwise specified.

K. Cooling coils as specified. Extend drain and vent piping through cabinets. Provide grommets at all pipe penetrations through cabinets.

L. Heating coils as specified. Extend drain and vent piping through cabinets. Provide grommets at all pipe penetrations through cabinets.
   1. Location as indicated.

2.4 DRAW THROUGH AIR HANDLING UNITS CONSTANT VOLUME (DIRECT DRIVE ECM)

A. Provided with:
   1. Consist of multiple, ECM motorized impeller supply fan assemblies. Provide minimum number of fans as indicated on drawings.
   2. Insulated sheet metal cabinet with removable panels for access to the interior.
   3. Hinged double wall doors with two-step safety handles.

B. Motors and Control:
   1. Electrically commutated motor (ECM).
   2. Motor shall be a brushless DC type with a permanent magnet rotor with integral motor overloads.
   3. Fan Electrical Power (FEP) rated in accordance with AHRI 430-2020.
   4. Motor efficiency class shall comply with IE4.
   5. The fan section shall be provided with a externally mounted factory installed single point of electrical connection NEMA 1 or NEMA 4 motor control panel. All fans shall be factory wired to the unit exterior mounted motor control panel. Wire sizing shall be determined, and installed, in accordance with applicable NEC standards. In addition, the motor control panel shall include the following:
      a. Control panel box shall be UL508a compliant and manufactured by a UL508a approved manufacturer or UL certified during air handler installation.
      b. Hand/off/auto switch for unit startup and commissioning.
      c. Fused main disconnect with lock out tag out feature.
      d. Common control terminal block for common signal wiring. Single 0-10vdc signal used for fan speed control.
      e. Individual motor protection with individual disconnecting means with lockable feature.

f. Dial potentiometer to be included to for manual speed control in the 'hand' position.
g. Potentiometer shall be powered by line input. No separate 24V required.
h. Control panel shall be able to operate fans without a BAS signal for purposes of troubleshooting and commissioning.

6. Control panel shall be mounted to air handling units as to not restrict access to fans or motors.
7. Each unit shall be provided with an adjustable signal generator to be used to operate the unit fans prior to BMCS completion. The adjustable signal generator shall generate a 0-10V signal by rotating a multi-cycle precise potentiometer. In addition, the signal generator shall include a LED display for both output current and voltage as well as a calibrating potentiometer. Manufacturer shall provide all devices as required to power signal generator.

C. Supply Fans:

1. Single width, single inlet, direct driven plenum fan with backward inclined, high efficiency welded aluminum impeller that is dynamically balanced as an assembly. Fan shall be provided with perforated panel or flow grid on the inlet cone side of fan assembly.
2. Minimum of Class II fans.
3. Factory dynamic fan balancing to G6.3 per AMCA 204 shall be conducted by the fan manufacturer to identify and eliminate critical speeds to ensure stable operation through the entire operating range of the fan. Field fan balancing is not acceptable. Forward factory balancing test report to Engineer upon request.
4. Fan assembly shall be installed by the air handling manufacturer at their factory. Utilization of outside modifications groups for installation is not acceptable.
5. Provide each multiple fan unit with factory installed backdraft dampers for each fan. Damper shall automatically close on fan failure to allow remaining fans to continue to operate.
6. The fan array shall produce a uniform air flow profile and velocity profile within the air handling unit not to exceed the specified cooling coil and/or filter bank face velocity.
7. Fans applied in an array shall be tested as a system and the total fan vibration shall be less that 0.42 (in/s) RMS including all fan-to-fan interaction. This system effect shall be accounted for by the air handler manufacturer.
8. Fan performance shall be rated in accordance with AHRI 430-2020. Fan shall be spaced to minimize aerodynamic fan interaction. Minimum center-to-center spacing between fans shall be 1.6 diameter ratio to ensure proper performance.
9. Fan array shall be designed and constructed for easy field assembly and maintenance. Fan shall be assembled to bulkhead wall with minimal fasteners and the fan shall have quick disconnects for the high voltage and low voltage connections
10. Fan wheels shall be constructed of materials that comply with UL 1995 requirements of flame and smoke spread per NFPA 90A. The flame

spread index not exceeding 25 and a smoke-developed index not exceeding 50.

11. For units utilizing multiple fans in a fan section, a fan curve shall be provided showing the performance of the entire bank of fans at design conditions. In addition, a fan curve shall be provided showing the performance of each individual fan in the bank of fans at design conditions. Also, a fan curve shall be provided showing the performance of the bank of fans, if one fan is down. The percent redundancy of the bank of fans with one fan down shall be noted on the fan curve or in the tabulated fan data

D. Select fan to operate at or near its maximum efficiency point when handling the required air quantity and static pressure. In addition, operating point shall not exceed 70 Hz.

E. Stainless steel condensate pan with positive slope in all directions to outlet. Line the condensate drain pan with minimum 1-1/2" waterproof insulation.

F. Insulation, vapor barriers, facings and adhesives shall have:
1. Flame spread not higher than 25.
2. Smoke developed rating not higher than 50.

G. Double wall casing construction. Construct interior casing panels with 3 lb. minimum density insulation for acoustical and condensation control.
1. Condensation on the exterior of the air handling units is not acceptable.

H. Filter section:
1. Constructed with substantial hinges.
2. Neoprene gasketing.
3. Permanent quick release latching devices.
4. Arranged to accommodate the 2" thick filters as specified.

I. Cooling coils as specified. Extend drain and vent piping through cabinets. Provide grommets at all pipe penetrations through cabinets.

J. Heating coils as specified. Extend drain and vent piping through cabinets. Provide grommets at all pipe penetrations through cabinets.

K. Provide units with factory fabricated mixing box section that include an additional 2” thick metal perforated inner liner which utilizes fiberglass insulation. Liner shall be installed on all walls and top surface.

L. Provide each fan section with an additional 2” think perforated metal inner liner which utilizes fiberglass insulation. Liner shall be installed on all walls and top surface.

2.4 DRAW THROUGH AIR HANDLING UNITS CONSTANT VOLUME (DIRECT DRIVE STANDARD MOTORS)

A. Provided with:
   1. Non-Overloading direct drive plenum fans. Provide minimum number of fans as indicated on drawings.
   2. Insulated sheet metal cabinet with removable panels for access to the interior.
   3. Hinged double wall doors with two-step safety handles.

B. Drive assembly:
   1. Sized for 50% overload.

C. Motors and Control:
   1. Totally enclosed, fan cooled, Variable speed, 1750 rpm.
   2. Maximum operating point of 70 Hz.
   3. Minimum 90% nominal efficiency at loads of 70%-100%.
   4. Premium efficiency inverter duty
   5. NEMA B design, with Class B insulation, capable to operate continuously at 104 deg F without tripping overloads.
   6. +/- 10% voltage utilization range to protect against voltage variation.
   5. Cast iron frame and end plate
   6. Forged steel lifting eye
   7. Oversized conduit box with ground lug
   8. Provide with factory installed shaft grounding rings by Aegis
   9. Motor selected so that the brake horsepower required to deliver the design air quantity at the system static pressure will not exceed the motor nameplate rating.

D. Supply Fans:
   1. Single width, single inlet, backward curved welded aluminum plenum fan.
   2. Statically and dynamically balanced to a BV-3 per AMCA 204 test standard.
   3. Tested after being installed in the fan sections.
   4. Selected for the design air quantities and pressure of the system.
   5. Mounted on a common shaft if multiple wheels.
   6. The fan shall be rated in accordance with AMCA 210 for performance and AMCA 260 for sound.
   7. Minimum of Class II fan.

E. Fans selected with isolation shall be internally isolated with spring isolators. A flexible connection shall be installed between fan and unit casing to ensure complete isolation. Flexible connection shall comply with NFPA 90A and UL 181 requirements. If fans and motors are not internally isolated, then the entire unit shall be externally isolated from the building, including supply and return duct work, piping, and electrical connections. External isolation shall be furnished by the installing contractor to avoid transmission of noise and vibration through the ductwork and building structure.

F. Each direct drive fan in a multiple-fan array shall be provided with integral back flow prevention: a backdraft damper that prohibits recirculation of air in the event a fan or multiple fans become disabled. Dampers are tested and rated based on AMCA Standard 500. Dampers to be heavy duty type capable of a maximum back pressure that exceeds the design total static pressure with minimal leakage. The dampers should have a minimal total effect on airflow performance; both pressure drop when open and system effect on the fan. The damper blades and frame shall be extruded aluminum with blade edge seals locked into the blade edge. Adhesive type seals are unacceptable. AHU manufacturer responsible for providing proper spacing upstream of dampers to ensure full, uniform airflow through upstream components. For units where the damper(s) are supplied at the jobsite, the installing contractor shall contract a certified TAB contractor to verify uniform airflow thru upstream components.

G. Select fan to operate at or near its maximum efficiency point when handling the required air quantity and static pressure.

H. Stainless steel condensate pan with positive slope in all directions to outlet. Line the condensate drain pan with minimum 1-1/2" waterproof insulation.

I. Insulation, vapor barriers, facings and adhesives shall have:
   1. Flame spread not higher than 25.
   2. Smoke developed rating not higher than 50.

J. Double wall casing construction. Construct interior casing panels with 3 lb. minimum density insulation for acoustical and condensation control.
   1. Condensation on the exterior of the air handling units is not acceptable.

K. Filter section:
   1. Constructed with substantial hinges.
   2. Neoprene gasketing.
   3. Permanent quick release latching devices.
   4. Arranged to accommodate the 2" thick filters as specified.

L. Cooling coils as specified. Extend drain and vent piping through cabinets. Provide grommets at all pipe penetrations through cabinets.

M. Heating coils as specified. Extend drain and vent piping through cabinets. Provide grommets at all pipe penetrations through cabinets.

N. Provide units with factory fabricated mixing box section that include an additional 2” thick metal perforated inner liner which utilizes fiberglass insulation. Liner shall be installed on all walls and top surface.

O. Provide each fan section with an additional 2” think perforated metal inner liner which utilizes fiberglass insulation. Liner shall be installed on all walls and top surface.

P. Factory dynamic fan balancing shall be conducted from 16Hz to 60Hz to identify and eliminate critical speeds to ensure stable operation through the entire operating range of the fan and drive assembly. Field fan balancing is not acceptable. Forward factory balancing test report to Engineer upon request.

2.5 DRAW THROUGH AIR HANDLING UNITS – VARIABLE AIR VOLUME (BELT DRIVEN FORWARD CURVE)

A. Provided with:
   1. V-belt drive assembly and motor with totally enclosed belt guard.
   2. Insulated sheet metal cabinet with removable panels for access to the interior.
   3. Full hinged double wall doors with two-step safety handles.

B. Drive assembly:
   1. Sized for 50% overload.
   2. Matched belts.
   3. Minimum two belt drive.

C. Select proper fan drives from an assortment of fixed pitch cast iron pulleys and matched belts.
   1. Pulleys keyed to the shaft.

D. Motor selected so that the brake horsepower required to deliver the design air quantity at the system static pressure will not exceed the motor nameplate rating.
   1. Totally enclosed, fan cooled, Variable speed.
   2. Minimum 90% nominal efficiency at loads of 70%-100%.
   3. Premium efficiency.
   4. Cast iron frame and end plate
   5. Forged steel lifting eye
   6. Over sized conduit box with ground lug
   7. Provide with factory installed shaft grounding rings by Aegis

E. Supply fans shall be:
   1. Double width, double inlet, non-overloading, air-foil blade centrifugal fan, or forward curve fan as required.
   2. Statically and dynamically balanced
   3. Tested after being installed in the fan sections
   4. Mounted on a common shaft if multiple wheels

F. Select fan to operate at or near its maximum efficiency point when handling the required air quantity and static pressure.

G. Stainless steel condensate pan with positive slope in all directions to outlet; condensate drain pan with a minimum of 1-1/2" waterproof insulation.

H. Fan bearings:
   1. Remote grease fittings grouped on the motor access side of the unit.
   2. Self-aligning.
   3. Selected for an average life of 200,000 hours.

I. Insulation, vapor barriers, facings and adhesives shall have:
   1. Flame spread not higher than 25.
   2. Smoke developed rating not higher than 50.
   3. 3 lb. density insulation in interior casing panels.

J. Double wall casing construction. Construct interior casing panels with 3 lb. Minimum density insulation for acoustical and condensate control.
   a. Condensation on the exterior of the air handling units is not acceptable.

K. Filter Section:
   1. Constructed with substantial hinges.
   2. Neoprene gasketing.
   3. Permanent quick release latching devices.
   4. Arranged to accommodate 2" thick filters as specified.
   5. Low velocity angled filter section unless otherwise specified.

L. Cooling coils as specified. Extend drain and vent piping through cabinets. Provide grommets at all pipe penetrations through cabinets.

M. Heating coils as specified. Extend drain and vent piping through cabinets. Provide grommets at all pipe penetrations through cabinets.

N. Equipment capacities as indicated.

O. Factory dynamic fan balancing shall be conducted from 16Hz to 60Hz to identify and eliminate critical speeds to ensure stable operation through the entire operating range of the fan and drive assembly. Field fan balancing is not acceptable. Forward factory balancing test report to Engineer upon request.

2.6 DRAW THROUGH AIR HANDLING UNITS – VARIABLE AIR VOLUME (DIRECT DRIVE ECM)

A. Provided with:
   1. Consist of multiple, ECM motorized impeller supply fan assemblies. Provide minimum number of fans as indicated on drawings.
   2. Insulated sheet metal cabinet with removable panels for access to the interior.
   3. Hinged double wall doors with two-step safety handles.

B. Motors and Control:
   1. Electrically commutated motor (ECM).
   2. Motor shall be a brushless DC type with a permanent magnet rotor with integral motor overloads.
   3. Fan Electrical Power (FEP) rated in accordance with AHRI 430-2020.
   4. Motor efficiency class shall comply with IE4.
   5. The fan section shall be provided with a externally mounted factory installed single point of electrical connection NEMA 1 or NEMA 4 motor control panel. All fans shall be factory wired to the unit exterior mounted motor control panel. Wire sizing shall be determined, and installed, in accordance with applicable NEC standards. In addition, the motor control panel shall include the following:
      a. Control panel box shall be UL508a compliant and manufactured by a UL508a approved manufacturer or UL certified during air

handler installation.

b. Hand/off/auto switch for unit startup and commissioning.

c. Fused main disconnect with lock out tag out feature.

d. Common control terminal block for common signal wiring. Single 0-10vdc signal used for fan speed control.

e. Individual motor protection with individual disconnecting means with lockable feature.

f. Dial potentiometer to be included to for manual speed control in the 'hand' position.

g. Potentiometer shall be powered by line input. No separate 24V required.

h. Control panel shall be able to operate fans without a BAS signal for purposes of troubleshooting and commissioning.

6. Control panel shall be mounted to air handling units as to not restrict access to fans or motors.

7. Each unit shall be provided with an adjustable signal generator to be used to operate the unit fans prior to BMCS completion. The adjustable signal generator shall generate a 0-10V signal by rotating a multi-cycle precise potentiometer. In addition, the signal generator shall include a LED display for both output current and voltage as well as a calibrating potentiometer. Manufacturer shall provide all devices as required to power signal generator.

C. Supply Fans:

1. Single width, single inlet, direct driven plenum fan with backward inclined, high efficiency welded aluminum impeller that is dynamically balanced as an assembly. Fan shall be provided with perforated panel or flow grid on the inlet cone side of fan assembly.

2. Minimum of Class II fans.

3. Factory dynamic fan balancing to G6.3 per AMCA 204 shall be conducted by the fan manufacturer to identify and eliminate critical speeds to ensure stable operation through the entire operating range of the fan. Field fan balancing is not acceptable. Forward factory balancing test report to Engineer upon request.

4. Fan assembly shall be installed by the air handling manufacturer at their factory. Utilization of outside modifications groups for installation is not acceptable.

5. Provide each multiple fan unit with factory installed backdraft dampers for each fan. Damper shall automatically close on fan failure to allow remaining fans to continue to operate.

6. The fan array shall produce a uniform air flow profile and velocity profile within the air handling unit not to exceed the specified cooling coil and/or filter bank face velocity.

7. Fans applied in an array shall be tested as a system and the total fan vibration shall be less that 0.42 (in/s) RMS including all fan-to-fan interaction. This system effect shall be accounted for by the air handler manufacturer.

8. Fan performance shall be rated in accordance with AHRI 430-2020. Fan shall be spaced to minimize aerodynamic fan interaction. Minimum center-to-center spacing between fans shall be 1.6 diameter ratio to

ensure proper performance.

9. Fan array shall be designed and constructed for easy field assembly and maintenance. Fan shall be assembled to bulkhead wall with minimal fasteners and the fan shall have quick disconnects for the high voltage and low voltage connections
10. Fan wheels shall be constructed of materials that comply with UL 1995 requirements of flame and smoke spread per NFPA 90A. The flame spread index not exceeding 25 and a smoke-developed index not exceeding 50.
11. For units utilizing multiple fans in a fan section, a fan curve shall be provided showing the performance of the entire bank of fans at design conditions. In addition, a fan curve shall be provided showing the performance of each individual fan in the bank of fans at design conditions. Also, a fan curve shall be provided showing the performance of the bank of fans, if one fan is down. The percent redundancy of the bank of fans with one fan down shall be noted on the fan curve or in the tabulated fan data

D. Select fan to operate at or near its maximum efficiency point when handling the required air quantity and static pressure. In addition, operating point shall not exceed 70 Hz.

E. Stainless steel condensate pan with positive slope in all directions to outlet. Line the condensate drain pan with minimum 1-1/2" waterproof insulation.

F. Insulation, vapor barriers, facings and adhesives shall have:
1. Flame spread not higher than 25.
2. Smoke developed rating not higher than 50.

G. Double wall casing construction. Construct interior casing panels with 3 lb. minimum density insulation for acoustical and condensation control.
1. Condensation on the exterior of the air handling units is not acceptable.

H. Filter section:
1. Constructed with substantial hinges.
2. Neoprene gasketing.
3. Permanent quick release latching devices.
4. Arranged to accommodate the 2" thick filters as specified.

I. Cooling coils as specified. Extend drain and vent piping through cabinets. Provide grommets at all pipe penetrations through cabinets.

J. Heating coils as specified. Extend drain and vent piping through cabinets. Provide grommets at all pipe penetrations through cabinets.

K. Provide units with factory fabricated mixing box section that include an additional 2” thick metal perforated inner liner which utilizes fiberglass insulation. Liner shall be installed on all walls and top surface.

L. Provide each fan section with an additional 2” think perforated metal inner liner which utilizes fiberglass insulation. Liner shall be installed on all walls and top surface.

2.7 BLOW THROUGH AIR HANDLING UNIT - MULTI-ZONE

A. Provided with:
   1. V-belt drive assembly and motor with totally enclosed belt guard.
   2. Insulated sheet metal cabinet with removable panels for access to the interior.
   3. Full hinged double wall doors with two-step safety handles.

B. Drive assembly:
   1. Sized for 50% overload.
   2. Matched belts.
   3. Minimum two belt drive.
   4. Provide adjustable pitch motor pulley for motors.
   5. Construct pulley of cast iron; keyed to the shaft.

C. Select motor so that the brake horsepower required to deliver the design air quantity at the system static pressure will not exceed the motor nameplate rating.
   1. Open, drip proof, 1750 rpm.
   2. Minimum 90% nominal efficiency at loads of 70% - 100%.
   3. Premium efficiency.

D. Supply Fans:
   1. Double width, double inlet, forward curve blade centrifugal fan.
   2. Statically and dynamically balanced.
   3. Tested after being installed in the fan sections.
   4. Selected for the design air quantities and pressure of the system.
   5. Mounted on a common shaft if multiple wheels.

E. Select fan to operate at or near its maximum efficiency point when handling the required air quantity and static pressure.

F. Stainless steel condensate pan with positive slope in all directions to outlet. Insulate the condensate drain pan with a minimum of 1-1/2" waterproof insulation.

G. Fan Bearings:
   1. Remote grease fittings grouped on the motor access side of the unit.
   2. Self-aligning.
   3. Select for an average life of 200,000 hours.

H. Insulation, vapor barriers, facings and adhesives shall have:
   1. Flame spread not higher than 25.
   2. Smoke developed rating not higher than 50.
   3. 3 lb. density insulation on interior casing panels

I. Double wall casing construction. Construct interior casing panels with 3 lb.

minimum density insulation for acoustical and condensation control.

1. Condensation on the exterior of the air handling units is not acceptable.

J. Filter section:
   1. Constructed with substantial hinges.
   2. Neoprene gasketing.
   3. Permanent quick release latching devices.
   4. Arranged to accommodate 2" thick filters as specified.
   5. Low velocity angled filter section unless otherwise specified.

K. Cooling coils as specified. Extend drain and vent piping through cabinets. Provide grommets at all pipe penetrations through cabinets.

L. Heating coils as specified. Extend drain and vent piping through cabinets. Provide grommets at all pipe penetrations through cabinets.

M. Provide a factory installed equalizing grid in the hot deck where heating coils are not installed.

N. Factory installed zone mixing dampers:
   1. 16 Ga. galvanized steel blades.
   2. Extruded aluminum zone partitions with blade stop angles, silicone blade seals and neoprene foam jamb seals.
   3. Insulated frame and divider between hot and cold deck.
   4. Single solid 1/2" diameter plated steel blade shaft per zone.
   5. Bronze oilite shaft bearings with thrust washer.
   6. 6" or 8" wide zone sizes
   7. Blades interconnected by a single rod between hot and cold deck. Rod couplings between hot and cold deck are not acceptable.
   8. Zones interconnected by a single rod that may be cut on site to allow separation for zoning requirements.
   9. Leakage not to exceed 1/2% at 5" W.G.
   10. Duct cleats.
   11. Linkage and drive extensions at both ends of shafts to enable damper actuators to be installed on each side.
   12. Acceptable manufacturer: Arrow Model 354.

O. Design the entrance to the hot and cold decks and baffle to preclude wiping action of the air stream.

P. Equipment capacities as indicated.

2.8 BLOW THROUGH VARIABLE AIR VOLUME AIR HANDLING UNIT – DOUBLE DUCT

A. Provided with:
   1. V-belt drive assembly and motor with totally enclosed belt guard.
   2. Insulated sheet metal cabinet with removable panels for access to the interior.
   3. Full hinged double wall doors with two-step safety handles.

B. Drive assembly:
   1. Sized for 50% overload.
   2. Matched belts.
   3. Minimum two belt drive.
   4. Provide adjustable pitch motor pulley for motors.
   5. Construct pulley of cast iron; keyed to the shaft.

C. Motor selected so that the brake horsepower required to deliver the design air quantity at the system static pressure will not exceed the motor nameplate rating.
   1. Variable Speed
   2. Minimum 90% nominal efficiency at loads of 70% - 100%.
   3. Premium efficiency
   4. Cast iron frame and end plate
   5. Forge steel lifting eye
   6. Oversized conduit box with ground lug
   7. Provide with factory installed shaft grounding ring by Aegis.

D. Supply Fans shall be:
   1. Double width, double inlet, non-overloading, air-foil blade centrifugal fan, or forward curve fan as required.
   2. Statically and dynamically balanced.
   3. Tested after being installed in the fan sections.
   4. Mounted on a common shaft if multiple wheels.

E. Select fan to operate at or near its maximum efficiency point when handling the required air quantity and static pressure.

F. Stainless steel condensate pan with positive slope in all directions to outlet. Insulate the condensate drain pan with a minimum of 1-1/2" waterproof insulation.

G. Fan Bearings:
   1. Remote grease fittings grouped on the motor access side of the unit.
   2. Self-aligning.
   3. Select for an average life of 200,000 hours.

H. Insulation, vapor barriers, facings and adhesives shall have:
   1. Flame spread not higher than 25.
   2. Smoke developed rating not higher than 50.
   3. 3 lb. density insulation on interior casing panels

I. Double wall casing construction. Construct interior casing panels with 3 lb. minimum density insulation for acoustical and condensation control.
   1. Condensation on the exterior of the air handling units is not acceptable.

J. Filter section:
   1. Constructed with substantial hinges.
   2. Neoprene gasketing.
   3. Permanent quick release latching devices.

4. Arranged to accommodate 2" thick filters as specified.
5. Low velocity angled filter section unless otherwise specified.

K. Cooling coils as specified. Extend drain and vent piping through cabinets. Provide grommets at all pipe penetrations through cabinets.

L. Heating coils as specified. Extend drain and vent piping through cabinets. Provide grommets at all pipe penetrations through cabinets.

M. Provide a factory installed equalizing grid in the hot deck where heating coils are not installed.

N. Factory dynamic fan balancing shall be conducted from 16Hz to 60Hz to identify and eliminate critical speeds to ensure stable operation through the entire operating range of the fan and drive assembly. Field fan balancing is not acceptable. Forward factory balancing test report to Engineer upon request.

O. Design the entrance to the hot and cold decks and baffle to preclude wiping action of the air stream.

P. Equipment capacities as indicated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air handling units according to manufacturer's instructions.

B. Provide additional drive packages as required by the Testing and Balancing firm.

C. Air leaks detectable by sound or touch are to be corrected.

D. Air handling units are to be properly supported to prevent flexing, bending or distorting base rails.

E. All coils are to be cleaned prior to substantial completion if units are used during construction.

F. Clean all air handling units and return to original manufacturer's condition prior to substantial completion. Vacuum clean all debris from inside air handling equipment.

G. Install piping to unit with full size 6 inch long dirt leg with 1/2" valve at bottom for cleaning.

H. Provide for positive gravity drainage of coil condensate. Pipe full size of unit connection.

I. Adjust fan drives as required to obtain scheduled capacities as directed by the Test and Balance Firm to include sheave and belt replacement.

J. Align belts to eliminate wear and vibration of belts.

K. Verify correct drainage of condensate from condensate pan.

L. Verify correct rotation of fan and wiring of motor.

M. Lubricate all greaseable ball bearings with manufacturer's suggested lubricant.

N. Replace filters as required if units are used during construction.

O. Provide piping installation so that after piping is completed and insulated there is full access to service unit and remove fan housing. Piping to coils shall not block fan section access or cause damage to piping insulation during access.

3.2 IDENTIFICATION

A. Furnish each unit with a durable, deep etched, .025" thick, factory installed aluminum identification plate, permanently mounted with the following information:
1. Unit identification as indicated on Contract Drawings.
2. Serial Number.
3. Model Number.
4. Capacity (CFM) and static pressure.
5. Motor HP.
6. Unit power supply: Volts / PH / Amps.
7. Supply Fan Type.
8. Coil GPM and pressure drop.
9. Sales Order #.
10. Date unit manufactured.

END OF SECTION 237313

SECTION 237314 - AIR HANDLING UNITS WITH MODULATING HOT GAS REHEAT

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install air handling units with casing, fans, coils, filters, modulating gas reheat and special items.

1.2 RELATED WORK

A. Division 23 Mechanical
   1. Air Balance
   2. Controls
   3. Electrical Provisions of Mechanical Work
   4. Ductwork
   5. Air filtration
   6. Heating and Cooling Coils

1.3 REFERENCES

A. ANSI/ARI 410 - force circulation air cooling and air heating coils

B. National Electrical Code

1.4 QUALITY ASSURANCE

A. Unit shall be certified in accordance with UL Standard 1995, Safety Standard for Heating and Cooling Equipment.

B. Unit and refrigeration system shall comply with ASHRAE 15, Safety Standard for Mechanical Refrigeration.

C. Unit shall be safety certified by ETL and be ETL US listed.

1.5 SUBMITTALS

A. Submit manufacturer's dimensioned product data sheets.
   1. Show location of filter access doors.

B. Submit fan performance curve for each unit:
   1. Plot fan volume against static pressure, horsepower and efficiency.
   2. Show point of rating based on static requirements of the system.

C. Submit the fan performance plot at each motor speed position with consideration for the reduced internal static.

D. Submit a chart of specific sound power level at each octave band center frequency.

E. Submit manufacturer's certified heating and cooling coil capacity data.

F. Submit filter manufacturer's product data sheets and capacity information.

G. Submit manufacturer's data on housing insulation material.

H. Product Data: Literature shall be provided that indicates dimensions, weights, capacities, ratings, fan performance, filter information, electrical characteristics and connection requirements. Installation, Operation and Maintenance manual shall be provided.

I. Shop Drawings: Unit drawings shall be provided that indicate assembly, unit dimensions, construction details and connection details. Computer generated fan curves for each blower shall be submitted with specific design operation point noted. Wiring diagram shall be provided with detail for power and control systems and differentiate between factory installed and field installed wiring.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Unit shall be wrapped in plastic prior to shipment to prevent damage during transport and thereafter while in storage awaiting installation.

B. Unit shall be stored in a clean, dry place protected from weather and construction traffic in accordance with Installation, Operation and Maintenance manual instructions.

C. Unit shall be handled carefully to avoid damage to components, enclosures and finish.

1.7 WARRANTY

A. Manufacturer shall provide a warranty for a period of 12 months from the date of substantial completion. Warranty shall cover material and workmanship that prove defective, within the specified warranty period, provided manufacturer’s written instructions for installation, operation, and maintenance have been followed. Warranty excludes parts associated with routine maintenance, such as belts and air filters.

1.8 CAPACITY

A. Refer to equipment schedule.

1.9 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units until ductwork is clean, filters are in place, bearings lubricated, condensate properly tapped, piping connections verified and leak tested, belts aligned and tensioned, all shipping braces have been removed, and fan has been tested under observation.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Aaon

B. Addison

2.2 UNIT HOUSING

A. All cabinet walls and access doors shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.

B. Unit insulation shall have a minimum thermal resistance R-value of 6.25. Foam insulation shall have a density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D-1929 for a minimum flash ignition temperature of 610°F.

C. 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, prevents heat transfer through the panel and prevents exterior condensation on the panel.

D. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Sealing shall be included between panels and between access doors and openings to reduce air leakage. Refrigerant piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.

E. Access to filters, cooling coil, reheat coil, heaters, supply fans and electrical and controls components shall be through hinged access doors. Stainless steel hinges shall be included on the doors.

F. Access doors shall be flush mounted to cabinetry, with stainless steel removable hinges and quarter-turn, zinc cast handles.

G. Condensation on the exterior of the unit is not approved.

H. Insulation, vapor barriers, facings and adhesives shall have:
   1. Flame spread not higher than 25.
   2. Smoke developed rating not higher than 50.

2.3 ELECTRICAL

A. Unit shall be provided with standard power block for connecting power to the unit.

B. Unit shall include a factory installed 24V control circuit transformer.

2.4 SUPPLY FANS

A. Unit shall include direct drive, backward curved, plenum supply fans.

B. Blower and motor assembly shall be dynamically balanced and mounted on rubber isolators.

C. Motor shall be standard (premium) efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points.

D. Variable frequency drive shall be factory wired and mounted in the control compartment. Fan motor shall be premium efficiency.

2.5 COOLING COIL

A. Coil shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and galvanized steel end casings.

B. Coil with dual circuits shall have interlaced circuitry.

C. Coil shall be furnished with a factory installed electronic thermostatic expansion valves. The sensing bulbs shall be field installed on the suction line immediately outside the cabinet.

D. Coil shall have left hand external piping connections. Liquid and suction connections shall be sweat connection. Coil connections shall be labeled, extent beyond the unit casing and be factory sealed with grommets that cover both the interior and exterior of the unit casing, to minimize air leakage and condensation inside the panel assembly.

E. Cooling coils shall be mechanically supported above the drain pan by multiple supports that allow drain pan cleaning and coil removal.

F. Reference Schedule and Specification Section 23 82 16.

G. Provide evaporator coil coated with corrosion resistant epoxy utilizing a dip and bake process. Coating shall be flexible and uniformly bonded to all evaporator coil surfaces.

2.6 REFRIGERATION SYSTEM

A. Air handling unit and matching condensing unit shall be capable of operation as an R-410A split system air conditioner.

B. Each refrigeration circuit shall be equipped with thermostatic (electronic) expansion valve type refrigerant flow control.

C. Modulating hot gas reheat shall be provided on the lead refrigeration circuit. Refrigeration circuit shall be provided with (interlaced) hot gas reheat coil, modulating valves, electronic controller, supply air temperature sensor and a dehumidification control signal terminal which allow the unit to have a dehumidification mode of operation, which includes supply air temperature control to prevent supply air temperature swings and overcooling of the space. Modulating reheat valves shall be factory installed. Reheat line connections shall be labeled, extend beyond the unit casing and be located near the suction and liquid line connections for ease of field connection. Connections shall be factory sealed with a grommet on the exterior of the unit casing to minimize air leakage.

2.7 ELECTRIC HEATING

A. Unit shall include an include electric heater consisting of electric heating coils, fuses and a high temperature limit switch, with capacities as shown on the plans.

B. Heater shall have stages of capacity as scheduled.

C. Electric heating coils shall be located in the reheat position downstream of the supply fans.

2.8 FITLERS

A. Unit shall include 4 inch thick, pleated panel pre filters with an ASHRAE efficiency of 30% and MERV rating of 8, upstream of the cooling coil.

B. Locate behind access doors.
   1. Construct with substantial hinges
   2. Neoprene gaskets
   3. Permanent quick-release latching devices

C. Provide full length tracks to support the filter.

2.9 CONDENSATE DRAIN PANS

A. IAQ style drain pans shall be provided under all coils.
   1. Pitch to drain connection
   2. Fabricated from 16 gauge 304 stainless steel
   3. Triple pitched for complete drainage with no standing water
   4. Insulated to prevent condensation

5. Welded corners
6. Stainless drain connection

2.10 CONTROLS

A. Control panel shall be connected to the air handling unit with a 6 foot low voltage and high voltage connections and shall be mounted in the field.

B. Factory Installed and Factory Provided Controller
   1. Unit controller shall be capable of controlling all features and options of the unit. Controller shall be factory installed in the unit controls compartment and factory tested.
   2. Controller shall be capable of stand alone operation with unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling available without dependence on a building management system.
   3. Controller shall have an onboard clock and calendar functions that allow for occupancy scheduling.
   4. Controller shall include non-volatile memory to retain all programmed values, without the use of an external battery, in the event of a power failure.
   5. With the modulating hot gas reheat option a space humidity sensor and supply air temperature sensor shall be furnished with the unit for field installation. Suction pressure sensor shall be factory installed. Supply air temperature and space humidity setpoints, for the dehumidification mode of operation, shall be adjustable.

C. Make-Up Air Controller:
   1. Outside air temperature sensor and supply air temperature sensor shall be furnished with the unit for field installation.
   2. Unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling shall be accomplished with connection to interface module with LCD screen and input keypad, interface module with touch screen, or with connection to PC with free configuration software. Controller shall be capable of connection with other factory installed and factory provided unit controllers with individual unit configuration, setpoint adjustment, sensor status viewing, and occupancy scheduling available from a single unit. Connection between unit controllers shall be with a modular cable. Controller shall be capable of communicating and integrating with a BACnet network.

PART 3 - EXECUTION

3.1 SPARE PARTS

A. Provide the following spare parts and material to the Owner for use after the warranty period.
   1. One spare fan motor for each size of fan motor on the project

2. One spare set of filters or filter media for each fan coil unit on the project

3.2 ELECTRICAL REQUIREMENTS

A. Bring electrical connections to a common junction box.

3.3 STORAGE

A. Storage and shipping in accordance with manufacturer's recommendations.

3.4 INSTALLATION

A. Install unit so motor connections and filters are accessible.

END OF SECTION 237314

SECTION 238127 - VARIABLE REFRIGERANT VOLUME DX SYSTEM

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

B. Refer to Document 00 21 13, Instructions to Bidders and 00 22 13 Supplementary Instructions to Bidders, for substitution of materials and products.

C. Addenda issued during the bidding period that affect this section of the specifications.

1.2 WORK INCLUDED

A. Provide and install a multiple evaporator, direct expansion, variable capacity air conditioning system with simultaneous cooling and heating configurations. System shall consist of multiple fan coil units, branch selector boxes, refrigerant piping joints and headers, control wiring, sensors and matched variable speed outdoor heat recovery condensing units.

1.3 RELATED WORK

A. Division 23 Mechanical:
1. Ductwork
2. Air Balance
3. Electrical provisions for mechanical work
4. Air Filtration
5. Vibration Isolation
6. Refrigerant piping

1.4 QUALITY ASSURANCE

A. All system components shall be manufactured in an ISO 9001 and ISO 14001 facility.

B. All system wiring, internal and external to components, shall be in accordance with the National Electrical Code.

C. System shall be safety certified by ETL and be UL listed.

D. All units shall be certified, for both performance and efficiency, to AHRI 1230 standard.

E. Energy-Efficiency Ratio: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings." Provide certified efficiency ratings per AHRI-1230 standard. (DOE Waiver is not acceptable) Scheduled EER and IEER ratings scheduled shall be considered minimum efficiency allowed.

F. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings." Provide certified efficiency ratings per AHRI-1230 standard. (DOE Waiver is not acceptable) Scheduled COP ratings scheduled shall be considered minimum efficiency allowed.

1.5 PERFORMANCE

A. Provide performance as scheduled on drawings.

B. Each fan coil unit or group of fan coil units associated with each individual branch cool/heat selector box shall be independently capable of operating in either heating or cooling mode regardless of the modes of the other zones on the system. The system shall have a five minute maximum cooling/heating changeover time.

C. Each zone shall be capable of operating separately with individual temperature controls.

1.6 SUBMITTALS

A. Product Data:
   1. Literature shall be provided that indicates dimensions, operating and shipping weights, certified capacities, ratings, factory supplied accessories, electrical characteristics, and connection requirements. Installation, Operation and Maintenance manual with startup requirements shall be provided.

B. Shop Drawings:
   1. Unit drawings shall be provided that indicates assembly, unit dimensions, construction details, service and air flow clearances, and connection details. Wiring diagram shall be provided with details for both power and control systems and differentiate between factory installed and field installed wiring.

C. Submit a manufacturer generated detailed refrigerant piping diagram indicating each condensing unit system, each fan coil unit, each branch selector boxes, each line length and each line size.

D. Submit coordination drawings as specified. Give consideration to adjacent structures as they affect air flow patterns.

E. Provide a comprehensive list of the total pounds on refrigerant and type of refrigerant required by each variable refrigerant volume system.

F. Submit sequence of operation in narrative form.

G. Contractor must have completed the manufacturer's installation training. The contractor shall submit a copy of the training completion certificate for the project manager and at least 2 pipe installers with this submittal.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Unit shall be shipped with doors bolted shut to prevent damage during transport and thereafter while in storage awaiting installation.

B. Follow Installation, Operation and Maintenance manual instructions for rigging, moving, and unloading the unit at its final location.

C. Unit shall be stored in a clean, dry place protected from construction traffic in accordance with the Installation, Operation and Maintenance manual.

1.8 WARRANTY

A. The VRF manufacturer shall provide a full parts warranty for all VRF equipment and controls for 10 years and a 5 years labor warranty from the date of substantial completion.

B. All warranty shall be executed by the manufacturer's authorized representative. Contractor warranty shall not be allowed.

C. Copies of the warranty paperwork and startup documentation shall be submitted upon close out of the installation.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Carrier

B. Daikin

C. LG

D. Trane

2.2 GENERAL DESCRIPTION

A. The variable capacity, heat recovery air conditioning system shall be a Variable Refrigerant Volume (heat and cool model) split system as specified. The system shall consist of multiple evaporators, branch selector boxes, manufacturer supplied refrigerant joints and headers, a two or three pipe refrigeration distribution system using PID control, and matched variable speed outdoor condensing units. The outdoor unit is a direct expansion (DX), air-cooled heat recovery, multi-zone air-conditioning system with variable speed driven compressors using R-32/R-454B refrigerant. All zones are each capable of operating separately with individual temperature control.

B. The operation of the system shall permit either individual cooling or heating of each fan coil simultaneously or all of the fan coil units associated with one branch cool/heat selector box. See drawings for Branch Selector locations and associated fan coil units.

C. Branch selector (BS) boxes shall be located as shown on the drawing. The branch selector boxes shall have the capacity to control up to 96 MBH (cooling) downstream of the BS box. The BS box shall consist of five electronic expansion valves, refrigerant control piping and electronics to facilitate communications between the BS box and main processor and between the BS box and fan coils. The BS box shall control the operational mode of the subordinate fan coils. The use of five EXV's ensures continuous heating during defrost, no heating impact during changeover and reduced sound levels. If solenoid valves in the selector box cause a "clicking" sound upon changeover, then the contractor shall be required to provide additional acoustic wrapping of the box until sound levels are acceptable to the owner and engineer.

D. The indoor units shall be connected to the condensing unit utilizing manufacturer specified piping joints and headers to ensure correct refrigerant flow and balancing. T style joints are not acceptable. All joints shall be installed per manufacturer's instructions.

E. Equipment capacities to meet leaving air temperatures (LAT) and Total and Sensible capacities as scheduled.

2.3 AIR COOLED VARIABLE REFRIGERANT VOLUME CONDENSING UNIT

A. General:
   1. The outdoor unit shall be used with only variable refrigerant volume system components of the same manufacturer.
   2. Unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. Dual and triple frame outdoor units shall be field piped with factory supplied fittings per the manufacturer's instruction.
   3. The units' onboard controls shall perform all functions required to effectively and efficiently operate the variable refrigerant volume system.
   4. Each unit shall be run tested at the factory.

5. The unit shall incorporate an auto-charging feature and a refrigerant charge check function. If units are provided without the auto-charge feature, a factory service representative must be present at startup.
6. The unit shall include an automatic oil recovery cycle which occurs 2 hours after startup and then once every 8 hours of operation.
7. The unit shall be provided with a minimum of the following safety devices; high pressure switch, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal compressor protectors, thermal fan motor protectors, overcurrent protection for the inverter and anti-short cycling timers.
8. The system shall store all setting and programs such that reprogramming is not required upon power failure. In addition, the system shall automatically restart operation after a power failure.
9. Units shall be capable of operating down to zero degree F ambient air.
10. Unit shall have a tested sound rating no higher than 58 dB throughout the full range of unit capacity modulation.
11. VFD Inverter Control – Each condensing unit shall use a high efficiency, variable speed "inverter" compressor coupled with inverter fan motors for superior part load performance. Compressor capacity shall be modulated automatically to maintain constant suction and condensing pressures while varying the refrigerant volume for the needs of the cooling or heating loads.
12. To ensure the liquid refrigerant does not flash when supplying to the various indoor units, the circuit shall be provided with a sub-cooling feature.
13. Condenser fan shall be direct drive motors that have multiple speed operation via a DC (digitally commutating) inverter.

B. Frame and Casing:
1. The condensing unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from rust-proofed milled steel panels coated with a baked enamel finish.
2. Provide with access panels at control boards, fans, motors and expansion valves. Access panels shall not require a unique tool for removal.

C. Compressor:
1. The inverter scroll compressors shall be variable speed (PVM inverter) controlled which is capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit. In addition, samplings of evaporator and condenser temperatures shall be made so that the high/low pressures detected are read every 20 seconds and calculated. With each reading, the compressor capacity (INV frequency or STD ON/OFF) shall be controlled to eliminate deviation from target value.
2. The inverter driven compressor in each condensing unit shall be of highly efficient reluctance DC (digitally commutating), hermetically sealed scroll "G2-type" with a maximum speed of 7,980 rpm.

3. Neodymium magnets shall be adopted in the rotor construction to yield a higher torque and efficiency in the compressor instead of the normal ferrite magnet type. At complete stop of the compressor, the neodymium magnets will position the rotor into the optimum position for a low torque start.
4. The capacity control range shall be as low as 4% to 100%.
5. Each non-inverter compressor shall also be of the hermetically sealed scroll type.
6. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.
7. Oil separators shall be standard with the equipment together with an intelligent oil management system.
8. The compressor shall be spring mounted to avoid the transmission of vibration.
9. In the case of multiple condenser modules, conjoined operation hours of the compressors shall be balanced by means of the Duty Cycling Function ensuring sequential starting of each module at each start/stop cycle, completion of oil return, completion of defrost or every 8 hours.

D. Fan:
1. Fan shall be direct drive variable speed propeller type.
2. Fan shall be configured for vertical discharge airflow.
3. Fan motor shall have inherent protection and have permanently lubricated bearings.
4. All fans shall be provided with a raised guard to limit contact with moving parts.
5. Night setback control of the fan motor for low noise operation by way of automatically limiting the maximum speed shall be a standard feature. Operation sound level shall be selectable from 3 steps as shown below.

Operation Sound (dB)	Night Mode Maximum Sound Pressure Level (dB)
Step 1	55
Step 2	50
Step 3	45

E. Condenser Coil:
1. Provide copper tubes with mechanically bonded aluminum fins and aluminum end casings.
2. Provide factory installed louvered hail / vandalism guards for condenser coils.
3. Provide coils with a factory applied corrosion resistant coating.

F. Electrical and Controls:
1. Unit shall be provided with electrical power characteristics as specified on drawings.
2. Unit shall be capable of operation within voltage limits of +/- 10%.
3. Low voltage control power shall be factory provided from the units' main

power supply. A separate control voltage power supply shall not be required.
4. The system shall be controlled by integral microprocessors.
5. Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 feet (total 6,560 feet).
6. Transmission (control) wiring between the indoor unit and remote controller shall be a maximum distance of 1,640 feet.

2.4 BRANCH SELECTOR BOXES (HEAT RECOVERY SYSTEMS)

A. ISOLATION VALVES - Full port, bi-directional flow isolation valves shall be installed upstream of all Branch Selector boxes. Where multi-port boxes are used, provide isolation valves both upstream and downstream of the box to facilitate isolation of individual fan coil units. Ensure Schrader fitting is positioned on the downstream side of the valve.

B. During simultaneous heating and cooling, the units in heating mode shall energize their sub-cooling electronic expansion valve.

C. Construction:
1. The Branch Selector boxes shall have a galvanized sheet plate casing.
2. Each Branch Selector shall house 5 electronic expansion valves for refrigerant control. (Multi-port boxes shall maintain independent EEV construction. Sharing of valves between zones is not allowed)
3. Where multiple boxes are installed on the same system, the piping shall be such that isolation of one box shall not disrupt refrigerant flow to other boxes. “Pass through” of refrigerant should not be used where isolation for service will prevent usage of other zones.
4. The cabinet shall contain a sub-cooling heat exchanger.
5. The unit shall have a sound absorption thermal insulation material made of flame and heat resistant foamed polyethylene.
6. All pipe connections shall be brazed type.

D. Electrical:
1. The unit electrical power shall be as specified on drawings.
2. The control voltage between the indoor units and condensing unit shall be low voltage and installed by BMCS Contractor.

2.5 AIR HANDLING UNIT INTEGRATION KIT

A. Where specified, the Variable Refrigerant Volume system shall be capable of integrating to a modular built up air handling unit. The unit shall be of construction as specified in section 23 73 13 Air Handling Units.

B. Refer to 23 09 33 Building Management and Control System for operating sequence.

C. ISOLATION VALVES - Full port, bi-directional flow isolation valves shall be installed upstream of Air Handling Unit integration kit. Ensure Schrader fitting is positioned on the downstream side of the valve.

D. The integration kit shall allow connection and control in addition to full integration of non VRF air handling equipment into a VRF system.

E. The integration kit shall include an electronic expansion valve capable of 2000 steps to control refrigerant flow to coil.

F. Integrated control module shall communicate with VRV condensing unit.

2.6 INDOOR UNIT - EVAPORATOR-FAN UNIT – HORIZONTAL DUCTED

A. Concealed Horizontal Ducted Unit Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.

B. Indoor unit shall be a built-in ceiling concealed fan coil unit, operable with refrigerant R-32/R-454B equipped with an electronic expansion valve, direct-drive DC (ECM) type fan with auto CFM adjustment at commissioning, for installation into the ceiling cavity. It is constructed of a galvanized steel casing. It shall be available in capacities scheduled. It shall be a horizontal discharge air with horizontal return air configuration. All models feature a low height cabinet making them applicable to ceiling pockets that tend to be shallow. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. Included as standard equipment, a condensate drain pan and drain pump kit that pumps to 18-3/8" from the drain pipe opening.

C. Indoor Unit:
1. The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. The unit shall be equipment with automatically adjusting external static pressure logic that is selectable during commissioning. This adjusts the airflow based on the installed external static pressure.
2. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
3. All refrigerant lines shall be insulated from the outdoor unit.
4. The indoor units shall be equipped with a condensate pan and condensate pump. The condensate pump provides up to 18-3/8" of lift from the center of the drain outlet.
5. The indoor units shall be equipped with a return air thermistor.
6. The indoor unit will be powered with 208~230V/1-phase/60Hz. (single point)
7. The voltage range will be 253 volts maximum and 187 volts minimum.

D. Unit Cabinet:

1. The cabinet shall be located into the ceiling and ducted to the supply and return openings.
2. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

E. Fan:
1. The fan shall be direct-drive DC (ECM) type fan, statically and dynamically balanced impeller with three fan speeds available.
2. The unit shall be equipment with an automatically adjusting external static pressure logic selectable during commissioning.
3. The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz with a motor output range of 0.12 to 0.47 HP respectively.
4. The airflow rate shall be available in three settings.
5. The fan motor shall be thermally protected.
6. The fan motor shall be equipped as standard with adjustable external static pressure (ESP) settings.

F. Coil:
1. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
2. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
3. The coil shall be a 3 row cross fin copper evaporator coil with 13 FPI design completely factory tested.
4. The refrigerant connections shall be flare connections and the condensate will be 1-1/4” outside diameter PVC.
5. A condensate pan shall be located under the coil.
6. A condensate pump with an 18-3/8” lift shall be located below the coil in the condensate pan with a built in safety alarm.
7. A thermistor will be located on the liquid and gas line.

G. Electrical:
1. The unit electrical power shall be as specified on drawings.
2. The control voltage between the indoor units and condensing unit shall be low voltage and installed by BMCS Contractor.

H. Filters:
1. The units shall be provided with a fabricated rear return angled filter housing (field installed). Filter box shall be configured to accept owner’s standard sizes of 16x20x2, 16x25x2, 20x20x2, 20x25x2 only.
2. Provide minimum MERV 11 filter during construction. Contractor to install clean MERV 10A filters just prior to owner acceptance.

2.7 EVAPORATOR-FAN UNIT – DUCTLESS CASSETTE

A. Ceiling cassette fan coil units shall be equipped with an electronic expansion valve for installation into the ceiling cavity. It shall be a round flow air distribution type. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition.

B. The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, condensate drain pump, condensate safety shutoff and alarm, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.

C. Return air shall be through the concentric panel, which includes a resin net, mold resistant, antibacterial filter.

D. The indoor units shall be equipped with a condensate pan with antibacterial treatment and condensate pump. The condensate pump provides up to 20" of lift and has a built in safety shutoff and alarm.

E. Units shall be equipped with a return air thermistor.

F. Return air shall have an outside air connection collar external to the unit. Provide optional outside air connection collar.

2.8 CONTROLS

A. Zone Controller: Each zone/FCU shall include a wall mounted temperature sensor with the following features:
   1. Backlit LCD display. Display of temperature information shall be Fahrenheit. The controller shall be able to display and adjust room temperature in one degree increments or be locked out from allowing user input.
   2. The controller shall have COOL, HEAT, FAN ONLY, DRY (dehumidification), and AUTO-CHANGE-OVER modes.
   3. For AUTO change over mode, the controller shall allow independent setpoints for heating and cooling to eliminate wide swings in temperature and unnecessary change over. Independent setpoint control shall be available at both local controller and the central controller
   4. Setback function shall be included with adjustable setback temperature override.
   5. The programmable controller shall have the capability of individually disabling the following buttons:
      a. Menu/OK
      b. ON/OFF
      c. Mode
      d. Fan Speed
      e. Setpoint Adjustment (Up/Down Keys) (Set point adjustment shall be in 1 deg F increments)
   6. The controller shall allow for a local (controller-level) adjustable limitation of user setpoint range.
   7. SCHEDULING: (Schedules shall be controlled via the BAS Interface - See control sequence.)
   8. The Remote Controller shall display error codes on the screen in the event of a system error.
   9. The following Fan Coil Unit sensor values shall be available at the wall

mounted remote controller:
   a. Controller thermistor temp
   b. (Refrigerant) Liquid line temperature
   c. (Refrigerant) Gas line temperature
10. 48 Hour battery backup of clock/date. All other settings shall be stored in non-volatile memory to ensure that settings are not lost upon power failure.

B. Central Controller:
1. The building shall be installed with a web-enabled factory native central controller with BACnet IP connection for BAS system. The manufacturer's controller shall provide (via web interface or via BACnet) ability for users to manipulate the following functions:
   a. On/Off Control
   b. Schedule-Adjustment (schedules to be maintained by BAS)
   c. Mode Selection – See control sequence for heat/cool changeover control
   d. Setpoint Control (Independent heating and cooling setpoints available)
   e. Operational Status and Alarm Notifications
   f. Provide with battery backup and USB port for software updates
   g. User and Administrator Levels with password protection.
   h. Customize groups and zones

C. Control Sequence:
1. The VRF system shall be provided with required hardware and software to perform the core operational sequences detailed in this section. In addition to the manufacturer's control system, the VRF supplier will provide a BACnet gateway to provide the monitoring and control points to the Building Automation Contractor. A fully functional VRF system to be provided to the owner including interface to the BAS system. Through the VRF BACnet gateway, the BAS system shall provide operation schedule, zone setpoints to the VRF controller. In addition the BAS shall be able to view individual zone temperature and humidity. The specified interaction is minimum.
2. The VRF manufacturer shall be responsible for coordinating installation, by BAS manufacturer, of all low voltage communication wiring between their components and central controller to facilitate these sequences
3. The VRF central controller shall be provided onsite as a touch screen panel located in the administration office mechanical room (or as directed by the district). It shall additionally be capable of being accessed to the internet via a district provided IP address and Ethernet connection. All functions detailed below shall be available via touch screen interface and internet access.
4. Display interface: The controller shall provide a floor plan layout of the building with the fan coil icons and temperature information visible on the screen. At commissioning, the fan coil units shall have the tagging updated to provide the applicable room numbers for the as-built installation. The visual interface shall provide clear indication of what fan coil units are connected to which particular condensing unit system.

5. The controller shall combine all indoor units onto a single central controller interface. The central controller shall provide these basic functions per zone:
   a. Alarm Identification per fan coil unit (also available on the BAS system)
   b. Min/Max set point limiting
      1. Heating set point and cooling set points shall be controlled individually
      2. Set points shall be adjustable at the zone level with adjustable limits controlled by the VRF central controller (initial programming shall limit cooling setpoint control to between 73 – 76 deg. Heating initial range to be 69 – 72 deg)
   c. Occupied/Unoccupied set point control – Each room served by a dedicated ceiling cassette shall be provided with a motion sensor compatible with the VRF system controls (Sensor provided by the VRF supplier and installed by the BAS contractor). The motion sensor shall be used to facilitate an automatic set point adjustment when a room is unoccupied. During the regular operation hours (determined by the district's central control system) these zones shall control between the district set point limits. When the room is vacant for more than 5 minutes, as indicated by the motion sensor the fan coil unit(s) shall be turned off. The VRF controller shall automatically enable the fan coil unit(s) if the room temperature rises more than 2 degrees above the standard 75 deg cooling set point (adj) or 2 deg below the standard 72 deg heating set point (adj). The unit shall return to normal operation when motion is detected.
   d. Timed override for after-hours air conditioning: During periods where the building is not in use (determined by the district schedule and BAS system) the fan coil units shall be capable of being turned on at the wall mounted controller via a local override button. The VRF system shall automatically turn off after 60 minutes (adj) of operation. This shall not require additional programming by the BAS central control system. District personnel shall have the ability to override the after-hours operation to prevent operation (see applicable portion of the BAS system control sequence)
   e. When the system is off according to the district schedule, the VRF controller shall cycle the cooling/heating if the temperatures exceed the unoccupied threshold temperatures. (85 cooling & 60 heating)

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be installed by a manufacturer's factory trained and certified contractor. Submit proof of factory certified training with bid package.

B. Install according to manufacturer's recommendations and as shown on drawings.

C. Installing contractor shall install field installed components, in accordance with Installation, Operation and Maintenance manual instructions.

D. Manufacturer shall inspect, test and adjust field assembled components and equipment installation, including connection, and assist in field testing. Report all findings to the architect and engineering in writing.

E. Manufacturer or factory-authorized representative shall visit the site regularly during the installation process to ensure proper means and methods are being employed. Include a minimum of two (2) such visits.

3.2 PARTS AVAILABILITY

A. The installed system shall have a minimum of one local parts distributer with local stock of all critical components. Local availability shall include all fan blades, fan motors, compressors, circuit boards, valves, sensors, etc. If local stock of parts is not available, the manufacturer shall provide all parts with next day freight at no additional cost to the owner for a period of 5 years from the date of substantial completion.

3.3 SPARE PARTS

A. Provide with a spare set filters for each indoor unit.

3.4 START UP

A. Provide unit with a factory start up performed by a factory representative or factory certified technician.

B. Provide the owner with a minimum of 8 hours of training and certifications classes such that the owner is equipped with the knowledge to adjust, operate and maintain the variable refrigerant volume system.

C. Provide a minimum of 8 hours of BAS coordination and BAS setup time. During this time VRF manufacturer shall work side by side with BAS contractor to ensure all communications between the VRF BACnet controller and the BAS is fully functional. A fully functional system includes proper mapping of zones in the BAS graphics.

D. The installing contractor shall complete the installation and complete a total system pressure test of 550 psi for 24 hours prior to startup.

E. The manufacturer or manufacturer’s agent shall be responsible for all evacuation and charging of refrigerant for each system at startup. Contractor startup is not allowed.

F. The manufacturer's agent shall provide the following startup services:
1. Evacuation of the piping system to a 400 micron vacuum (hold 3 hours)
2. Provide and charge the system completely with R-32/R-454B.
3. Execution of all standard diagnostics.
4. Connection to the system with the manufacturer's Service Checker software and creating an operational log of the following information for verification:
5. Each system operates with proper temperatures, delta T and superheat conditions in both cooling and heating modes.

G. Each fan coil unit is heating/cooling properly (verification that piping work has been installed properly.

H. A digital copy of these operational logs shall be stored by the manufacturer's agent as well as delivered to the owner with warranty documentation.

END OF SECTION 238127

SECTION 238146 - WATER TO AIR HEAT PUMP UNIT

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install water to air heat pump units.

1.2 RELATED WORK

A. Division 23 Mechanical
   1. Electrical provisions of mechanical work
   2. Pipe and pipe fittings
   3. Vibration isolation

1.3 REFERENCES

A. AHRI 320 – Water Source Heat Pumps

B. AHRI 410 – Forced Circulation Air Cooling and Air Heating Coils

C. National Electrical Code

1.4 SUBMITTALS

A. Submit manufacturer's dimensioned product data sheets.
   1. Show location of filter access doors.

B. Submit fan performance curve for each unit:
   1. Plot fan volume against static pressure, horsepower and efficiency.
   2. Show point of rating based on static requirements of the system.

C. Submit the fan performance plot at each motor speed position with consideration for the reduced internal static.

D. Submit a chart of specific sound power level at each octave band center frequency.

E. Submit manufacturer's certified heating and cooling coil capacity data.

F. Submit filter manufacturer's product data sheets and capacity information.

G. Submit manufacturer's data on housing insulation material.

1.5 WARRANTY

A. Provide a manufacturers warranty to include parts and labor for a period of two years from substantial completion.

1.6 ACCEPTABLE MANUFACTURERS

A. Trane

B. York

C. Daikin

D. Carrier

PART 2 - PRODUCTS

2.1 COMPONENTS

A. Hermetic compressors

B. DX coil sections

C. Condensate drain pan lined

D. Water cooled heat exchanger

E. Unit capacity as scheduled

2.2 CONTROL SYSTEM

A. Control system shall be factory wired.
   1. Installed so that the unit can be serviced without shutting down the system.
   2. Panel wiring shall be UL approved.
   3. Each circuit fused.

B. Safety devices shall be monitored and interlocked to prohibit compressor short cycling.

C. Provide identified terminal strips for low voltage terminal wiring.

D. Provide equipment for heat pump reverse cycle operation.

E. Provide with BACNET control interface.

2.3 EVAPORATOR FAN ASSEMBLY

A. Provide with:
   1. V-belt drive assembly and motor with totally enclosed belt guard.

B. Drive assembly:
   1. Sized for 50% overload
   2. Matched belts

C. Provide adjustable pitch motor pulley.

D. Provide motor and fan pulley of cast iron keyed to the shaft.

E. Motor selected so that the brake horsepower required to deliver the design air quantity at the system static pressure will not exceed the motor nameplate rating.

F. Supply fans shall be double width, double inlet, forward curve blades.

G. Fans shall be:
   1. Statically and dynamically balanced
   2. Tested after being installed in the fan sections
   3. Selected for the design air quantities and pressure of the system
   4. Mounted on a common shaft if multiple wheels

H. Select fan to operate at or near its maximum efficiency point when handling the required air quantity and static pressure.

I. Nominal fan outlet velocities shall not exceed 1800 fpm.

J. Fan bearings:
   1. Permanently lubricated
   2. Self-aligning
   3. Selected for an average life of 200,000 hours

2.4 CONDENSATE DRAIN PANS

A. IAQ style drain pans shall be provided under all coils.
   1. Pitch to drain connection
   2. Fabricated from 16 gauge 304 stainless steel
   3. Triple pitched for complete drainage with no standing water
   4. Insulated to prevent condensation
   5. Welded corners
   6. Stainless drain connection

2.5 EVAPORATOR COIL

A. Reference Schedule and Specification Section 23 82 16.

2.6 WATER COOLED HEAT EXCHANGER

A. Tube-in-tube or shell and coil condenser with continuous copper tubing.
   1. Construction shall be in accordance with ASME safety code.

2.7 CONDENSER COIL PIPING CONNECTION

A. Provide a flexible stainless steel braided hose.
   1. Minimum of two feet long
   2. Fixed MPT on one end and a swivel with adapter on the other.
   3. Suitable for water temperatures ranging from 23°F to 211°F without the use of glycol.

B. Reference Details and Specification Section 23 05 23.

2.8 CABINET

A. Corrosion resistant galvanized steel construction

B. Provide a duct flange on four sides of the return air inlet and supply air outlet of the unit.
   1. Sized to permit connection of the flexible connection to the ductwork
   2. Extend beyond the primary drain pan
   3. Minimum dimension 2"

C. Provide insulated, removable panels for access to the interior.
   1. Plated captive screws and nuts
   2. Neoprene gaskets

D. Internally insulate the entire unit with neoprene coated, 1-1/2 lb. density glass fiber insulation, applied to internal surfaces with adhesive and weld pins. Coat exposed edges of insulation with adhesive.

E. Insulation, vapor barriers, facings and adhesives:
   1. Flame spread not higher than 25
   2. Smoke developed rating not higher than 50

F. Condensation on the exterior of the cabinet is not approved.

2.9 COMPRESSOR

A. Equip each compressor with:
   1. High and low pressure protection

2. Loss of charge protection
3. Current sensitive overload relays

B. Provide suitable vibration isolators

C. Locate the compressors in a sound attenuating compartment located in the unit cabinet.

D. Provide refrigerant not scheduled for phase out.

E. Provide each refrigeration compressor with a parts and labor warranty against failure for a period of five years from the date of acceptance.
1. The warranty shall indicate model, serial number of the unit and commencing date. (Commencing date shall not start prior to substantial completion.)
2. The warranted compressor assembly consists of the starter, rotor, eccentric shaft, eccentric rods, pistons, wrist pins, suction valves, discharge valves, unloading mechanisms, oil pump, and the housing in which these parts are enclosed.

2.10 FILTERS

A. Filter section shall contain 1" thick disposable filters.

B. Arrange the filter section to permit filter change without unit shutdown or cabinet panel removal.
1. Give particular attention to construction of filter section to ensure easy removal of filters.

2.11 SPACE THERMOSTAT

A. Provide a space thermostat for remote wall mounting.

B. Provide for individual heating and cooling setpoint adjustment.
1. Automatic heating-cooling change over with dead band setting.

C. Subbase controls.
1. System "On-off".
2. Fan "On" in system "On" position.

D. Provide with locking Lexan Thermostat Guard with circulation holes on sides only.

PART 3 - EXECUTION

3.1 SPARE PARTS

A. Provide the following spare parts and material to the Owner for use after the warranty period.
   1. One spare fan motor for each size of fan motor on the project
   2. One spare set of filters or filter media for each fan coil unit on the project

3.2 ELECTRICAL REQUIREMENTS

A. Bring electrical connections to a common junction box.

3.3 STORAGE

A. Storage and shipping in accordance with manufacturer's recommendations.

3.4 INSTALLATION

A. Install and start-up the system in accordance with the manufacturer's installation start-up and service instructions.

B. The heat pump unit shall be self-contained, factory assembled.
   1. Pressure tested, dehydrated and charged with refrigerant and oil.

END OF SECTION 238146

SECTION 238216 - HEATING AND COOLING COILS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install heating and cooling coils.

1.2 SUBMITTALS

A. Submit manufacturer's product data sheets and unit capacity information as specified.

B. Submit manufacturer's Installation, Start-Up and Service Instructions.

C. Submit internal wiring diagram.
   1. Electrical interlocks. *

1.3 RELATED WORK

A. Division 23 Mechanical.
   1. Air Handling Units.
   2. Fan Coil Units.
   3. Weatherproof Roof Mounted Air Handling Units.
   4. Ductwork.
   5. Terminal Boxes.

PART 2 - PRODUCTS

2.1 HOT WATER COILS

A. Hot water coils:
   1. Constructed of copper tubes and aluminum fins.
   2. Designed and circuited for hot water.
      a. Maximum temperature 200°F.

B. Where coils are installed in fan powered VAV boxes, unit heaters and other locations where the incoming air is not filtered, the maximum approved fin spacing is 8 fins per inch.

C. Non-trapping circuit design:
   1. Working pressure 200 psi
   2. Tappings for drain and air vent

D. Provide a Peterson Pete's Plug with retainer strap on the inlet and outlet of each coil.
   1. Positioned to permit accurate pressure readings.

E. Coils shall be constructed in casings as required for installation.

2.2 CHILLED WATER COILS

A. Chilled water coils:
   1. Constructed of copper tubes and aluminum fins
   2. Designed and circuited for chilled water
   3. Minimum of six rows

B. Non-trapping circuit design:
   1. Working pressure 200 psi.
   2. Tappings for drain and air vent.

C. Provide a Peterson Pete's Plug with retainer strap on the inlet and outlet of each coil. Position to permit accurate pressure readings.

D. Coils shall be constructed in casings as required for installation.

E. Where coils are stacked, provide intermediate drain pans with drop tubes to drain condensate to the main drain pan without flooding the lower coil.

2.3 DIRECT EXPANSION COOLING COILS

A. DX cooling coils:
   1. Constructed of copper tubes and aluminum fins.
   2. Designed and circuited for use with direct expansion refrigeration.

B. Cooling coil face velocity:
   1. Not of magnitude to cause moisture to be carried off the coil.
   2. Maximum velocity as scheduled.

C. Circuit cooling coil with interlaced tubes so the entire face is active under all modes of unloading. Refer to the schedule on the drawings.

D. Coils shall be constructed in casings as required for installation.

E. Where coils are stacked, provide intermediate drain pans with drop tubes to drain condensate to the main drain pan without flooding the lower coil.

2.4 ELECTRIC HEATERS

A. Capacity shall be as scheduled on the drawings. Heater shall have 80% nickel, 20% chromium, open resistance coils insulated by floating ceramic bushings, and be supported in an aluminum steel frame.

B. Ceramic bushings shall be recessed into embossed openings and staked into supporting brackets spaced 3-1/2" maximum center to center.

C. Coil shall be machine-crimped into threaded terminals and insulated with phenolic bushings. All terminal hardware shall be stainless steel.

D. Heater shall be listed by the Underwriters Laboratories for zero clearance to combustible surfaces and for use with central air conditioners.

E. For primary protection, furnish a disk-type automatic reset thermal cutout for pilot duty only.

F. For secondary protection, load-carrying manual reset thermal cutouts shall be wired in series with each heater circuit. Cutouts shall be rated at 480 volts minimum.

G. Voltage, phase and number of heating stages shall be furnished in accordance with duct heater schedule. Three-phase heaters shall have single-phase circuits for operation from a 3-phase, 4-wire power source. Circuits shall be rated at 48 amperes maximum. Furnish one set of line terminals to feed all circuits. Heater shall be tested dielectrically at 2000 volts before shipment. Field-installed conductors feeding the heater shall be sized for 125% of the connected load.

H. Built-in components shall be factory wired to terminal blocks for field connection. All internal wiring shall be insulated for 105°C. Built-in magnetic contactors shall disconnect all ungrounded conductors to each circuit. Furnish heaters with an air flow switch that will not allow heaters to energize without proof of air flow. Built-in transformer shall be dry industrial type, sized to carry full contactor holding coil load. Primary windings shall be fused at the factory. Built-in fuses shall be factory wired to each circuit to protect all underground conductors. Type NON or NOS fuses to be factory installed in phenolic fuse blocks. Built-in disconnect switch to be snap action, industrial type. Provide a door interlock mechanism to prevent hinged terminal box cover from being opened when the switch is on. Switch shall be unfused.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install the duct heaters in accordance with the manufacturer's Installation, Start-Up and Service Instructions.

END OF SECTION 238216

SECTION 238218 - DUCTLESS MINI SPLIT DX UNITS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Furnish and install mini split system. Complete with a slim silhouette, compact, high wall mounted indoor fan coil section with wireless remote controller and a slim silhouette horizontal discharge outdoor condensing unit. Unit shall be provided with constant speed compressor, pre-charged with R-32/R-454B refrigerant. air-cooled condensing units complete with casing, compressor, condenser coil, condenser fan and controls required for a split air conditioning system.

1.2 RELATED WORK

A. Refrigerant Piping.

B. Electrical Provisions of Mechanical Work.

1.3 PERFORMANCE

A. Provide performance as scheduled on drawings, and head pressure control to enable unit to operate in temperatures as low as 20 degrees F. ambient.

1.4 QUALITY ASSURANCE

A. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL) and bear the ETL label.

B. All wiring shall be in accordance with the National Electrical Code (N.E.C.).

C. The units shall be rated in accordance with Air-conditioning, Heating, and Refrigeration Institute’s (AHRI) Standard 210 and bear the AHRI Certification label.

D. The units shall be manufactured in a facility registered to ISO 9001 Quality assurance Standards and ISO 14001 which are set of standards applying to sustainability and environmental protection set by the International Standard Organization (ISO).

E. A pressure charge of R-32/R-454B refrigerant sufficient for up to twenty-five (25) feet of refrigerant tubing shall be provided in the outdoor condensing unit.

F. A dry air holding charge shall be provided in the indoor section.

G. System efficiency shall meet or exceed 13.4 SEER2.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Carrier

B. Trane

C. Mitsubishi Electric

2.2 INDOOR UNIT GENERAL

A. The indoor shall be factory assembled, wired and run tested. Contained within the unit cabinet shall be all factory wiring, internal piping, electronic control circuit board and fan with fan motor.

B. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, and auto restart after power interruption function, an emergency operation function and a test run switch.

C. Indoor unit and refrigerant pipes shall be charged with dry air before shipment from the factory. All refrigerant piping must be insulated.

2.3 UNIT CABINET

A. The casing shall have a smooth front, top return, in a Munsell No. 1.0Y 9.2/0.2 white finish.

B. Multi directional drain and refrigerant piping offering four (4) directions for refrigerant piping and two (2) directions for draining shall be standard.

C. There shall be a separate installation plate which secures the unit firmly to the wall. Secure mounting of plate and all mounting hardware shall be furnished by and be the responsibility of the installer.

2.4 FAN

A. The indoor unit fan shall be an assembly with a line-flow fan direct driven by a single motor mounted in rubber motor mount.

B. The fan shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings.

C. Manual adjustable vertical guide vanes shall be provided with the ability to change the airflow from side to side (left to right).

D. An integral, motorized, horizontal air sweep flow louver shall provide an automatic change in airflow by directing the air up and down to provide for uniform air distribution.

E. The indoor unit fan motor shall operate in four (4) selectable speeds, Powerful, High, Medium, and Low.

2.5 FILTER

A. Return air shall be filtered by means of easily removed, washable, Catechin air filter and an anti-allergy enzyme filter – blue bellows type.

2.6 COIL

A. The indoor unit (evaporator) coil shall be of nonferrous construction with smooth, pre-coated aluminum fins on copper tubing.

B. Tubing shall have inner groves for high efficiency heat exchange.

C. All tube joints shall be brazed with PhosCopper or silver alloy.

D. The coil shall be pressure tested at the factory.

E. A sloped condensate pan and drain with extension hose shall be provided under the coil. Drain connections shall be provided at each end of the drain pan. (Option: A condensate mini-pump shall be provided to provide a means of condensate disposal when a gravity drain is not available.)

2.7 ELECTRICAL

A. Power for the indoor unit shall be supplied from the outdoor unit via Mitsubishi Electric A-Control using three (3) fourteen (14) gauge AWG conductors (N, L1, 2) plus ground wire connecting the units.

B. Power supply shall be 115 volts, 1 phase, 60 hertz. The system shall be capable of satisfactory operation within voltage limits of 103 volts to 127 volts. Wiring shall be 14.

C. The unit shall be equipped with Mitsubishi Electric's micro-processor control system directing indoor and outdoor unit coordinated operation.

D. The indoor unit shall not have any supplemental electrical heat elements.

2.8 CONTROL

A. This system shall have a wireless remote controller to perform input functions necessary to operate the system. The controller shall consist of a Power On / Off switch, Mode Selector, Temperature Setting, Timer Control, Fan Speed Select and Auto Vane Selector.

B. Temperature changes shall be by 1°F increments with a range of 65°F to 87°F.

C. There shall be a 24 hour On / Off timer.

D. The unit shall have an emergency operation mode to allow operation without the remote controller.

E. The microprocessor located in the indoor unit shall have the capability of sensing return air temperature and indoor coil temperature, receiving and processing commands from the wireless remote controller, providing emergency operation and controlling the outdoor unit.

F. The control voltage between the indoor unit and the outdoor unit shall be 115 volts, AC.

G. The system shall be capable of automatic restart when power is restored after power interruption.

H. The control system shall control the operation of the air sweep louvers, as well as provide on / off and system / mode function switching.

2.9 OUTDOOR UNIT GENERAL

A. The outdoor unit is designed specifically for use with MS series indoor units. These units are equipped with a circuit board that interfaces to the MS indoor unit circuit board. The outdoor unit shall be completely factory assembled, internally piped and wired. Each unit shall be run tested at the factory.

B. When refrigerant lines are exposed on exterior of building provide “LINE-HIDE” line set cover system.
   1. Material, Weather resistant, UV stabilized, ASA/PVC/ABS/Poly/PE
   2. Assembly Screws, stainless steel.

2.10 UNIT CABINET

A. The casing shall be fabricated from zinc coated steel, bonderized with an electrostatically applied, thermally bonded, acrylic or polyester powder coating for corrosion protection.

B. Case and mounting feet shall be as follows:
   1. The MS-A09WA base shall be of Aluminum-Zinc-Magnesium alloy coated steel, with welded mounting feet.
   2. The base for the MS-A12WA shall have a galvanized steel base with welded mounting feet.

C. Cabinet mounting and construction shall be sufficient to withstand 155 MPH wind speed conditions for use in Hurricane condition areas. Mounting, base support, and other installation to meet Hurricane Code Conditions shall be by others.

2.11 FAN

A. The unit shall be furnished with a directive drive propeller type fan, statically and dynamically balanced for smooth and quiet operation.

B. The fan motor shall have inherent protection, be equipped with permanently lubricated bearings. The fan motor shall be mounted and isolated for quiet operation.

C. The fan shall be provided with a raised guard to prevent contact with moving parts.

D. The outdoor unit shall have horizontal discharge airflow.

2.12 COMPRESSOR

A. The compressor shall be a Mitsubishi Electric high performance, hermetic, rolling piston, rotary type.

B. Compressor shall be mounted using rubber isolating bushings to avoid the transmission of vibration.

C. Compressor shall be protected by an automatic over current relay and a thermal overload switch.

2.13 OPERATION

A. The outdoor unit shall have an accumulator.

B. The outdoor unit must have the ability to operate with a maximum height difference of 35 feet between indoor and outdoor units.

C. The unit shall have a maximum refrigerant tubing length of 65 feet between indoor and outdoor units without the need for line size changes, traps or additional oil. All refrigerant lines must be insulated.

D. The unit shall be pre-charged for a maximum of 25 feet of refrigerant tubing.

2.14 ELECTRICAL

A. The electrical power of the system shall be 115 volts, 1 phase, 60 hertz. The unit shall be capable of satisfactory operation within voltage limits of 103 volts to 127 volts.

B. The outdoor unit shall be controlled by the microprocessor located in the indoor unit. The control voltage between the indoor unit and the outdoor unit shall be 115 volts, AC.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mount condensing units on 4" foundation pads and pipe as shown on Drawings or as recommended by the equipment manufacturer. Install refrigerant filter dryer and sight indicating glass.

B. Install units on vibration isolation pads.

3.2 CONTROL WIRING

A. Furnish and install control wiring as required. Install control wiring in conduit.

3.3 DELIVERY, STORAGE AND HANDLING

A. Unit shall be stored and handled according to the manufacturer’s recommendations.

B. The wireless controller shall be shipped inside the carton with the indoor unit and able to withstand 105°F storage temperatures and 95% relative humidity without adverse effect.

3.4 WARRANTY

A. The units shall have a manufacturer’s parts and defects warranty for a period five (5) years from the date of the original installation. The compressor shall have a warranty of seven (7) years from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer. This warranty does not include labor.

3.5 START-UP

A. Follow the manufacturer's start-up procedures.

B. Provide flexible elastomeric rubber closed cell insulation to prevent condensation from occurring op suction piping. After completion of successful start-up, installing contractor shall seal all openings in insulation and apply a protective aluminum sheetmetal jacket over insulation exposed on exterior of building.

END OF SECTION 238218

SECTION 238239 - ELECTRIC UNIT HEATERS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide and install electric unit heaters complete with heating element, propeller mounting brackets and other options as specified.

1.2 RELATED WORK

A. Division 23 - Mechanical.
   1. Electrical Provisions of Mechanical Work.
   2. Ductwork.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Modine

B. Reznor

C. Chromalox

D. Trane

E. Markel

2.2 COMPONENTS

A. Casing:
   1. Construct casing of sheetmetal with a structural frame.
   2. Enamel or lacquer finish to manufacturers standard.

B. Electric Heating Elements:
   1. Shall bear the UL label.
   2. Corrosion resistant materials.
   3. Heating coil of 80-20 nickel-chrome wire.

C. Components:
   1. Fused control circuits
   2. Contactors in accordance with the staging requiremens
   3. Control power transformer

4. Control voltage 120

D. Louvers:
1. Adjustable vertical and horizontal louvers for air discharge.

E. Mounting brackets:
1. As indicated

2.3 CONTROLS

A. Automatic controls:
1. Factory mounted
2. Prewired to the junction box
3. Unit mounted thermostats 24-volt low voltage

B. Safety Controls:
1. A primary and secondary thermal cut-off to de-energize each circuit.
2. Manual reset high limit
3. Automatic reset thermal protection

2.4 FAN

A. Propeller blade fan:
1. Construct the fan of aluminum or other corrosion-resistant material.
2. Statically and dynamically balanced
3. Substantial fan guard

2.5 MOTOR

A. Totally enclosed ball bearing motor:
1. Permanently lubricated bearings
2. 120 volt, single phase, 60 cycle motor
3. Sized to operate the fan at the required capacity

2.6 ELECTRICAL

A. Single point connection:
1. Factory wiring
2. Only direct line supply and thermostat field connections
3. Terminal blocks for line voltage wiring
4. Wiring diagram permanently attached
5. Balance phases

PART 3 - EXECUTION

3.1 INSTALLATION

A. Furnish units with suitable connections for mounting as shown or as otherwise approved.

B. Provide start-up to ensure correct operation of unit.

C. Adjust discharge louvers to control direction of air flow.

END OF SECTION 238239